

**STUDY OF VARIATIONS IN CANOPY TEMPERATURE AND  
LIGHT USE EFFICIENCY DUE TO DIFFERENT FERTILIZER  
LEVELS IN ROSE UNDER POLYHOUSE CONDITION DURING  
KHARIF AND WINTER SEASON**

**By**

**NAWADKAR RAKESH BHANUDAS**

**Reg. No. 07/213**

**A thesis submitted**

**To**

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

*in partial fulfillment of the requirements for the degree of*

**MASTER OF SCIENCE (AGRICULTURE)**

**In**

**AGRICULTURAL METEOROLOGY**

**DEPARTMENT OF AGRICULTURAL METEOROLOGY,  
COLLEGE OF AGRICULTURE,**

**PUNE - 411 005**

**2009**

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**COLLEGE OF AGRICULTURE, PUNE – 411 005**

**2009**

## **CANDIDATE'S DECLARATION**

I hereby declare that the thesis entitled, **“Study of variations in canopy temperature and light use efficiency due to different fertilizer levels in rose under polyhouse conditions during kharif and winter season”** or part thereof, has not been submitted by me or any other person to any other University or Institute for a degree or diploma.

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The assistance and help received during the course of this investigation and sources of literature referred to have been duly acknowledged.

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*Date: 06 /01 /2010*

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## ABBREVIATIONS

Ave.	:	Average
CD	:	Critical Difference
cm	:	Centimeter
DAB	:	Days after Bending
DAT	:	Days after Transplanting
<i>et al.</i>	:	And other
etc.	:	Et cetra
fc	:	Foot Candle
Fig.	:	Figure
ft.	:	Feet
FYM	:	Farm Yard Manure
gm	:	Gram
ha	:	Hectare
Hi-Tech	:	High Technology
hrs.	:	Hours
i.e.	:	That is
kg	:	Kilogram
lb.	:	Pounds
lit.	:	Litre
LUE	:	Light Use Efficiency
m	:	Metre
m <sup>2</sup>	:	Metre Square
mg	:	Milligram
Max.	:	Maximum
Min.	:	Minimum
MJ	:	Mega Joule
mm	:	Milimetre

MSL	:	Mean Sea Level
nm.	:	nano metre
NPK	:	Nitrogen(N): Phosphorus(P <sub>2</sub> O <sub>5</sub> ): Potassium(K <sub>2</sub> O)
pl.	:	Plant
pH	:	Negative logarithm of hydrogen ion
ppm	:	Parts per million
RH-I	:	Relative Humidity at 7:30 hr.
RH-II	:	Relative Humidity at 14:30 hr.
SE	:	Standard Error
Sq. m.	:	Square metre
Temp.	:	Temperature
T <sub>a</sub>	:	Air temperature
T <sub>c</sub>	:	Canopy temperature
UV	:	Ultra violet
viz.	:	Videlicet (namely)
W	:	Watt
wk.	:	Week
%	:	Percentage
μ	:	Micron
μmolm <sup>-2</sup> s <sup>-1</sup>	:	Micro mol per metre square per second
/	:	Per
@	:	At the rate of
<sup>0</sup> C	:	Degree Celsius
<sup>0</sup> F	:	Degree Fahrenheit
Φ	:	Diameter of pot

## ABSTRACT

### “STUDY OF VARIATIONS IN CANOPY TEMPERATURE AND LIGHT USE EFFICIENCY DUE TO DIFFERENT FERTILIZER LEVELS IN ROSE UNDER POLYHOUSE CONDITIONS DURING KHARIF AND WINTER SEASON”

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<b>Department</b>	:	<b>Agricultural Meteorology</b>

The present investigation entitled as “Study of variations in canopy temperature and light use efficiency due to different fertilizer levels in rose under polyhouse conditions during kharif and winter season” was conducted at Hi-tech Floriculture and Vegetable Project, College of Agriculture Pune – 411 005 during August,2008 to December 2008.

The experiment was laid out in a randomized block design with five treatments viz; T<sub>1</sub>(NPK @ 400:400:400 mg/wk/pl), T<sub>2</sub> (NPK @ 450:400:400 mg/wk/pl), T<sub>3</sub> (NPK @ 500:400:400 mg/wk/pl), T<sub>4</sub> (PK @ 550:400:400 mg/wk/pl) T<sub>5</sub> (NPK @ 600:400:400 mg/wk/pl) and replicated four times with ten plant per treatment. Passion cultivar of rose was selected. The growth parameters viz; days to sprouting, days required for flowering and number of leaf pairs, the quality parameters such as length of shoot, diameter of flower bud, length of flower bud and yield parameters like number of flowering shoots produced per plant, total yield

of flowers (per plant) were significantly influenced by different fertilizer levels.

The results indicated that various vegetative observations like maximum length of shoot (64.39 cm), maximum number of leaf pairs per flowering shoot (20.07), highest number of flowering shoots produced per plant (5.27) and maximum number of flowers per plant (9.58) were observed in treatment T<sub>5</sub> (NPK @ 600:400:400 mg/wk/pl) and qualitative characters such as maximum diameter of flower bud (2.30 cm) and highest length of flower bud (2.86 cm) were observed in treatment T<sub>4</sub> (NPK @ 550:400:400 mg/wk/pl). It was observed that the treatments, T<sub>5</sub> (NPK @ 600:400:400 mg/wk/pl) followed by treatment T<sub>4</sub> (NPK @ 550:400:400 mg/wk/pl) were optimum for growth and yield in rose. Although T<sub>4</sub> (NPK @ 550:400:400 mg/wk/pl) produced superior quality flowers, its performance in respect of yield of flowers was found to be slightly reduced.

It was observed that the weekly mean incident radiation under open condition was  $942.81 \mu\text{molm}^{-2}\text{s}^{-1}$  which was 69.32% more than weekly mean incident radiation under polyhouse conditions  $289.25 \mu\text{molm}^{-2}\text{s}^{-1}$ .

It was found that, weekly mean reflected radiation under open condition was  $85.81 \mu\text{molm}^{-2}\text{s}^{-1}$  which was 71.09% more than weekly mean reflected radiation under polyhouse conditions  $24.8 \mu\text{molm}^{-2}\text{s}^{-1}$ . That as fertilizer levels increased, amount of reflected radiation was found to be decreased. It was also noticed that on an average amount of reflected radiation increase with increased in the age of crop.

It was revealed that, weekly mean transmitted radiation under open condition was  $134 \mu\text{molm}^{-2}\text{s}^{-1}$  which was 31.76% more than weekly mean transmitted radiation under polyhouse conditions  $91.44 \mu\text{molm}^{-2}\text{s}^{-1}$ . That as fertilizer levels increased, the amount of transmitted radiation

decreased. It was also noticed that on an average amount of transmitted radiation decreases at 93, 100 and 121 DAT, this may be due to development of dense crop canopy with age of crop.

It was noticed that, weekly mean absorbed radiation under open condition was  $713.56 \mu\text{molm}^{-2}\text{s}^{-1}$  which was 75.93% more than weekly mean absorbed radiation under polyhouse condition  $171.77 \mu\text{molm}^{-2}\text{s}^{-1}$ . That as fertilizer levels increase, amount of absorbed radiation was also increased. It was also noticed that on an average amount of absorbed radiation increased with increase in the age of crop. This may be due to development of dense crop canopy with advancement in the age of crop. Under polyhouse it was observed that decrease in albedo was noticed with increase in fertilizer levels table 21. The highest albedo (12 %) and lowest albedo (5.98 %) were observed in the treatment T<sub>4</sub> (NPK @ 550:400:400 mg/pl/wk). From the comparison between open field and polyhouse it was observed that open field had more albedo (9.12 %) than under polyhouse (8.41%).

Under polyhouse it was observed that transmissivity decreased with increase in the fertilizer levels table 23. The highest transmissivity was observed in the treatment T<sub>1</sub> (NPK @ 400:400:400 mg/pl/wk) (49.85 %) while lowest transmissivity observed in treatment T<sub>5</sub> (NPK @ 600:400:400 mg/pl/wk) (20.41 %). In general under polyhouse the transmissivity was much higher (32.45 %) than open field condition (15.04 %) because of directionality effect of radiation i.e. under polyhouse conditions direct radiation was less and diffused radiation was more than open conditions.

Under polyhouse it was seen that increase in absorptivity with increase in fertilizer levels table 25, this might be due to development of dense crop canopy. The highest absorptivity was observed in the treatment T<sub>5</sub> (NPK @ 600:400:400 mg/pl/wk) (72.51 %) while lowest absorptivity

observed in treatment T<sub>1</sub> (NPK @ 400:400:400 mg/pl/wk) (40.64 %). From the comparison between open field and polyhouse it was observed that open field had more absorptivity (75.8 %) than polyhouse (59.33 %).

Relative humidity (RH-I) during the experiment period ranged between 89 and 98% , 86 and 96% under polyhouse and open field condition respectively at 7.30 a.m. while relative humidity (RH-II) at 2.30 p.m. in afternoon ranged between 37 and 80% and 27 and 75% under polyhouse condition and open field condition respectively.

While weekly temperature during experimental period ranged between 16.3 and 24.2 °C , 13.5 and 22.3 °C under poly house and open field conditions respectively at 7.30 a.m. Whereas afternoon temperature at 2.30 p.m. under polyhouse and open field condition ranged between 26.1 and 36.7 °C , 27.5 and 32.9 °C respectively. Thus in general temperature inside polyhouse was more than open field condition.

Canopy-air temperature differential was recorded at weekly intervals. The highest negative value (-4.8) T<sub>1</sub> whereas lowest (-1.2) observed at T<sub>5</sub> (NPK @ 600:400:400 mg/wk/pl).

The highest green weight light use efficiency (19.57g/MJ) was observed in T<sub>5</sub> (NPK @ 600:400:400 mg/wk/pl) and lowest was observed in T<sub>1</sub> (no fertilizer application) (16.16 g/MJ).

The highest dry weight light use efficiency (6.57g/MJ) was observed in T<sub>5</sub>(NPK @ 600:400:400 mg/wk/pl) and lowest was observed in T<sub>1</sub> (NPK @ 400:400:400 mg/wk/pl) (4.75 g/MJ).

## 1. INTRODUCTION

some words instantaneously suggest beauty because they are associated with things that afford pleasure and delight .The rose is one of them(Pal,1991).

Rose is usually acclaimed as king of flowers. No other flower is a better symbol of love, adoration ,innocence and other virtues than the rose, and not in our time only, but so it has been for thousands of years. The history of man and rose is linked together for about 5000 years (Dhua,1999).Apart from making garlands, bouquets, buttonholes, preserves and use for worship in temples; rose make one of the best cut-flower and as such is in great demand in the domestic as well as in foreign markets. Rose is the most preferred flower in the international market. The demand for roses has been growing at a higher rate compared with other flowers .Roses alone share 51 per cent of European market (Rajagopalan,2000).

Presently in Maharashtra area under protected cultivation in the state of Maharashtra is 400 ha.(Sabale,2006). Rose is reported to be cultivated on 78 ha under polyhouse, producing around 1170 lakhs of flowers stem. The total export of floriculture produce from India in 2005 was Rs. 8174 lakhs while it increased to Rs. 10117 lakh by April 2006.Scientifically *Rosa hybrida* belongs to the family *Rosaceae*. In India several species are found growing widely. Rose is world-leading cut flowers in production as well as in market. It shares about 24% of world trade of cut flowers. Rose posses different characters required for cut flower such as more number of petals, slow opening of bud, more longevity, attractive colors, long and strong stem etc. On the contrary, among the most of flowers rose bushes have an average lifetime of 6-7 years.

Germany is by far the largest market in the world for rose flowers. The Netherlands is the largest supplier of roses to Europe. The rose is dominantly cultivated under subcontinent conditions of India. The nutritional requirements are met by way of fertigation. The exact nutritional requirements of rose grown under pot culture conditions in polyhouse are however, not clearly defined like the other agricultural crops.

Maharashtra is one of the leading states in flower production under protected cultivation, especially in polyhouse. The quality of flowers is also very important which is influenced by the level of nutrients being applied through fertigation. Potassium plays an important role in improving nutrient use efficiency, yield and quality of flowers with respect to stalk length, diameter and shelf life. The potassium however is supplied through  $\text{KNO}_3$ ,  $\text{K}_2\text{SO}_4$  and  $\text{KCl}$ . Higher temperature during field conditions decreases vase life and quality of cut flowers. Rose cv. 'Carol' and 'Dr. Verhage' grown at high temperature, yield very pale flowers, but produce normal colour when cut at the bud stage and kept in sucrose solution (Halevy and Mayak, 1974). A relative humidity of about 90-92% has generally been recommended for all floral crops. Mortenson and Fjeld (1995) reported that increasing humidity from 65 to 85% has no effect on the vase life of roses, while a further increase to 90% significantly decreased it.

Mukhopadhyaya *et al.* (1989) recorded an interaction effect of N and P on the improvement of flower diameter of rose Cv. 'Happiness'. Bhattachajee and Mukharjee (1995) observed that flower size with higher doses of N and P on *Dahlia variabilis* Cv. 'Black Out'. Nagaraju *et al.* (2003) studied that on field grown roses the effect of N, P and multiplex on growth, production and quality. As a result the plants receiving 30g N + 24gK recorded significantly improved performance in terms of number and

fresh weight of flowers, stem and bud length, bud diameter and also production of good quality flowers. Uri *et al.* (1990) concluded that calyx splitting and high percentage of the disorder brittle stem (associated with K deficiency) were observed in outdoor crops of cultivar, Standard (Syn – White candy) grown on a sandy loam soil in Sitaria in coastal zone of Israel. The flower quality of calyx splitting and brittle stem was improved by supplying the highest ‘K’ level. Pre-harvest factors like genetical, light, temperature, soil, nutrient, relative humidity, season/day, CO<sub>2</sub> enrichment, chemical applications, irrigation, pest and diseases affect the quality of cut flowers in the range of 30 to 70% (Halevy and Mayak, 1979). Flowers can be stored wet in water at 2-5<sup>0</sup>C for 5-7 days.

Quality of flowers under open field condition is not suitable for international markets, at the same time there is no guarantee of consistent production from open cultivation as the crop is exposed to number of natural environmental factors which change frequently. Recently a polyhouse cultivation showed a way to the Indian growers for getting higher yield with export quality. Number of varieties have been introduced from abroad for this purpose. However, there is less information available regarding rose cultivation under our conditions. Therefore, the present investigation was carried out with the following objectives

1. To study the variations in canopy temperature due to different fertilizer levels under polyhouse conditions.
2. To study the variations in light use efficiency due to different fertilizer levels under polyhouse conditions.
3. To study the effect of N, P, and K levels on the growth, yield and quality of rose in relation to meteorological parameters.

## 2. REVIEW OF LITERATURE

The literature pertaining to the “Study of variations in canopy temperature and light use efficiency due to different fertilizer levels in rose under polyhouse conditions during kharif and winter season” are reviewed in this chapter.

### 2.1 Growing conditions

Polyhouse is framed structure clad with polythene film, which can provide the favorable conditions for the growth of the plants in several ways *viz.*, favorable environmental conditions protection from heavy winds, pests, and diseases and other climatic conditions (Khan 1995).

Sabale (2006) studied the microclimates of net, glass, polythene houses and methods of micrometeorological modification in greenhouse. The limited references are available on rose crop, therefore references on others floriculture crops grown in polyhouse are also included in this chapter.

Jeevajothi *et al.* (2003) studied that the influence of three growing environments *viz.*, glasshouse, shade house and open field on ten cultivars of gerbera. The flowers produced in glasshouse had greatest flower stalk length (46.16cm) and flower diameter (8.11 cm), followed by shade house with stalk with flower diameter of (40.89 cm) and (7.32 cm) respectively, Whereas growth in open field had the lowest stalk length and flower diameter (33.87 cm) and (6.73 cm), respectively.

Kumar and Sook (2003) conducted an experiment to study the effect of shading and media on gerbera, cultivar Priyadarshni recorded the maximum number of leaves (5.73), plant spread (31.84 cm), number of

flowers (2.00), stalk length (31.84 cm) and flower diameter (8.08 cm) under 75% shading conditions.

## **2.2. Characterization of coco peat**

Pythlewsiki and Martyn (1989) noticed that the mixer of coco peat :sand or peat : perlite with the proportion of 1:1 was suitable for rose cultivation for obtaining high yields.

Allera et al.(2000) observed that the coconut fiber induced higher yields and the best quality flowers of rose better stem length and stem weight.

The suitable of coco peat either alone or in combination with other medium leaf mould with the proportion of 1:1 for floricultural potted plants has been reported by Singh and Sindhu (2002).

Rajhans (2003) concluded that organic matter like FYM,perlite,vermicompost,sawdust,composted free bark coco peat and rice husk were improve the growing media.

## **2.3 Effect of Environmental factors**

### **2.3.1 Effect of Temperature on flowers crops**

Hanan (1960) found that flowers produced during summer were characterized by the absence of central petals and that high temperature is also responsible for low petal counts and increased the problem of calyx splitting.

Harris *et. al.* (1968) reported that, rate of growth in size of the flower were decreased by either low temperature or low light intensities. But only low temperature caused an appreciable delay in anthesis.

Kho and Baer (1973) revealed that a low temperature (5<sup>0</sup>C) given either continuously or at night promoted the formation of secondary growing

centers within the flower of carnation. Effect of temperature on petals were exerted in the early stage of flower development before the flower bud become visible between the leaves.

Halevy and Mayak (1974) reported that rose cv. 'Carol' and 'Dr. Verhage' grown at high temperature, yield very pale flowers, but produce normal colour when cut at the bud stage and kept in sucrose solution .

Higher temperature during field conditions decreases vase life and quality of cut flowers. But Moe (1975) observed that a decrease in temperature before harvest from 21-24<sup>0</sup>C to 12-15<sup>0</sup>C reduces the vase life of cut roses.

Kim *et al.* (1990) revealed that gerbera cultivars grown in greenhouse began to flower in about 9-14 weeks and 1<sup>st</sup> flowering peak occurred in about 7-8 months after planting. Flower stem length varied with season and diameter tended to decrease at both low and high temperatures. The percentage of flowers produced in grade I was 83.1 in 1<sup>st</sup> year which declined to 63.7% in 2<sup>nd</sup> year.

Celikel and Karacaly (1991) concluded that carnation flowers grown at relatively low pre-harvest temperature in the summer had a longer vase life than those cut in the spring.

Gorsal (1993) In Bouvardia, reported that vase life decreases with increasing greenhouse temperature from 18 days at 25<sup>0</sup>C to 9 days at 15<sup>0</sup> C. In spring, a temperature of 18<sup>0</sup>C is optimal.

Sivaswamy and Bhattachajee (2001) revealed that Cut roses can be stored wet for 2 days only retaining their ultimate vase life in ambient temperature .

Palnikumar and Bhattachajee, (2001) concluded that the cut rose cultivars 'Golden Giant', 'Raktagandha' and 'Queen Elizabeth' can be

stored under 4<sup>0</sup>C for maximum 5 days, and under 8<sup>0</sup>C the cut roses can be stored for maximum 2 days without affecting their ultimate keeping quality of vases at ambient temperature.

Kumar and Singh (2004) reported that long photoperiod resulted in maximum plant height and percent flowering rose shoots. However, the total number of side shoots/plant and number of leaf pair to flower were significantly reduced by this photoperiod and these were recorded to be the highest under short photoperiod of winter.

Nozaki *et al.* (2006) the experiment and concluded the results which indicated that the mean temperature is more important than either day or night temperature in determining the degree of flowering colouration.

Sabale (2006) reported that the optimum day temperature for rose crop was reported to be 21-24<sup>0</sup>C and night temperature 16 to 17<sup>0</sup>C

### **2.3.2 Effect of light intensity**

Light is another factor that regulates several physiological processes like chlorophyll synthesis, phototropism, respiration and stomatal opening. Most commercial flowers need high light intensity (3000-8000 f.c.). Absorption of red light (625-700 nm) through a pigment, phytochrome, is essential for carbohydrate production which determines the longevity of cut flowers.

Harris *et al.* (1968) reported that, rate of growth in size of the flower were decreased by either low temperature or low light intensities but only low temperature caused an appreciable delay in anthesis. Effect of low light intensities could be stimulated by partial defoliation in gerbera and appeared to be mediated through effects on photosynthesis.

Halevy and Mayak (1974) reported that light intensity also influenced colour of petals. Colour intensity of petals depends upon the availability of carbohydrates in surrounding tissue.

Halevy and Mayak (1979) observed that cut flowers carnation having comparatively higher amount of stored carbohydrates show longer vase life. It is well known that the carnation and chrysanthemum is longer under high light intensity.

Conover (1980) concluded that higher light intensity causes changes in vertical orientation of *Aglaonema* and *Dieffenbachia*.

Nowak and Rudnicki (1990) reported that low temperature associated with low light intensity and short days of winter is decreased the longevity of cut carnations, gerberas and roses in comparison with long warm days of summer.

Verberkt (1990) observed that several pot plants grown with high light quantities, not only showed better growth and improved quality, but also a better keeping quality.

Slootweg and Van Meeteren (1991) observed that cut rose buds grown under low light intensity produced normally coloured petals when treated with sugar solution whereas flowers left on the plant had a paler colour petal.

Bredmose (1993) reported that the supplemental lighting increases larger leaf area and accelerates flower development in field grown roses.

Celikel and Karacaly (1995) observed that the high temperature in summer season has an adverse effect on the 'keep ability' in carnation.

Krishna *et al.* (1999) observed that fertigation levels had no significant effect on plant height up to 90 days after transplanting, bud length, bud diameter, flower diameter, stem length, number of flowers per

plant, flower yield and unmarketable flower. Interaction between fertigation and cultivars were identified for plant height after 105 days, bud length, flower diameter, stems length, days for bud initiation.

Autio (2000) noticed that the 12 hrs. photoperiod produced the highest number of inflorescences if the same daily supplementary light integral was used. It was also concluded that increase in daily light integral by increased supplementary light intensity strongly affected the number of inflorescences in 12 hrs. photoperiod.

Kumar and Singh (2004) reported that long photoperiod resulted in maximum plant height and percent rose flowering shoots. However, the total No. of side shoots/plant and No. of leaf pair to flower were significantly reduced by this photoperiod and these were recorded to be highest under short photoperiod of winter.

### **2.3.3 Interaction effects**

Zonzora *et al.* (1988) grown the plants of paper cv. 'Lamuyo' in growth chambers in sand culture with  $\text{NO}_3:\text{NH}_4$  ratios of 100:0 or 80:20 and with light intensities of 240 or 300  $\text{W/m}^2$ . plants given both forms of nitrogen in high light intensity showed lower nutrient uptake than those with  $\text{NO}_3$  only. The effect was more pronounced for N and K. plants with both forms of N at low light intensity showed increased uptake of N.

Poole and Conover (1988) studied they pot plants of *Codiaeum variegatum* cv. Petra, *Hedera helix* Cv. Glacier, *Peperomia obtusifolia*, *Philodendron scandens* subsp. *Oxycardium*, *Radermachia sinica* and *Spathiphyllum* Cv. Tasson were grown from 27 Dec. at thermostat settings of 55, 60, 65 or 70  $^{\circ}\text{F}$ . the plants also received NPK fertilization at recommended levels (specified) and 2 $\times$  and 3 $\times$ . The responses to increasing fertilizer levels were adequate. It was established that a temperature between

60 and 65<sup>0</sup>F was adequate for all species and it was economically the most viable: raising the temperature from 60 to 65 <sup>0</sup>F increased fuel usage by 78% whereas increasing it from 60 to 70<sup>0</sup>F increased consumption by 212%.

#### **2.4 Nutrient requirement of flower crops**

Studies on the nutritional requirements of the perpetual carnation on were initiated by Chan et al. (1958). He found that application of K markedly increased the yield of flowers with the optimum level beyond 90 ppm.

Iyengar (1970) reported that mixture containing 6 parts of nitrate of potash, 2 parts of sulphate of ammonia, 16 parts of super phosphate, 8 parts of sulphate of potash, 2 parts of magnesium and ½ part of phosphate of iron by weight in rose.

Arora and Saini (1976) concluded that application of N at 20 or 40 g/m<sup>2</sup>, phosphorus at 10 or 20 g/m<sup>2</sup> an potassium at 60 g/m<sup>2</sup> increased the plant shoot and number of flowers. Large number of flowers was obtained from nitrogen and potassium. Incidence of calyx splitting was least with nitrogen and phosphorous.

Hujig (1991) reported that optimum quantities of nutrients in the solution are 175 ppm N, 150 ppm K, 40 ppm Mg for carnations. The total trace element concentration must be around 150 ppm .

Mineral nutrition of carnation varieties ‘Tanga’ and ‘Pallas Orange’ grown in a greenhouse was studied by Stronjny *et al.* (1992). Both the varieties were grown in mixture of 40% mineral soil + 20% composted pink bark + 20% sphagnum peat + 20% sand. First year yields were highest with 100 mg N + 25 mg P + 100 mg K/1 for both varieties. This treatment also gave the highest 2<sup>nd</sup> year yield of ‘Tanga’ but the 200 mg N + 25 mg P + 100

mg K/1 treatment gave the highest 2<sup>nd</sup> year yield of 'Pallas Orange', 'Tanga' was more susceptible to *Fusarium oxysporum* f. sp. *Dianthi* than 'Pallas Orange'.

## **2.5 Effect of NPK levels on growth, quality and yield of rose**

Post and Fisher (1951) reported that a potassium level of 100 lb per acre was insufficient to obtain higher yield of flowers in rose. However, there was no advantage in maintaining a level higher than 300 lb per acre.

Cardus and Aqnila (1957) carnation cultivars 'Ambra', 'Duca' and 'Joly' responded well in respect of flower quality with higher rate of potassium.

Mukhopadhyaya *et al* (1989) recorded an interaction effect of N and P on the improvement of flower diameter of rose cv. 'Happiness'.

Uri *et al.* (1990) concluded that calyx splitting and high percentage of the disorder brittle stem (associated with K deficiency) were observed in outdoor crops of cultivar, Standard (Syn – White candy) grown on a sandy loam soil in Sitaria in coastal zone of Israel. The flower quality of calyx splitting and brittle stem was improved by supplying the highest 'K' level.

Sawant and Singhalkar (1995) studied the effect of different levels of N, P, and K on growth and flower production of Gaillardia. The result indicated that growth, days of flowering, total flowering period and flower production per plant increased significantly with increased levels of N, P and K.

Rajmani and Soorinatha Sundaram (1997) conducted the experiment on influence of varying levels of N, P, K on growth and yield of rose and they also concluded increasing K application above 50g per plot did not help

to improve the flower production possibly because of the optimal K availability in the soil.

Mohanty *et al.* (1999) recorded that the uptake of N, P and K nutrients by tuberose significantly varied in different treatments and were found to be increasing with age of the crop. The uptake of N and K were found to be more than the uptake of P.

Gurav *et al.* (2002) they noticed that the addition of NPK @ 15:20:20 gm NPK m<sup>-2</sup> produces significantly highest number of gerbera flower plant<sup>-1</sup> (35 Nos.) with maximum stalk length (86.56 cm) stalk diameter (0.93 cm) and flower diameter (10.80 cm).

Nagaraju *et al.* (2003) studied that on field grown roses the effect of N, P and multiplex on growth, production and quality. As a result the plants receiving 30g N + 24g K recorded significantly improved performance in terms of number and fresh weight of flowers, stem and bud length, bud diameter and also production of good quality flowers.

Selvaraj (2003) noticed that under polyhouse the effect of N, P and K on the vegetative flower characters of *Gladiolus*, in that he observed the height of number of florets *viz.*, 13 per spike was recorded in the treatment with 100:100:100 kg NPK ha<sup>-1</sup>.

Sunitadevi *et al.* (2003) they observed that, with the increasing level of nitrogen, height of the plant, number of leaves per plant, leaf area, diameter of stem and number of branches per plant increased significantly. However number of days taken for opening of flower bud reduced with the increasing level of nitrogen, phosphorus while N, P interactions were less effective N<sub>3</sub> (Nitrogen 30 g/m<sup>2</sup>) proved to be most effective in increasing height of plant (30.80cm), higher number of leaves (144.66), maximum leaf area (1084.33 sq. cm.) maximum diameter of stem (0.80 cm) and maximum

number of branches (9.03) per plant as compared to control and other levels of nitrogen.

Kore *et al.* (2004) reported that the application of higher dose of 150 kg K ha<sup>-1</sup> and black polythene mulching gave significantly maximum plant height (775.20) plant of Marigold.

Shetty and Ashok (2004) investigated to standardize the concentration of K in the nutrient solution for the pot grown Lisianthus under greenhouse from that they founded the influence of K in the growth and flowering of Lisianthus observed might also have been partly due to change in the cation to anion ratio in the nutrient solution.

### **2.5.1 Number of shoots per plant**

Mahesh (1996) recorded that the genotype with 'Red Edge' the least and 'Sterile Top' had the most number of primary branches in carnation (1.87 and 4.20), respectively.

Bonztok *et al.* (1998) recorded that the maximum number of stem (stems/plant) were obtained by using an N:K ratio of 1:1 in carnation cultivar 'Scorpio'.

### **2.5.2. Days of flowering**

Goszczyńska and Reid (1985) tight rose buds of cv. 'Sonia' were developed to commercial maturity in vase solution containing 8-HQC (300 ppm) + sucrose (2%).

Sparnaaij *et al.* (1990) studied the variation between genotype of carnation (*Dianthus caryophyllus* varieties and inter specific hybrids) in flowering time and response of long days.

Ten carnation varieties were compared by Bhautkar (1994) for cut flower production in pot trials under protected cultivation. Var. 'Eveline' took longest to initiate flower buds (119).

De *et al.* (1996) reported to facilitate opening of immature flower buds, the flowers are harvested at a stage when buds are loose tipped with no unfurled petals and sepals are unfurled, and remaining at right angles to the axis of flower bud .

### **2.5.3.Diameter of flower**

Arora and Saini (1976) assessed that the effect of K at 0,30, or 60 g/m<sup>2</sup>. the largest flowers were obtained with K 60 gm in carnation Cv. ‘Marguerite Scarlet’.

Nijjar and Rehala (1977) studied the effect of N, P and K on growth and flowering of rose Cv. ‘Superstar’ and found that diameter of flowers increased significantly with the application of 50 gm N in combination with 25 gm K per plant.

Bonztok *et al.* (1998) reported in carnation cv. ‘Scorpio’ that the good quality flowers (diameter of 3-6 cm) were obtained by using N:K ratio of 1:1.

Nagaraju *et al.* (2003) studied that on field grown roses the effect of N, P and multiplex on growth, production and quality. As a result the plants receiving 30g N + 24g K recorded significantly improved performance in terms of bud diameter (24 gm K: 38.50% 0gm K: 31.68%), while multiplex application (12 gm/ plant) significantly improved only on bud diameter.

### **2.5.4.Length of flower stalk**

Nijjar and Rehala (1977) studied the effect of N, P and K on growth and flowering of rose cv. ‘Superstar’ and found that diameter of flowers increased significantly with the application of 50 gm N in combination with 50 gm K per plant.

Hoshni and Elshoura (1996) reported that the flower stem length was decreased with increasing K (0.3, 0.6 or 0.9 gm K<sub>2</sub>O/ plant).

Krishna *et al.* (1999) reported that fertigation levels had no significant effect of stem length carnation cut flower stalk.

Mallick *et al.* (2001) concluded that the application of 20 gm each of N, P and K per square metre was found the most promising and economical for spike length as compared to other levels of nutrients in gladiolus.

Nagaraju *et al.* (2003) studied that on field grown roses the effect of N, P and potassium on growth, production and quality. As a result the plants receiving 30g N + 24g K recorded significantly improved performance in stem and bud length.

Shetty and Ashok (2004) reported that Lisianthus plants fed with 350 ppm potassium produced longer stem.

#### **2.5.5. Flower production**

Carnation cultivars 'Ambra', 'Duca' and 'Joly' responded well in respect of flower production with higher rate of potassium (Cardus and Aquila, 1957).

Nijjar and Rehala (1977) studied the effect of N, P and K on growth and flowering of rose Cv. 'Superstar' and found that flower number increased significantly with the application of 25 gm N in combination with 50 gm K per plant.

Hosni and Elshoura (1996) reported that flower number of carnation was significantly increased in the treatment with the highest (0.9 gm K<sub>2</sub>O/plant).

Rajamani and Sundaram (1997) reported that increasing potassium application above 50 gm per plot did not help to improve the flower production possibly because of the optimal K availability in the soil grown rose under open condition.

### **2.5.6. Yield per plant**

Sigedar *et al.* (1991) reported that highest number of flowers per plant was obtained when plants were supplied with 100 kg N and 50 kg P<sub>2</sub>O<sub>5</sub>/ ha. Favorable effects of 25 kg K<sub>2</sub>O/ ha were noticed on yield parameters of *Calendula officinalis*.

Kim et al. (1990) studied flower characteristics of 15 carnation in order to assess their suitability for cut flower production and reported that 'Beta' and 'White Sim' and medium intensity while as number of cut flower per plant averaged 8-10 but 'Shocking Pink' and 'White Sim' produced 15, 11 respectively.

Bonztok *et al.* (1998) reported the maximum yield (11 stems per plant, 5 flowers per plant) were obtained by using N:K ratio of 1:1 in carnation Cv. 'scropio'.

### **3. MATERIALS AND METHODS**

The present investigation on “Study of variations in canopy temperature and light use efficiency due to different fertilizer levels in rose under polyhouse condition during kharif and winter season” was undertaken during the year 2008-2009 at the Hi-tech Floriculture and Vegetable Project, College of Agriculture, Pune-5.

#### **3.1 Climatic conditions**

The experimental station is located at 18<sup>0</sup>32' N latitude and 73<sup>0</sup>51' E longitude at an altitude of 559 meters above MSL. The maximum and minimum temperatures during the growth period (2007– 08) were 32.0 °C and 18.6 °C, respectively. An annual rainfall of 904.8 mm was received in 46 rainy days.

The annual average RH-I and RH-II are 82% and 42%, respectively.

#### **3.2. Materials**

##### **3.2.1. Polyhouse**

The polyhouse installed at Hi-tech Floriculture and vegetable project, College of Agriculture, Pune-411005, was used for experiment. The polyhouse was naturally ventilated (GH II) type and U.V.stabilized 200 µm thickness polythene film was used as cladding material. For maintaining temperature 50% shadenet was provided in the polyhouse. For control of temperature and humidity misting system was provided.

##### **3.2.2. Earthen pots**

Earthen pot having 15 cm height, 30 cm upper diameter and with 4 liters capacity were used for experiment. Each pot was filled manually with

1.5 kg coco peat. The experimental material for the present investigation i.e. planting materials was procured from Kumar Agro-Biotech Ltd., Pune.

### **3.2.3. Coco peat**

The growing area should be filled with porous and well drained material. Coco peat was used as growing media and obtained from Sterling Farm Research and Services Pvt.ltd.(Cochin,Kerala , South India).Coco peat is waste from coconut palm (*Cocus nucifera*) industry after fiber has been extracted and allowed to be washed with 4-5 monsoons for producing low pH and EC.

### **3.2.4. Plants**

Passion cultivar of rose was selected on the basis of its performance in Hi-tech Floriculture and Vegetable Project,College of Agriculture,Pune-411 005.

### **3.2.5. Fertilizers**

A list of commercial grade water soluble inorganic fertilizers,which were used for experiments and their elemental composition are presented in Table 1.The qualities of fertilizers were used for preparation of stock solution and quantities were applied manually

### 3.3. Methods

#### 3.3.1. Experimental details

**Table: 1 Experimental details**

<b>a) Type of experiment</b>	Pot culture (15 h x $\Phi$ 30 cm)
<b>b) Date of bending</b>	1 <sup>st</sup> August 2008
<b>c) Variety</b>	Passion
<b>d) Growing media</b>	Coco peat
<b>e) Types of fertilizers</b>	Water soluble
<b>f) Source of fertilizers</b>	
<b>i. Nitrogen</b>	Urea (46%N)
<b>ii. Phosphorus</b>	Mono ammonium phosphate (61 %P <sub>2</sub> O <sub>5</sub> )
<b>iii. Potassium</b>	Potassium sulphate (48 % K <sub>2</sub> O)
<b>g) Number of replication</b>	4
<b>h) No of treatments</b>	5
<b>i) Pot capacity</b>	4 liters
<b>j) Design</b>	Randomized Block Design (RBD)

#### 3.3.2. Treatments details

Number of treatments :5

**Table: 2 Treatment Details**

<b>Treatments</b>	<b>Nitrogen mg/wk/plant</b>	<b>Phosphorus mg/wk/plant</b>	<b>Potassium mg/wk/plant</b>
<b>*T<sub>1</sub></b>	400	400	400
<b>T<sub>2</sub></b>	450	400	400
<b>T<sub>3</sub></b>	500	400	400
<b>T<sub>4</sub></b>	550	400	400
<b>T<sub>5</sub></b>	600	400	400

**Note:** \*T<sub>1</sub> - Presently applied dose of fertilizer for rose in Hi-tech Floriculture and Vegetable Project College of Agriculture, Pune -5.

### **3.4. Cultivation practices**

#### **3.4.1. Irrigation**

Drip irrigation is an system which is used for irrigating to rose crop other than experimental plots in Hi-Tech. The experimental plot was manually irrigated by giving seven litres water per sq. m. In the colder months more frequent irrigation resulted in a greater shoot and root growth. Over watering and poor drainage causes root death and stunted growth.

#### **3.4.2. Fertigation**

Water soluble fertilizers were used for the studies as per the treatments and were applied manually. The entire quantity of fertilizers was applied manually in splits with 7 days interval throughout the 4 months by manually process.

### **3.4.3. Disbudding**

Disbudding refers to removal of side buds so that the central or terminal bud receives maximum food for the full development also it is beneficial in large flowered types for obtaining good quality bloom, especially for exhibition purpose. The first disbudding was done at 82 DAT and then regularly done this operation so as to get sufficient food for terminal flower. All the side buds were removed from the plants except retaining the terminal bud to obtain only one.

### **3.4.4. Weeding**

Weeding was done once in a 15 days interval in order to avoid competition of weeds with the crop for space and nutrients. Weeding was done manually, while doing operation care was taken not to disturb the plant.

### **3.4.5. Insect pests and diseases**

**3.4.5.1. Insect pests:** White ants, Chafer Beetles, Aphids, Jassids, Thrips, Mites, Mealy bugs and nematodes are common insect pests reported on rose, they are controlled by application of suitable insecticide. The experimental plot affected by following insect and diseases

Aphids: They cause distortion to rose tender shoots or buds. They were controlled by spraying Dimethoate @ 2.0g/lit.

Jassids: controlled by spraying with 0.1% Malathion.

**3.4.5.2. Diseases :** several diseases like, Black spot, Powdery Mildew and rust infected to rose. Those were controlled through maintaining temperature, humidity and water as per required and also controlled by good sanitation .

### 3.4.6. Harvesting and Handling:

Red roses harvested when the petals out curve from flower head. For local markets, buds can be harvested at more advanced stage of opening. Flowers were cut at morning or evening, leaving at least 2-5 leaflets on the stem. Stem not to be cut very closely to the base which absorbs very little amount of water. There were not any damage on the foliage and the petal while harvesting. Stems were put in the buckets containing fresh water immediately after harvesting and shifted to the cold room (3-5<sup>0</sup>C). cooling removes fields heat from flowers, slows down respiration, reduces water loss and prevents opening of buds.

## 3.5. Details of instruments

### 3.5.1 LI-191 SA Line Quantum Sensor

The LI-191 sensor is designed for measuring PAR (Photosynthetically Active Radiation) in applications where the radiation is to be measured in spatially non-uniform canopies (such as within plant canopies). To achieve this, the sensor features a sensing area that is one meter in length (Plate 1). The LI-191 SA has quantum (photon) response through the wave length range of 400 to 700 nm for PPFD (Photosynthetic Photon Flux Density) as generally preferred for PAR measurements, and has an output in units of mole.

Where,

$$1\mu\text{mol m}^{-2} \text{ s}^{-1} = 1\mu\text{E m}^{-2} \text{ s}^{-1} = 6.02 * 10^{17} \text{ photon m}^{-2} \text{ s}^{-1}$$

The LI-191 SA line quantum sensor, which spatially averages radiation over its one meter length, minimize the errors and allows one to easily make many measurements in a short period of time. The sensor was connected to the LI-1000 data logger.

Since the sensing area is a flat acrylic diffuser, the response of given angle of incidence is fairly constant, as the azimuth angle around the sensor is varied. It is specified at less than  $\pm$  at a  $45^{\circ}$  angle of elevation for  $360^{\circ}$  sensor rotation.

### Specifications

Absolute calibration	: $\pm 10\%$ traceable to NBS. The LI-191 SA is calibrated under natural daylight, clear conditions, via transfer calibration using a reference LI-191 SA quantum sensor. Transfer error is $\pm 5\%$ . (included in the $\pm 10\%$ ).
Sensitivity	: Typically $3\ \mu\text{A per } 1000\ \text{m}^{-2}\ \text{s}^{-1}$
Linearity	: Maximum deviation of $1\%$ up to $10000\ \mu\text{mol m}^{-2}\ \text{s}^{-1}$ .
Stability	: $< \pm 2\%$ changes over a one year period.
Response time	: $10\ \mu\text{s}$
Temperature dependence	: $\pm 0.15\%$ per $^{\circ}\text{C}$ maximum
Cosine correction	: Acrylic diffuser
Azimuth	: At $45^{\circ}$ elevation $< \pm 2\%$ error over $360^{\circ}$
Sensitivity area	: $1\ \text{m L} * 12.7\ \text{mm W}$ ( $39.4'' * 0.50''$ ).
Detector	: High stability silicon photovoltaic detector (Blue enhanced)
Sensor housing	: Weather proof anodized aluminum case with acrylic diffuser and stainless steel hardware.
Size	: $116\ \text{L} * 2.54\ \text{W} * 2.5\ \text{cm D}$ ( $45.5'' * 1.0''$ ).

Weight : 1.8 kg (4.0 lb).

Cable length : 3.1 (10.0 ft).

### **3.5.2. LI-1000 Data logger**

The LI-1000 data logger is a 10 channel data logger that functions both as a datalogging device and a multichannel, auto ranging meter. The electronics of the LI-1000 have been optimized for highly accurate measurement of Li-1000 radiation sensors, which have a current signal. The LI-1000 is also well suited to measure low impedance voltage sensors such as thermocouples and sensors with a pulsed output (tipping bucket rain gauges, etc., Plate 2). A wide variety of other sensors for environmental and industrial test and measurement can also be measured with the LI-1000.

#### **Specifications**

##### **Analog Inputs**

Eight total analog inputs configured as voltage or current channels.

**Current Inputs** Eight channels; two seal BNC connectors and six channels accessed directly through 37 pin D connector or by connecting the 1000-05.

Terminal Block or the 1000-10

Thermocouple Terminal Block.

**Voltage Inputs** : Six single ended channels accessed directly through 37 pin D connector or by connecting the 1000-05 Terminal Block, Thermocouple Terminal Block 100-06 AC Terminal Block,

Channel 1 and 2 can also be configured for voltage measurement by placing an input impedance resistor in the sensor cable.

**Pulse counting Inputs** : Two pulse counting channels switch closure to ground (200Hz); external signal driving (1 KHz). Inputs have hysteresis so there is no minimum rise time.

## Analog to Digital converter

Type	:	Voltage to frequency
Resolution	:	14 bit (1 part in 16,000)
Scan rate	:	4 channel per second, (200 ms integration time for 50/60 Hz noise rejection)
Voltage	:	$\pm 0.3$ % of full scale reading (25 °C), $\pm 0.55$ % (0 to 55 °C).
Current	:	$\pm 0.2$ % of full scale reading (25 °C), $\pm 0.45$ % (0 to 55 °C).
Temp. Coefficient	:	$\pm 0.01$ % of reading per °C.
Linearity	:	0.05%
Normal mode rejection	:	> 60 dB at 50 or 60 Hz voltage Input Noise (25 °C)
Typical	:	$\pm 2.5$ $\mu$
Max.60 second Ave.	:	$\pm 5$ $\mu$ V
Typical	:	$\pm 0.4$ $\mu$ V
Max.60 second Ave.	:	$\pm 0.8$ $\mu$ V Current Input Noise (25 °C).
Typical	:	$\pm 25$ picoamps
Max.60 second Ave.	:	$\pm 50$ picoamps
Typical	:	$\pm 4$ picoamps
Max.60 second Ave.	:	$\pm 8$ picoamps

### Theory of operation

For measurement of radiation by line quantum sensors following commands are given

I	ON	V	Multiplier (-107.99)
II	INST MODI	VI	Label – UM
III	CH 1	VII	Ave. 1 minute
IV	Range A		

### 3.5.3 Infrared thermometer

The infrared thermometer is the instrument, which is used to measure the canopy temperature remotely.

#### Theory of operation

It detects minute difference between crop canopy and surrounding air temperature. The easy handling during operation and speed of measurement are the advantages over more laborious methods such as direct thermocouple placement on the leaves. Thus the use of infrared thermometer as research tool to measure crop or plant temperature remotely was becoming increasingly popular. Telatemp (model AG-42) was used for measurement of canopy temperature and canopy-air temperature differential in this experiment. This instrument is energized with the help of four 1.2-volt Ni-Cd rechargeable cells.

#### Working principle

The energy flux emitted by an object is a function of its absolute temperature. The infrared thermometer senses long wave radiation emitted

by the object and converts this value to a temperature scale according to Stefan's Law:

$$E = \varepsilon \sigma T^4$$

Where,

$E$  = Energy flux,  $\text{Wm}^{-2}$

$\varepsilon$  = Emmissitivity of the body

$\sigma$  = Stefan Boltzman constant =  $(5.67 \times 10^8 \text{ Wm}^{-2} \text{ K}^{-4})$ ,

$T$  = Absolute Temperature of the body,  $^{\circ}\text{K}$

### **Measuring temperature**

To take temperature measurement, the instrument is held by grip, which promptly "come to life" as evidenced by the digital display.

Point the instrument towards the object whose temperature is to be measured and display will immediately indicate the temperature of the object. The temperature difference between the target and the ambient air can be measured by pressing the trigger. The instrument will immediately display the differential temperature. The Telatemp (model AG -42) has an acceptance angle of  $45^{\circ}$  and "Sees" a one-foot spot at a 20-foot distance.

The emmissivity switch is a provision for the relative radiation efficiency of various types of targets. For most organic type targets, a setting of 0.95 to 0.99 will yield acceptance result.

#### **3.5.4 Temperature and humidity sensor**

Temperature and humidity in polyhouse measured with the help of temperature and humidity sensor (Vaisala HM 34) weekly and the average is drawn and recorded.

### **3.6 Observations recorded**

The following observations were recorded during the experimental period.

Hundred plants were selected and labeled for recording the observations from 1<sup>st</sup> September,2008 to 15th December,2008. Observations were recorded for days to sprouting, number of flowering shoot produced per plant, days required for flowering, length of the shoot (cm),diameter of the flower bud (cm),number of leaf pairs and total yield of flowers (per plant) and averages were worked out and subjected to statistical analysis .

#### **3.6.1. Growth**

##### **3.6.1.1. Days to sprouting**

Number of days required from bending to the days of sprouting were recorded.

##### **3.6.1.2. Days required for flowering**

Number of days required from sprouting to the day of first flower opening was recorded.

##### **3.6.1.3. Number of leaf pairs per flowering shoot**

Total number of leaf pairs from the harvested flower shoots were recorded. Numbers of leaf pairs produced per flower shoots were recorded at 14 days interval from 30 days after bending up to 121 days after bending. The leaf pairs per flower shoots of 5 randomly selected plants from each treatment were measured and average value has been reported.

#### **3.6.2. Yield**

##### **3.6.2.1. Number of flowering shoot produced per plant**

The total number of flowering shoots produced per plant were counted after sprouting. Numbers of shoots produced per plant were recorded at 14 days interval from 30 days after bending up to 135 days after

bending. The laterals of 5 randomly selected plants from each treatment were measured and average value has been reported.

### **3.6.2.2. Total yield of flowers per plant**

Total yield of flowers per plant from first flower harvest during the period of investigation was recorded.

### **3.6.2.3. Total green and dry matter**

Green matter was calculated by taking economic and biological yield (above ground level) of randomly selected five different plants and for dry matter the plant was dried in sun then dried in oven until constant weight was attained. The dry matter was measured by electronic balance.

### **3.6.3. Quality**

#### **3.6.3.1. Length of the shoot (cm)**

Length of each flower shoot harvested was recorded. The length of cut flower stalk was measured after harvest from its cut base end to the point of attachment of the flower bud to the stalk and expressed in centimeters.

#### **3.6.3.2. Diameter of flower bud (cm)**

Diameter of flower bud from each harvested flower shoot was recorded with the help of vernier caliper.

#### **3.6.3.3. Length of flower bud (cm)**

Length of flower bud from each harvested flower shoot was recorded with the help of vernier caliper.



**Plate No. - 1 Experimental site**



**Plate No. - 2 Measurement of reflected radiation with the help of Line Quantum Sensor and Data Logger (LI-1000)**

### **3.6.4. Meteorological observations**

#### **3.6.4.1. Measurement of incident PAR (PAR)**

For measurement of incoming PAR, line quantum sensor was positioned facing up 1ft. above the top of the canopy and value was recorded for incoming PAR.

#### **3.6.4.2. Measurement of reflected PAR (PAR)**

For measurement of reflected PAR, line quantum sensor was positioned facing down towards the bed and value was recorded for reflected PAR.

#### **3.6.4.3. Measurement of transmitted PAR (TPAR)**

Line quantum sensor was placed above the ground across the rows and value was recorded for TPAR.

#### **3.6.4.4. Determination of absorbed PAR (APAR)**

APAR was worked out by adopting the equation given by Gallo and Daughtry (1986).

$$APAR = (PAR + RPAR) - (TPAR + RPAR)$$

#### **3.6.4.5. Estimation of light use efficiency (LUE)**

$$\text{Incident radiation} = \text{Transmitted radiation} + \text{Reflected radiation} + \text{Absorbed radiation}$$

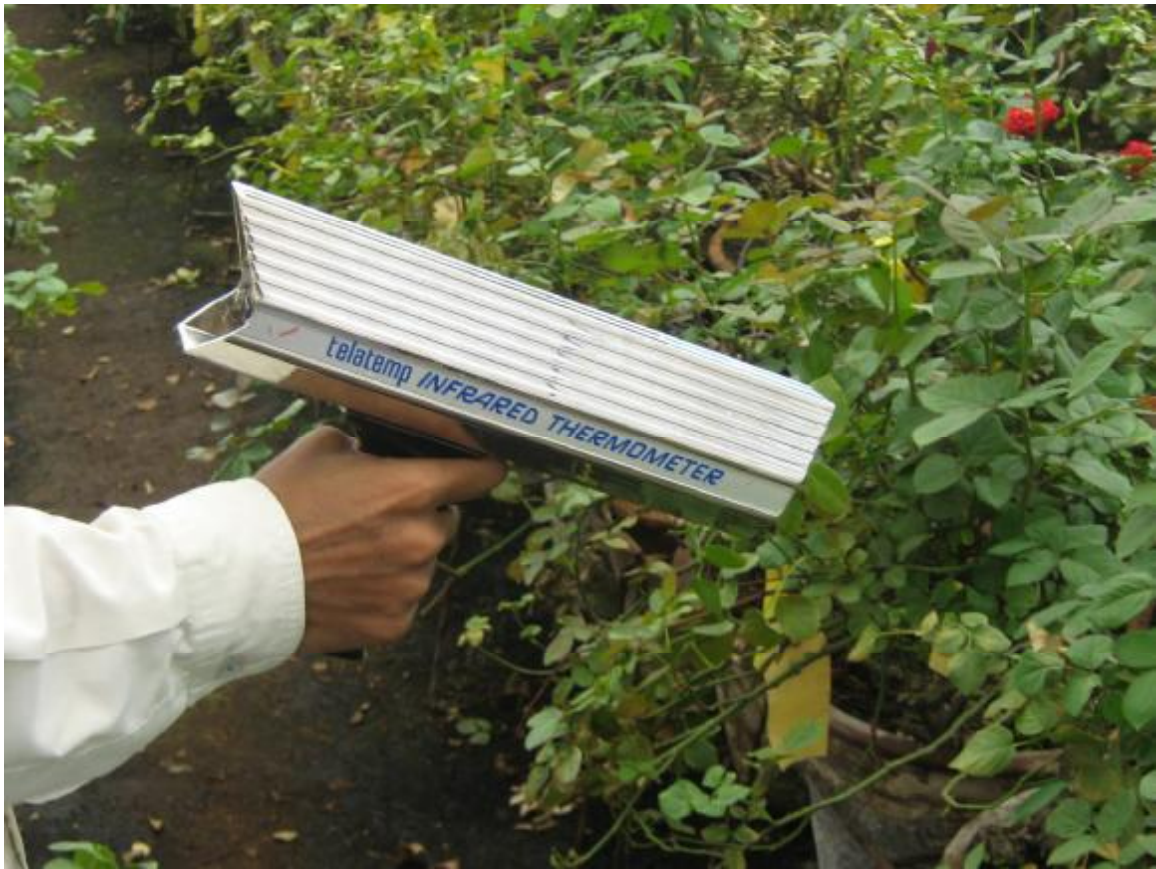
Therefore,

$$\text{Absorbed radiation} = \text{Incident radiation} - (\text{Transmitted radiation} + \text{Reflected radiation})$$

With the help of cumulative absorbed radiation and vegetative plant growth, it is possible to estimate the light use efficiency of a plant.



**Plate No. - 3 Measurement of transmitted radiation with the help of Line Quantum Sensor and Data Logger (LI-1000)**



**Plate No. - 4 Measurement of canopy temperature and air temperature with the help of Infrared thermometer**

Light use efficiency was determined as:

$$\text{LUE} = \frac{\text{Amount of green/dry matter produced (g/ m}^2\text{)}}{\text{Amount of cumulative light absorbed (MJ/m}^2\text{)}}$$

Incident radiation transmitted radiation and reflected radiation were measured with the help of line quantum sensor (LI COR) and Data logger (LI COR 1000). Radiation was recorded in terms of  $\mu\text{molm}^{-2} \text{s}^{-1}$ . But for estimation of LUE cumulated absorbed radiation was first estimated with the help of above equations and then converted from  $\mu\text{molm}^{-2} \text{s}^{-1}$  to  $\text{MJm}^{-2}$  by multiplication of factor 0.0188.

#### **3.6.4.6. Temperature in polyhouse**

Temperature in polyhouse was measured with the help of temperature and humidity sensor (Vaisala HM 34) weekly and the average is drawn and recorded.

#### **3.6.4.7. Humidity in polyhouse**

Humidity in polyhouse was measured with the help of temperature and humidity sensor (Vaisala HM 34) weekly at interval and the average is drawn and recorded.

#### **3.6.4.8. Canopy-air temperature differential**

Infrared thermometer detects minute difference between crop canopy temperature and surrounding air temperature. The canopy temperature was recorded at 7 days interval. The thermometer was held so as to view the crop obliquely in order to obtain a canopy temperature, minimally influenced by the underlying soils. Five random observations were recorded and the average value was taken.

**Table 3. Details of biometric and other observations**

<b>Particulars</b>	<b>Frequ ency  (No.)</b>	<b>Days after Bending (DAB)</b>	<b>Sample size</b>
<b>A. Micrometeorological studies</b>			
1.Incident photo synthetically active radiation (PAR)	14	30, 37, 44, 51, 58, 65, 72, 79, 86, 93, 100, 107, 114.	Above canopy
2.Transmitted photo synthetically active radiation (TPAR)	14	First observation at 30 DAB thereafter at 7 days interval up to first harvest.	Across the rows
3.Reflected photo synthetically active radiation (RPAR)	14	First observation at 30 DAB thereafter at 7 days interval up to first harvest	Below canopy
4.Absorbed photos synthetically active radiation (APAR)	14	Estimated from above measurement	All plants
5.infrared thermometer	14	First observation at 30 DAB thereafter at 7 days interval up to first harvest.	All plants (canopy)
<b>B. Growth parameters</b>			

1. Length of shoot	7	First observation at 30 DAB thereafter at 14 days up to first harvest.	Five plants
2. Number of leaf pairs per plant	7	First observation at 30 DAB thereafter at 14 days up to first harvest.	Five plants
3. Number of flowering shoots per plant	2	First observation at 30 DAB thereafter at 14 days up to first harvest.	Five plants
<b>C. Flower characters</b>			
1. Number of days taken for first flower appearance	1	At flower initiation stage	Five plants
2. Diameter of flower bud	1	At harvest	Five plants
3. Length of flower bud	1	At harvest	Five plants
<b>D. Yield parameters</b>			
1. Number of flowers per plant	1	At harvest	Five plants
2. Total green matter	1	At harvest	Five plants
3. Total dry matter	1	At harvest	Five plants

### **3.7 Statistical analysis and Interpretation of data**

The statistical analysis of the data was computed by standard method of testing variance (F test). The standard error (SE) was worked out for each parameter. When the results were significant, critical difference (CD) at 5 per cent level of significance was worked out. The data were suitably illustrated with graph and figures at appropriate places. The mean value of each character calculated from the observations recorded from hundred selected plants were pooled and subjected to analysis of variances in the randomized block design (Panse and sukhatme,1978).

## **4. RESULT AND DISCUSSION**

The present investigation, “Study of variations in canopy temperature and light use efficiency due to different fertilizer levels in rose under polyhouse condition during kharif and winter season” was conducted during August 2008 to December 2008 in Hi-Tech Floriculture and Vegetable Project located at College of Agriculture, Shivajinagar, Pune- 411 005.

The Study was undertaken with a view to know the effect of fertilizer levels on growth, yield and quality of roses in relation to weather parameters. Therefore, the observations were recorded. The result of the study are described below under appropriate sub-heads.

### **4.1. Growth**

The data in respect of days to sprouting, days required for flowering and number of leaf pairs are presented in table 4, 5 and 6, respectively.

#### **4.1.1. Days to sprouting**

Data on days to sprouting are presented in Table 4. The data revealed that the treatment T<sub>1</sub> plants required significantly more number of days (5.29 days) to sprouting than all other treatments plants. The treatment T<sub>5</sub> was the earliest to sprout (4.37 days) followed by T<sub>4</sub> (4.39 days) and both were on par. It was followed by T<sub>3</sub> and T<sub>2</sub> (4.95 and 5.11 days respectively). Treatment T<sub>5</sub> and T<sub>4</sub> were on par and significantly superior over treatments T<sub>1</sub> and T<sub>2</sub> and T<sub>3</sub>.

**Table 4 : Mean number of days to sprouting as influenced by different fertilizer levels.**

<b>Treatments - NPK Levels (mg/pl/wk)</b>	<b>Days to sprouting</b>
T <sub>1</sub> - 400:400:400	5.29
T <sub>2</sub> - 450:400:400	5.11
T <sub>3</sub> - 500:400:400	4.95
T <sub>4</sub> - 550:400:400	4.39
T <sub>5</sub> - 600:400:400	4.37
S.E (±)	0.14
C.D at 5%	0.42

#### **4.1.2. Days required for flowering**

Data on days required for flowering are presented in Table 5. It could be observed from that the treatment T<sub>1</sub>, T<sub>2</sub> and T<sub>3</sub> took significantly more days (45.41, 36.45 and 35.05 days respectively) for flowering than all other treatments, where as the treatment T<sub>4</sub> was the earliest (31.34 days) for flowering, which was followed by T<sub>5</sub> (32.08 days). The treatment T<sub>4</sub> and T<sub>5</sub> were found to be at par with each other.

**Table 5 : Mean number of days required for flowering as influenced by different fertilizer levels.**

<b>Treatments- NPK Levels (mg/pl/wk)</b>	<b>Days to flowering</b>
T <sub>1</sub> - 400:400:400	45.41
T <sub>2</sub> - 450:400:400	36.45
T <sub>3</sub> - 500:400:400	35.05
T <sub>4</sub> - 550:400:400	31.34
T <sub>5</sub> - 600:400:400	32.08
S.E (±)	1.10
C.D at 5%	3.39

#### 4.1.3. Number of leaf pairs (per flowering shoot)

Data on number of leaf pairs per flowering shoot are presented in Table 6, and represented graphically in figure 1. It is seen from the results that there were significant differences in the number of leaf pairs per flowering shoot due to different fertilizer levels. At 30 DAB the treatment T<sub>4</sub> and T<sub>5</sub> were found to be at par and treatment T<sub>5</sub> was significantly superior over rest of the treatments.

At 44 DAB the treatment T<sub>3</sub>, T<sub>4</sub> and T<sub>5</sub> were found to be at par and treatment T<sub>5</sub> was significantly superior over rest of the treatments. At 58, 72, 86 and 100 DAB all the treatments were found to be at par with each other. While at 114 DAB of leaf pairs varied from 20.07 in treatment T<sub>5</sub> which was the highest to 16.41 in treatment T<sub>1</sub> which was the lowest. The treatment T<sub>2</sub>, T<sub>3</sub> and T<sub>4</sub> recorded the intermediary values.

**Table 6 : Mean number of leaf pairs per flowering shoot under different fertilizer levels.**

Treatments-NPK Levels (mg/pl/wk)	DAB*						
	30	44	58	72	86	100	114
T <sub>1</sub> - 400:400:400	5.86	6.03	9.89	10.71	13.27	14.12	16.41
T <sub>2</sub> - 450:400:400	7.01	7.79	10.19	11.77	13.21	15.20	16.80
T <sub>3</sub> - 500:400:400	7.89	10.31	11.25	12.09	14.25	17.10	18.19
T <sub>4</sub> - 550:400:400	8.13	10.17	11.08	12.84	15.68	17.19	19.10
T <sub>5</sub> - 600:400:400	8.27	10.12	10.54	11.90	14.96	16.70	20.07
S.E (±)	0.13	0.28	0.42	0.44	0.55	0.62	0.70
C.D at 5%	0.41	0.86	1.30	1.36	1.70	1.90	2.16

\* DAB – Days after Bending

## 4.2. Yield

The data in respect to number of flowering shoots produced per plant, total yield of flowers (per plant) and yield of flowers per square meter are presented here under respective headings.

### 4.2.1. Number of flowering shoots produced per plant

The data on number of flowering shoots produced per plant are presented in Table 7. The data revealed that all treatments were significantly superior over T<sub>1</sub>. Treatment T<sub>5</sub> and T<sub>4</sub> were found to be at par with each other and produced significantly more number of flowering shoots per plant (5.27 and 5.11 respectively) than rest of treatments. Treatment T<sub>1</sub> produced the least number of flowering shoots (3.68 per plant) followed by T<sub>2</sub> (4.19) and T<sub>3</sub> (4.38).

**Table 7 : Mean number of flowering shoots produced per plant**

Treatments- NPK Levels (mg/pl/wk)	DAB*	
	86	114
T <sub>1</sub> - 400:400:400	3.41	3.68
T <sub>2</sub> - 450:400:400	4.08	4.19
T <sub>3</sub> - 500:400:400	4.27	4.38
T <sub>4</sub> - 550:400:400	4.9	5.11
T <sub>5</sub> - 600:400:400	4.81	5.27
S.E (±)	0.14	0.36
C.D at 5%	0.42	1.13

\* DAB – Days after Bending

#### 4.2.2. Total yield of the flowers per plant

The data in respect of the yield of flower per plant are presented in Table 8, show that the treatments had significant influence on the yield per plant. The treatment T<sub>4</sub> and T<sub>5</sub> were found to be at par and recorded significantly higher yield (9.58 and 9.26 per plant respectively) than the rest of the treatments. It was followed by the treatments T<sub>3</sub> and T<sub>2</sub> (8.74 and 7.71 per plant). Significantly the lowest yield was obtained in treatment T<sub>1</sub> (6.86 per plant). All treatment were significantly superior over the treatment T<sub>1</sub>, i.e., (400:400:400 mg NPK/week/plant)

**Table 8 : Mean value of total yield of flower per plant as influenced by different fertilizer levels**

<b>Treatments- NPK Levels (mg/pl/wk)</b>	<b>Flower yield per plant</b>
T <sub>1</sub> - 400:400:400	6.86
T <sub>2</sub> - 450:400:400	7.71
T <sub>3</sub> - 500:400:400	8.74
T <sub>4</sub> - 550:400:400	9.26
T <sub>5</sub> - 600:400:400	9.58
S.E (±)	0.31
C.D at 5%	0.96

#### 4.3. Quality

The data in respect to length of shoot (cm), diameter of flower bud (cm) and length of flower bud (cm) are presented in tables 9, 10 and 11 .

### 4.3.1. Length of shoot (cm)

The data in respect of the length of shoot are presented in Table 6, and represented graphically in figure 2, show that the treatment T<sub>5</sub> (64.39 cm) had significantly highest shoot length among the treatments and was at par with treatment T<sub>4</sub>. The T<sub>1</sub> treatment recorded lowest length of shoot 58.41 cm.

**Table 9 : Mean length of shoots as influenced by different fertilizer levels.**

<b>Treatments- NPK Levels (mg/pl/wk)</b>	<b>Length of shoot (cm)</b>
T <sub>1</sub> - 400:400:400	58.41
T <sub>2</sub> - 450:400:400	59.58
T <sub>3</sub> - 500:400:400	61.16
T <sub>4</sub> - 550:400:400	63.52
T <sub>5</sub> - 600:400:400	64.39
S.E (±)	1.38
C.D at 5%	4.26

### 4.3.2. Diameter of flower bud

The data on diameter of flower bud presented in the Table 10. A perusal of the data show that the treatments were on par with each other. The highest (2.30 cm) and the lowest (2.03 cm) diameter of flower bud was produced by T<sub>5</sub> and T<sub>1</sub> treatments respectively.

**Table 10 : Mean diameter of flower buds as influenced by different fertilizer levels**

<b>Treatments- NPK Levels (mg/pl/wk)</b>	<b>Diameter of flower buds (cm)</b>
T <sub>1</sub> - 400:400:400	2.03
T <sub>2</sub> - 450:400:400	2.08
T <sub>3</sub> - 500:400:400	2.14
T <sub>4</sub> - 550:400:400	2.30
T <sub>5</sub> - 600:400:400	2.21
S.E (±)	0.14
C.D at 5%	0.42

#### 4.3.3. Length of flower bud (cm)

Data in respect of the mean length of flower bud as influenced by the different fertilizer levels are presented in Table 11. The treatments were found to be at par. Maximum length of flower bud was noticed in treatment T<sub>4</sub> and lowest was recorded in the treatment T<sub>1</sub>.

**Table 11 : Mean length of flower buds as influenced by different fertilizer levels**

<b>Treatments- NPK Levels (mg/pl/wk)</b>	<b>length of flower buds (cm)</b>
T <sub>1</sub> - 400:400:400	2.70
T <sub>2</sub> - 450:400:400	2.73
T <sub>3</sub> - 500:400:400	2.78
T <sub>4</sub> - 550:400:400	2.86
T <sub>5</sub> - 600:400:400	2.82
S.E (±)	3.21
C.D at 5%	9.90

#### 4.4. Meteorological parameters

##### 4.4.1. Radiation

##### 4.4.1.1. Incident radiation (PAR)

Weekly data on mean incident, cumulative incident, weekly mean incident radiation cumulated at seven days intervals are presented in Table 12,13 and 14 respectively and depicted in Fig 3.

**Table 12 : Mean incident radiation ( $\mu\text{molm}^{-2}\text{s}^{-1}$ ) under different levels of fertilizer.**

DAB	Polyhouse					Open Field
	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	
30	205	208	211	213	210	640
37	206	212	210	211	208	677
44	260	262	261	240	258	892
51	238	239	243	233	237	923
58	281	289	283	283	291	933
65	230	241	223	225	252	870
72	174	210	191	184	210	697
79	314	316	314	304	319	970
86	322	317	324	313	319	1016
93	347	339	338	330	349	1075
100	324	312	316	321	317	1040
107	333	323	329	330	327	1087
114	341	338	331	343	342	1043
121	348	339	342	343	335	1017
128	359	364	352	360	360	1110
135	342	334	348	353	354	1095

It was noticed from the data presented in table 14 that the weekly mean incident radiation under open condition was  $942.81 \mu\text{molm}^{-2}\text{s}^{-1}$

<sup>1</sup>which was 69.64% more than weekly mean incident radiation under polyhouse condition  $289.25 \mu\text{molm}^{-2}\text{s}^{-1}$ . It was also noticed that on an average amount of incident radiation increase with increase in age of crop. The highest cumulative incident radiation was observed in treatment T<sub>5</sub> (NPK @ 600:400:400 mg/pl/wk) ( $4688 \mu\text{molm}^{-2}\text{s}^{-1}$ ) and lowest cumulative incident radiation was observed in treatment T<sub>3</sub> (NPK @ 500:400:400 mg/pl/wk) ( $4616 \mu\text{molm}^{-2}\text{s}^{-1}$ ).

**Table 13 : Cumulative incident radiation ( $\mu\text{molm}^{-2}\text{s}^{-1}$ ) under different levels of fertilizer.**

DAB*	Polyhouse					Open Field
	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	
30	205	208	211	213	210	640
37	411	420	421	424	418	1317
44	671	682	682	664	676	2209
51	909	921	925	897	913	3132
58	1190	1210	1208	1180	1204	4065
65	1420	1451	1431	1405	1456	4935
72	1594	1661	1622	1589	1666	5632
79	1908	1977	1936	1893	1985	6602
86	2230	2294	2260	2206	2304	7618
93	2577	2633	2598	2536	2653	8693
100	2901	2945	2914	2857	2970	9733
107	3234	3268	3243	3187	3297	10820
114	3575	3606	3574	3530	3639	11863
121	3923	3945	3916	3873	3974	12880
128	4282	4309	4268	4233	4334	13990
135	4624	4643	4616	4586	4688	15085

Thus it can be concluded that , UV stabilized 200 micron polythene film reduces the incident radiation by 69.64 %.

**Table 14 : Weekly mean incident radiation ( $\mu\text{molm}^{-2}\text{s}^{-1}$ ) under different levels of fertilizer.**

Incident radiation ( $\mu\text{molm}^{-2}\text{s}^{-1}$ )						
Polyhouse						Open
T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	Mean	Mean
289	290.18	288.5	285.81	293	289.25	942.81

#### 4.4.1.2. Reflected radiation (PAR)

Weekly data on mean reflected, cumulative reflected and weekly mean reflected radiation cumulated at seven days intervals are presented in Table 15,16 and 17 respectively and depicted in Fig. 1.

**Table 15 : Mean reflected radiation ( $\mu\text{molm}^{-2}\text{s}^{-1}$ ) under different levels of fertilizer.**

DAB	Polyhouse					Open Field
	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	
30	14	17	13	13	13	57
37	22	21	21	18	18	68
44	26	25	22	22	23	63
51	23	25	21	22	21	78
58	24	23	23	25	22	76
65	24	27	21	27	25	89
72	11	13	14	11	15	53
79	27	26	24	24	23	83
86	30	28	26	27	26	91
93	30	27	27	27	25	94
100	26	23	21	21	20	87
107	32	30	29	25	25	95
114	29	27	27	22	24	93
121	33	31	27	27	25	104
128	37	33	32	30	29	122
135	35	35	32	29	31	120

It was noticed from data presented in table.17 that the weekly mean reflected radiation under open condition was  $85.81 \mu\text{molm}^{-2}\text{s}^{-1}$  which was 71.10 % more than weekly mean reflected radiation under polyhouse condition  $24.8 \mu\text{molm}^{-2}\text{s}^{-1}$ .

**Table 16 : Cumulative reflected radiation ( $\mu\text{molm}^{-2}\text{s}^{-1}$ ) under different levels of fertilizer.**

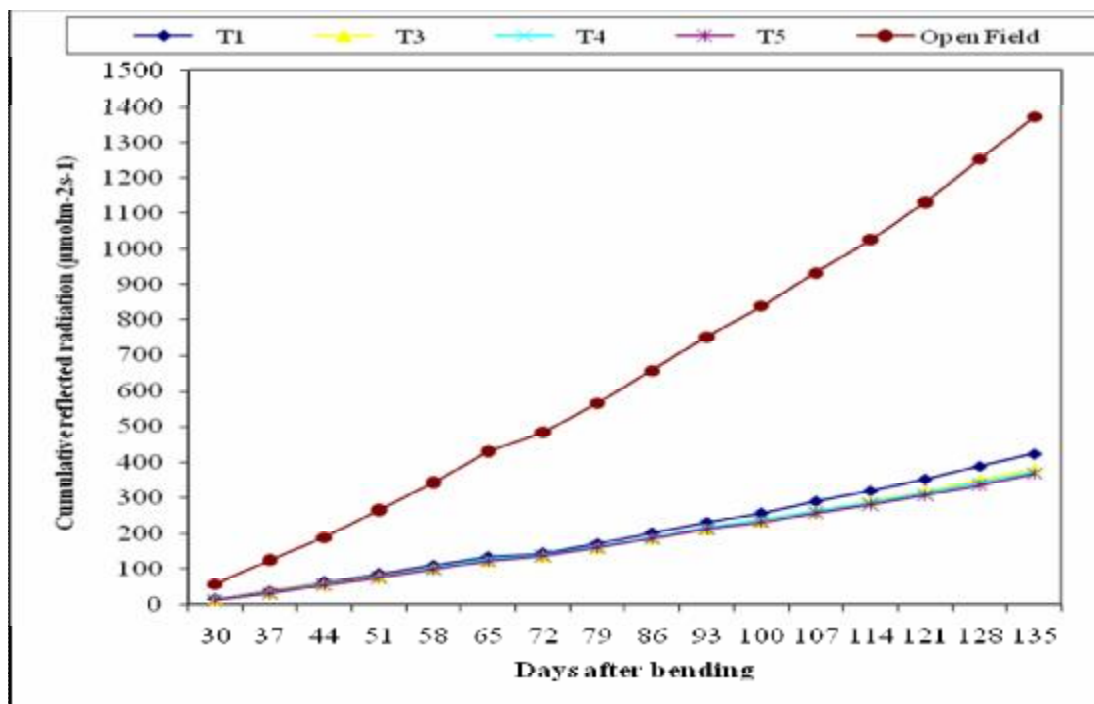
DAB*	Polyhouse					Open Field
	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	
30	14	17	13	13	13	57
37	36	38	34	31	31	125
44	62	63	56	53	54	188
51	85	88	77	75	75	266
58	109	111	100	100	97	342
65	133	138	121	127	122	431
72	144	151	135	138	137	484
79	171	177	159	162	160	567
86	201	205	185	189	186	658
93	231	232	212	216	211	752
100	257	255	233	237	231	839
107	289	285	262	262	256	934
114	318	312	289	284	280	1027
121	351	343	316	311	305	1131
128	388	376	348	341	334	1253
135	423	411	380	370	365	1373

\* DAB – Days after Bending

Further it was revealed from table. 15 and 16 that as fertilizer levels increases , amount of reflected radiation decreases. It was also

noticed that on an average amount of reflected radiation increase with increase in age of crop. The highest cumulative reflected radiation was observed in treatment T<sub>1</sub> (no fertilizer application) (423  $\mu\text{molm}^{-2}\text{s}^{-1}$ ) and lowest cumulative reflected radiation was observed in treatment T<sub>6</sub> (NPK @ 600:400:400 mg/pl/wk) (365  $\mu\text{molm}^{-2}\text{s}^{-1}$ ).

Thus it can be concluded that, UV stabilized 200 micron polythene film reduces the reflected radiation by 71.10 %.



**Fig.1 : Cumulative reflected radiation ( $\mu\text{molm}^{-2}\text{s}^{-1}$ ) under different levels of fertilizers.**

**Table 17 : Weekly mean reflected radiation ( $\mu\text{molm}^{-2}\text{s}^{-1}$ ) under different levels of fertilizer.**

Reflected radiation ( $\mu\text{molm}^{-2}\text{s}^{-1}$ )						
Polyhouse						Open
T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	Mean	Mean
26.43	25.69	25.44	23.12	22.81	24.8	85.81

#### 4.4.1.3. Transmitted radiation (PAR)

Weekly data on mean transmitted, cumulative transmitted and weekly mean transmitted radiation cumulated at seven days intervals are presented in Table 18,19 and 20 respectively and depicted in Fig 2.

**Table 18 : Mean transmitted radiation ( $\mu\text{molm}^{-2}\text{s}^{-1}$ ) under different levels of fertilizer.**

DAB*	Polyhouse					Open Field
	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	
30	90	83	79	75	71	96
37	65	67	68	63	52	93
44	78	77	76	76	63	109
51	90	90	87	72	70	129
58	116	109	98	94	86	166
65	95	83	79	71	79	133
72	56	51	47	52	44	87
79	107	104	103	95	89	155
86	95	87	86	72	81	132
93	132	127	120	109	96	182
100	98	95	89	88	83	135
107	166	160	150	113	122	228
114	101	96	87	73	70	135
121	103	91	89	90	93	143
128	134	124	123	106	115	178
135	141	126	123	119	131	164

\*DAB – Days after Bending

It was noticed that, weekly mean transmitted radiation under open condition was  $134 \mu\text{molm}^{-2}\text{s}^{-1}$  which was 31.76 % more than weekly

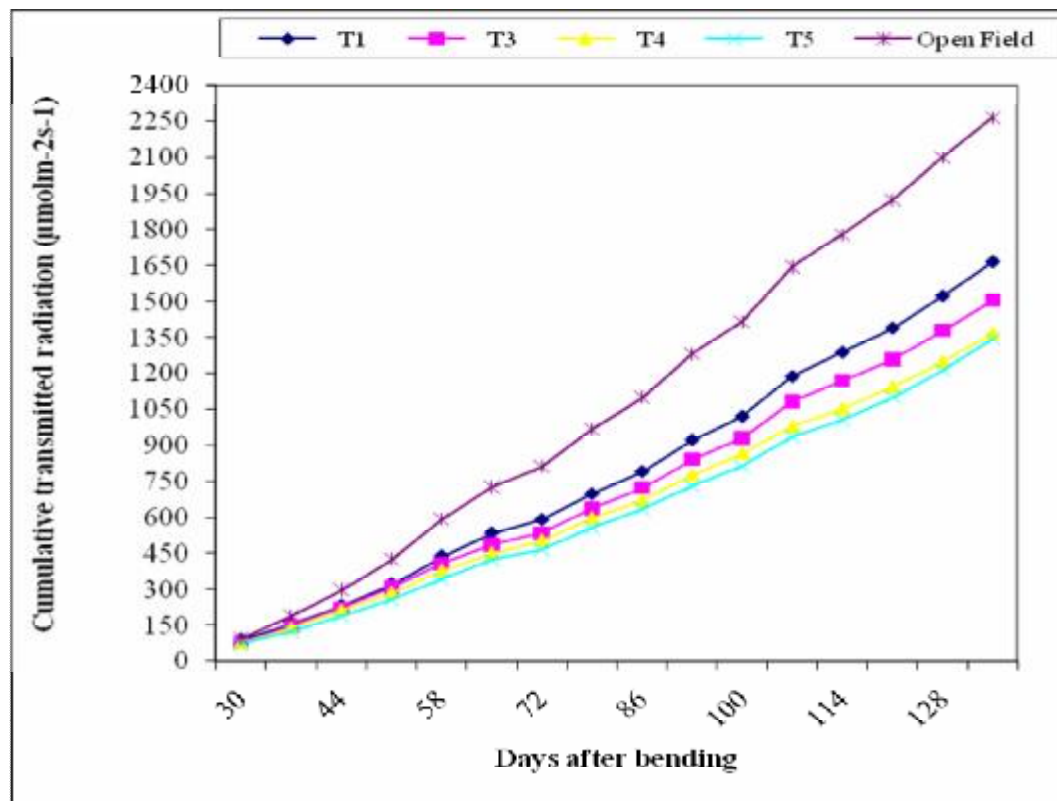
mean transmitted radiation under polyhouse condition  $91.44 \mu\text{molm}^{-2}\text{s}^{-1}$ . Further it was revealed from table. 18 and 19 that as fertilizer levels increases, amount of transmitted radiation decreases. It was also noticed that on an average amount of transmitted radiation decreases at 72,100 and 114 DAB, this may be due to development of dense crop canopy with age of crop.

**Table 19 : Cumulative transmitted radiation ( $\mu\text{molm}^{-2}\text{s}^{-1}$ ) under different levels of fertilizer.**

DAB*	Polyhouse					Open Field
	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	
30	90	83	79	75	71	96
37	155	150	147	138	123	189
44	233	227	223	214	186	298
51	323	317	310	286	256	427
58	439	426	408	380	342	593
65	534	509	487	451	421	726
72	590	560	534	503	465	813
79	697	664	637	598	554	968
86	792	751	723	670	635	1100
93	924	878	843	779	731	1282
100	1022	973	932	867	814	1417
107	1188	1133	1082	980	936	1645
114	1289	1229	1169	1053	1006	1780
121	1392	1320	1258	1143	1099	1923
128	1526	1444	1381	1249	1214	2101
135	1667	1570	1504	1368	1345	2265

\* DAB – Days after Bending

The highest cumulative transmitted radiation was observed in treatment T<sub>1</sub> (NPK @ 400:400:400 mg/pl/wk) ( $1667 \mu\text{molm}^{-2}\text{s}^{-1}$ ) and lowest cumulative transmitted radiation was observed in treatment T<sub>5</sub> (NPK @ 600:400:400 mg/pl/wk) ( $1345 \mu\text{molm}^{-2}\text{s}^{-1}$ ). Thus it can be concluded that, UV stabilized 200 micron polythene film reduces the transmitted radiation by 31.76 %.



**Fig.2 : Cumulative transmitted radiation ( $\mu\text{molm}^{-2}\text{s}^{-1}$ ) under different levels of fertilizers.**

**Table 20 : Weekly mean transmitted radiation ( $\mu\text{molm}^{-2}\text{s}^{-1}$ ) under different levels of fertilizer.**

Transmitted radiation ( $\mu\text{molm}^{-2}\text{s}^{-1}$ )						
Polyhouse						Open
T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	Mean	Mean
96.25	98.12	94.00	85.50	84.07	91.44	134.00

#### 4.4.1.4. Absorbed radiation (PAR)

Weekly data on mean absorbed, cumulative absorbed and weekly mean absorbed radiation cumulated at seven days intervals are presented in Table 21,22 and 23 respectively and depicted in Fig 6.

**Table 21 : Mean absorbed radiation ( $\mu\text{molm}^{-2}\text{s}^{-1}$ ) under different levels of fertilizer.**

DAB	Polyhouse					Open Field
	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	
30	95	108	119	125	126	473
37	119	124	122	130	138	516
44	156	160	163	142	172	704
51	123	124	135	139	145	716
58	141	157	162	164	183	691
65	111	131	115	127	148	648
72	107	146	130	121	151	557
79	180	186	187	185	207	732
86	197	202	212	214	212	793
93	185	185	191	194	228	799
100	200	194	206	212	214	818
107	136	133	150	192	180	764
114	211	215	217	248	248	815
121	212	217	226	227	217	770
128	188	207	226	227	217	770
135	166	174	174	193	205	811

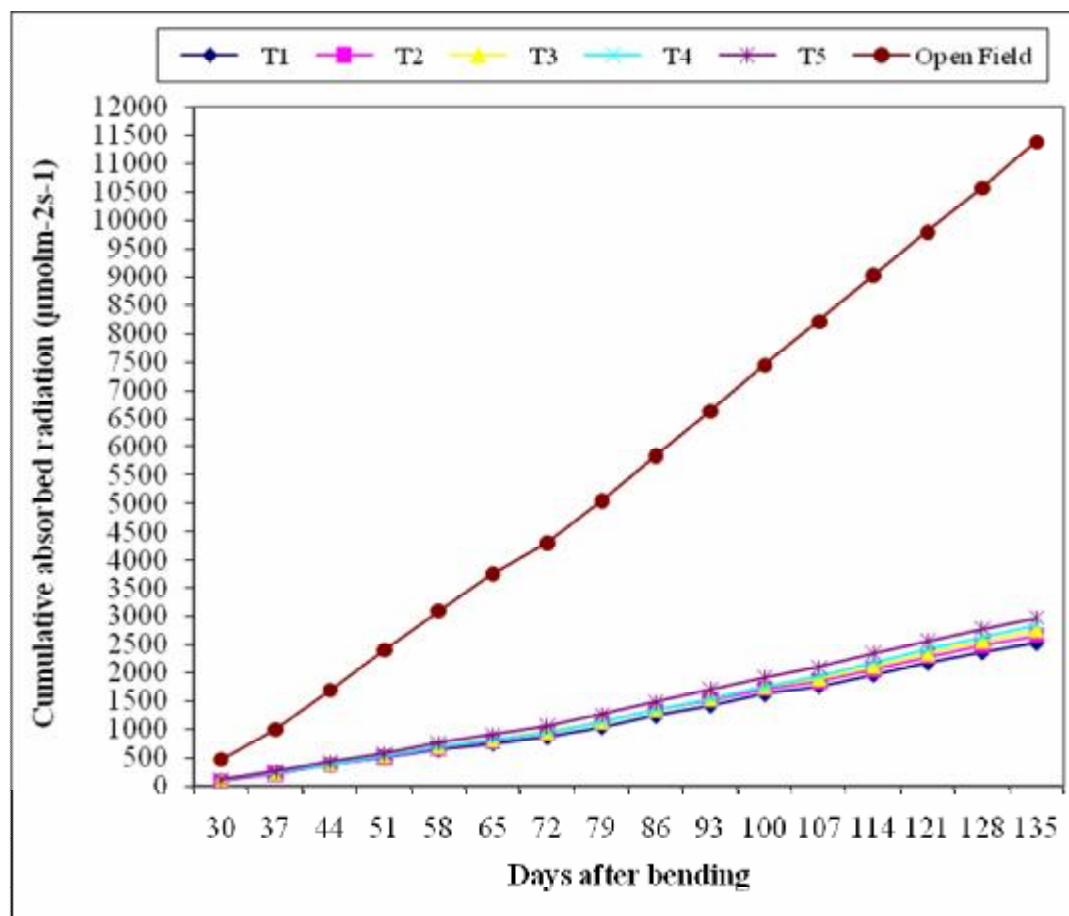
It was noticed that, weekly mean absorbed radiation under open condition was  $713.56 \mu\text{molm}^{-2}\text{s}^{-1}$  which was 75.93 % more than weekly mean absorbed radiation under polyhouse condition  $171.77 \mu\text{molm}^{-2}\text{s}^{-1}$ .

Further it was revealed from table. 21 and 22 that as fertilizer levels increases , amount of absorbed radiation increases. It was also noticed that on an average amount of absorbed radiation increase with increase in age of crop. This may be due to development of dense crop canopy with age of crop. The highest cumulative absorbed radiation was observed in treatment T<sub>5</sub> (NPK @ 600:400:400 mg/pl/wk) (2978  $\mu\text{molm}^{-2}\text{s}^{-1}$ ) and lowest cumulative absorbed radiation was observed in treatment T<sub>1</sub> (NPK @ 600:400:400 mg/pl/wk) (2527  $\mu\text{molm}^{-2}\text{s}^{-1}$ ).

**Table 22 : Cumulative absorbed radiation ( $\mu\text{molm}^{-2}\text{s}^{-1}$ ) under different levels of fertilizer.**

DAB	Polyhouse					Open Field
	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	
30	95	108	119	125	126	473
37	214	232	241	255	264	989
44	370	392	404	397	436	1693
51	493	516	539	536	581	2409
58	634	673	701	700	764	3100
65	745	804	816	827	912	3748
72	852	950	946	948	1063	4305
79	1032	1136	1133	1133	1270	5037
86	1229	1338	1345	1347	1482	5830
93	1414	1523	1536	1541	1710	6629
100	1614	1717	1742	1753	1924	7447
107	1750	1850	1892	1945	2104	8211
114	1961	2065	2109	2193	2352	9026
121	2173	2282	2335	2420	2569	9796
128	2361	2489	2561	2647	2786	10566
135	2527	2663	2754	2852	2978	11377

Thus it can be concluded that, UV stabilized 200 micron polythene film reduces the absorbed radiation by 75.93 %.



**Fig.3 : Cumulative absorbed radiation ( $\mu\text{molm}^{-2}\text{s}^{-1}$ ) under different levels of fertilizers.**

**Table 23 : Weekly mean absorbed radiation ( $\mu\text{molm}^{-2}\text{s}^{-1}$ ) under different levels of fertilizer**

Absorbed radiation ( $\mu\text{molm}^{-2}\text{s}^{-1}$ )						
Polyhouse						Open
T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	Mean	Mean
157.94	166.44	170.31	178.07	186.07	171.77	713.56

#### 4.4.1.5. Albedo (PAR)

Data on albedo i.e. ratio of weekly reflected radiation and weekly incident radiation were presented in Table: 24 and fig 4.

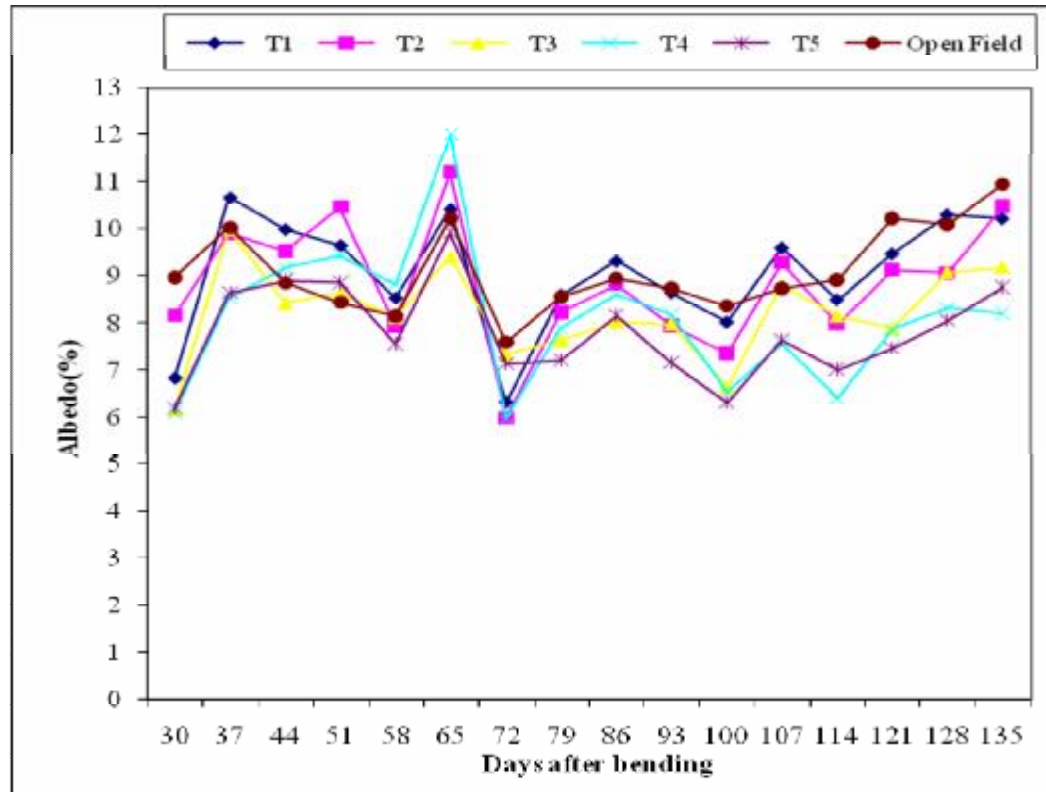
**Table 24 : Mean albedo(%) under different levels of fertilizers**

DAB*	Polyhouse					Open Field
	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	
30	6.83	8.17	6.16	6.10	6.19	8.97
37	10.68	9.91	10.00	8.53	8.65	10.04
44	10.00	9.54	8.43	9.17	8.91	8.86
51	9.66	10.46	8.64	9.44	8.86	8.45
58	8.54	7.96	8.13	8.83	7.56	8.15
65	10.43	11.20	9.41	12.00	9.92	10.23
72	6.32	6.01	7.33	5.98	7.14	7.60
79	8.60	8.23	7.64	7.89	7.21	8.56
86	9.32	8.83	8.02	8.62	8.15	8.96
93	8.65	7.96	7.99	8.18	7.16	8.74
100	8.02	7.37	6.65	6.54	6.31	8.37
107	9.61	9.29	8.81	7.58	7.65	8.74
114	8.50	7.99	8.16	6.41	7.02	8.92
121	9.48	9.14	7.89	7.87	7.46	10.23
128	10.31	9.07	9.09	8.33	8.06	10.10
135	10.23	10.48	9.19	8.21	8.76	10.96

\* DAB – Days after Bending

The albedo for different fertilizer levels under polyhouse and open condition maximum, minimum and average value of albedo (percentage) are given in Table: 25. The highest albedo (12 %) and lowest albedo (5.98 %). were observed in the treatment T<sub>4</sub> (NPK @ 550:400:400

mg/pl/wk). From the comparison between open field and polyhouse it was found that open field recorded more albedo (9.12 %) than polyhouse (8.41%).



**Fig. 4 :Mean albedo(%) under different levels of fertilizers**

**Table 25: Maximum, minimum and Mean of albedo (%) under different levels of fertilizers.**

	Polyhouse (%)					Open Field
	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	
<b>Max.</b>	10.68	11.20	10.00	12.00	9.92	10.96
<b>Min.</b>	6.32	6.19	6.16	5.98	6.19	7.60
<b>Mean</b>	9.07	8.86	8.22	8.10	7.81	9.12

#### 4.4.1.6. Transmissivity (PAR)

Data on transmissivity i.e. ratio of weekly transmitted radiation and incident radiation was presented in Table 26, and represented graphically in figure 5.

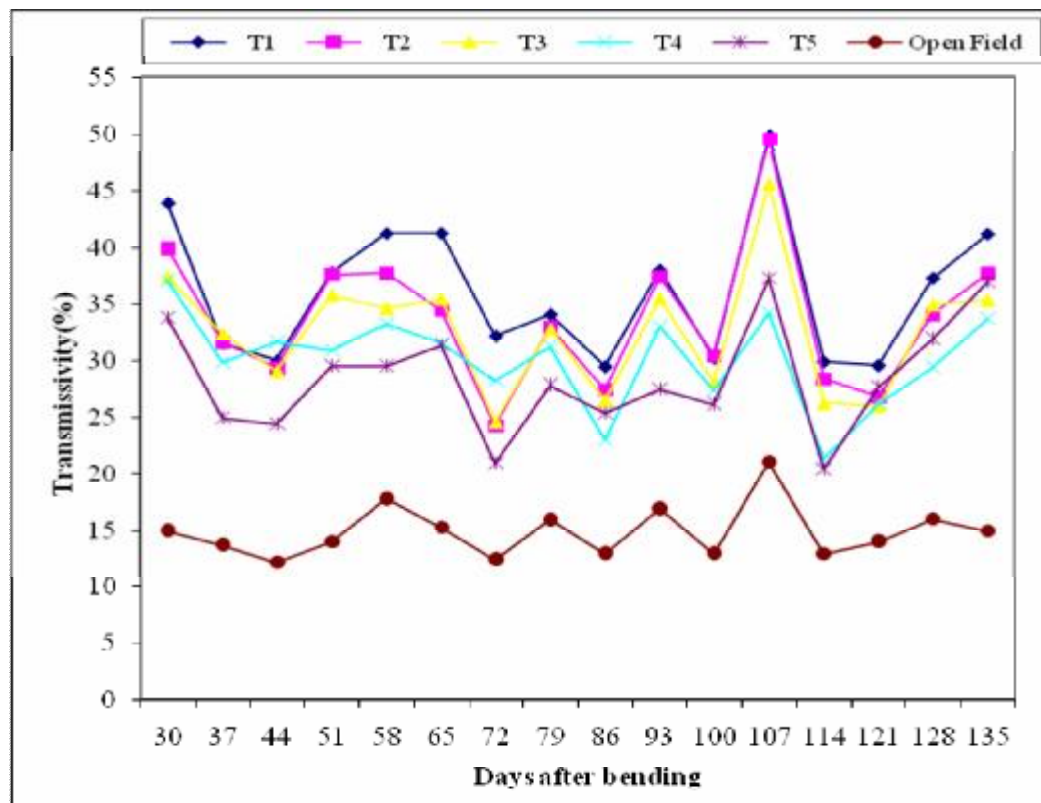
**Table 26 : Mean transmissivity (%) under different levels of fertilizers.**

DAB*	Polyhouse					Open Field
	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	
30	43.90	39.96	37.44	37.09	33.81	15.00
37	31.55	31.60	32.38	29.86	25.00	13.74
44	30.00	29.39	29.12	31.67	24.42	12.22
51	37.82	37.66	35.80	30.90	29.54	13.98
58	41.28	37.78	34.63	33.22	29.55	17.79
65	41.30	34.44	35.43	31.56	31.35	15.29
72	32.18	24.29	24.61	28.26	20.95	12.48
79	34.08	32.91	32.80	31.25	27.90	15.98
86	29.50	27.44	26.54	23.00	25.39	12.99
93	38.04	37.46	35.50	33.03	27.51	16.93
100	30.25	30.45	28.16	27.41	26.18	12.98
107	49.85	49.54	45.59	34.24	37.31	20.98
114	29.92	28.40	26.28	21.28	20.41	12.94
121	29.60	26.84	26.02	26.24	27.76	14.06
128	37.33	34.07	34.94	29.44	31.94	16.04
135	41.23	37.72	35.34	33.71	37.00	14.98

\* DAB – Days after Bending

Under polyhouse conditions Maximum, minimum and average values of transmissivity (percentage) under polyhouse conditions are given in Table:27. Under polyhouse showed that decrease in

transmissivity with increase in fertilizer levels (Table 26). The highest transmissivity was observed in the treatment T<sub>1</sub> (NPK @ 600:400:400 mg/pl/wk) (49.85 %) while lowest transmissivity observed in treatment T<sub>5</sub> (NPK @ 600:400:400 mg/pl/wk) (20.41 %).



**Fig. 5 : Mean transmissivity (%) under different levels of fertilizers.**

**Table 27 : Maximum, minimum and Mean of transmissivity(%) under different levels of fertilizer.**

	Polyhouse (%)					Open Field
	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	
<b>Max.</b>	49.85	49.54	45.59	37.09	37.31	20.98
<b>Min.</b>	29.50	26.84	26.02	23.00	20.41	12.22
<b>Mean</b>	36.00	34.37	32.90	30.17	28.84	15.04

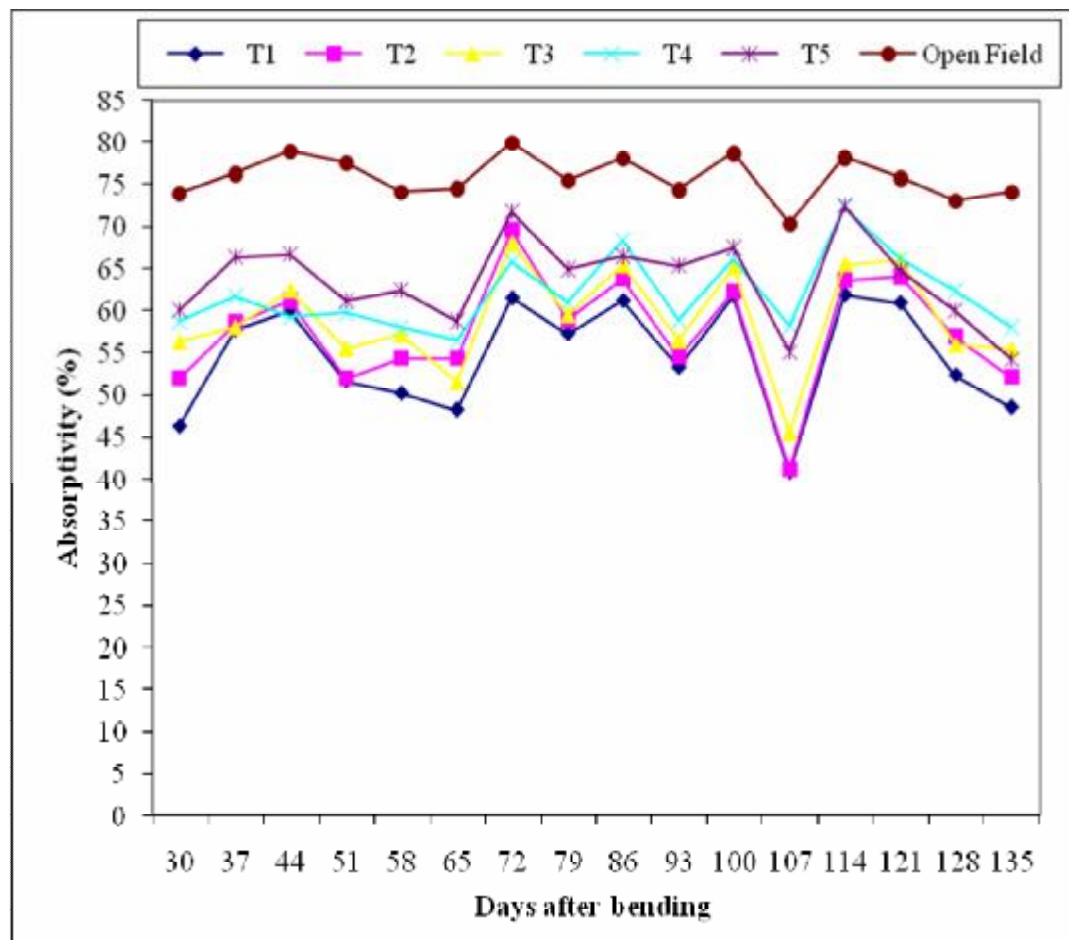
In general under polyhouse transmissivity was much higher (32.46 %) than open field condition (15.04 %) because of directionality effect of radiation i.e. under polyhouse conditions direct radiation was less and diffused radiation was more than open conditions.

#### 4.4.1.7. Absorptivity (PAR)

**Table 28 : Mean absorptivity (%) under different levels of fertilizer.**

DAB	Polyhouse					Open Field
	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	
30	46.34	51.92	56.40	58.69	60.00	73.91
37	57.77	58.49	58.10	61.61	66.35	76.22
44	60.00	61.07	62.45	59.17	66.67	78.92
51	51.68	51.88	55.56	59.66	61.18	77.57
58	50.18	54.33	57.24	57.95	62.39	74.06
65	48.26	54.36	51.57	56.45	58.73	74.48
72	61.49	69.52	68.06	65.76	71.90	79.91
79	57.32	58.86	59.55	60.86	64.90	75.46
86	61.18	63.72	65.43	68.37	66.46	78.05
93	53.31	54.57	56.51	58.79	65.33	74.33
100	61.73	62.18	65.19	66.04	67.51	78.65
107	40.84	41.18	45.59	58.18	55.05	70.29
114	61.88	63.61	65.56	72.30	72.51	78.14
121	60.92	64.01	66.08	66.18	64.78	75.71
128	52.37	56.87	55.97	62.33	60.00	72.98
135	48.54	52.10	55.46	58.07	54.24	74.06

Data on absorptivity i.e. ratio of weekly absorbed radiation and incident radiation were presented in Table 28, and represented graphically in figure 6.



**Fig. 6 : Mean absorptivity (%) under different levels of fertilizers.**

Under polyhouse, absorptivity showed general increasing trend. Maximum, minimum, average and range of absorptivity (%) under different fertilizer levels are given in Table 29. Under polyhouse condition it was found that increase in absorptivity with increase in fertilizer levels presented in Table 28, this might be due to development of dense crop canopy. The highest absorptivity was observed in the treatment T<sub>5</sub> (NPK @ 600:400;400 mg/pl/wk) (72.51 %) while lowest absorptivity observed in treatment T<sub>1</sub> (NPK @ 400:400;400 mg/pl/wk) (40.84 %). Form the comparison between open field and polyhouse it was noticed that open field have more absorptivity (75.8 %) than polyhouse (59.33 %).

**Table 29 : Maximum, minimum and Mean of Absorptivity (%)  
under different levels of fertilizer.**

Polyhouse (%)						Open
	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	Field
<b>Max.</b>	61.88	69.52	68.06	72.30	72.51	79.91
<b>Min.</b>	40.84	41.18	45.59	56.45	54.24	70.29
<b>Mean</b>	54.61	57.42	59.04	61.90	63.66	75.80

#### **4.4.2. Temperature and humidity during the experimental period**

In order to get idea about the effect of fertilizer levels on climatic conditions such as temperature and humidity prevailed during the period of investigation in polyhouse and open field conditions were recorded at seven days interval at 7:30 am and 14:30 pm and presented in Table 30.

##### **4.4.2.1. Temperature**

The data of temperature presented in Table 30 revealed that, the weekly temperature during crop growth ranged between 17.1 and 24.2<sup>0</sup>C, 13.5 and 22.3<sup>0</sup>C under poly house and open field conditions respectively at 7.30 a.m. Whereas afternoon temperature at 14.30 p.m. under polyhouse and open field condition were ranged between 26.1 and 37.1<sup>0</sup>C, 27 and 32.9<sup>0</sup>C respectively. In general it can be concluded that temperatures inside polyhouse was more than open field condition.

##### **4.4.2.2. Humidity**

The data of humidity presented in Table 30 revealed that, the weekly humidity during crop growth ranged between 98 and 89 % , 96 and 86 % under poly house and open field conditions respectively at 7.30 a.m. Whereas afternoon humidity at 14.30 p.m. under polyhouse and open field condition were ranged between 80 and 37 % ,75 and 27 % respectively. In general it can be concluded that humidity inside polyhouse was more than open field condition.

**Table 30 : Effect of fertilizer levels on temperature and humidity.**

DAB*	Polyhouse				Field			
	At 7:30 AM		At 14:30 PM		At 7:30 AM		At 14:30 PM	
	Temp. (°C)	Humidity (%)	Temp. (°C)	Humidity (%)	Temp. (°C)	Humidity (%)	Temp. (°C)	Humidity (%)
30	23.5	94	28.4	75	22.3	91	30.3	70
37	24.2	93	26.1	79	22.3	91	27.5	75
44	22	90	28.9	80	21.4	89	27	74
51	23.7	95	33.7	57	19	90	30.4	49
58	22.9	92	31.9	65	19	89	30.8	61
65	20.9	95	34.3	53	19.9	93	31.5	48
72	20	91	37.1	41	17.2	89	32.7	38
79	18.3	93	35.8	37	13.5	88	32.5	27
86	17.8	89	36.7	41	14.7	86	32.9	31
93	18.3	92	35	51	14.4	90	32.3	39
100	17.7	90	33.4	56	16.9	87	30.2	44
107	21.8	96	32.8	48	17.4	91	32	41
114	17.1	90	34.5	59	15.6	88	29.7	48
121	16.3	97	31.9	50	14.9	96	30.5	37
128	19.2	98	32.6	48	14.9	95	30.5	40
135	20.1	92	30.1	51	15.2	90	29.3	37

\* DAB – Days after Bending

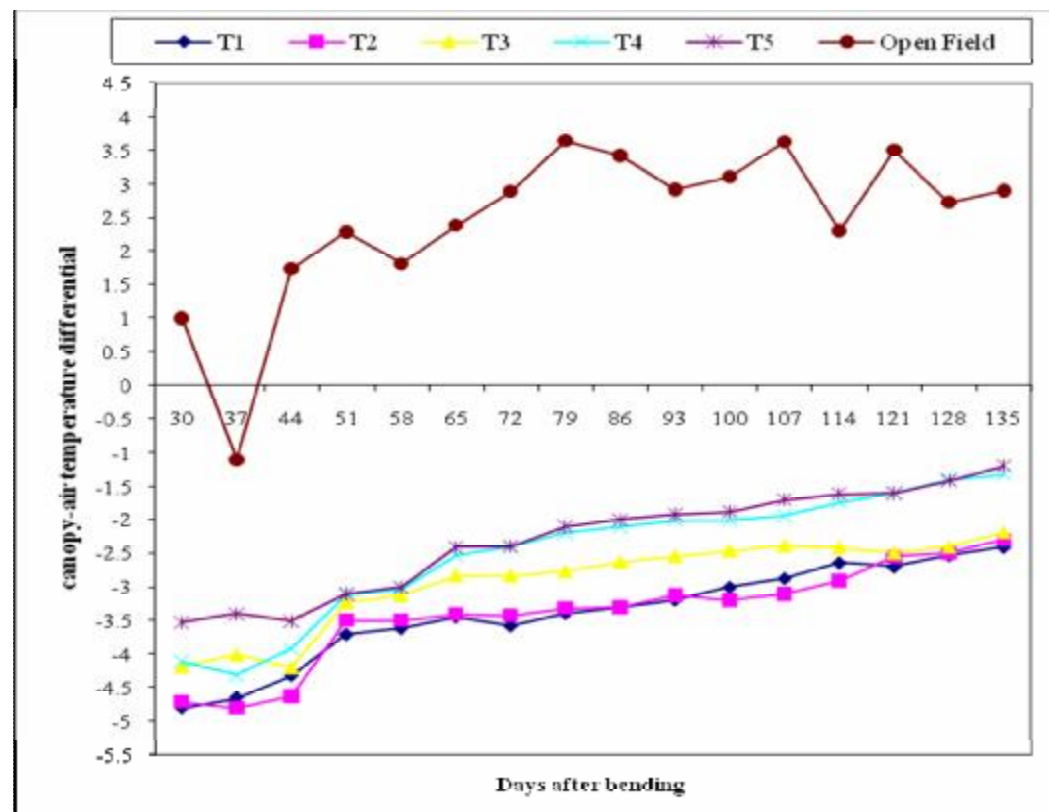
#### 4.4.3. Canopy-air temperature differential ( $\Delta T_c$ )

The data pertaining to canopy-air temperature recorded throughout the experiment at the period of five levels of fertilizer under polyhouse and also in open field conditions are presented in Table 31 and depicted in fig.7.

The canopy temperature ( $T_c$ ) and canopy-air temperature differential ( $\Delta T_c$ ) were measured at seven days interval starting from 30 DAB in all five levels of fertilizer under polyhouse and open field condition. It is revealed from data presented in the Table 25 that canopy-air temperature differential ( $\Delta T_c$ ) was negative in all the five levels of fertilizer under polyhouse. However, positive ( $\Delta T_c$ ) values recorded under open field condition.

This indicates that canopy was cooler than the ambient air due to sufficient availability of water potential and stomatal conductance causing higher transpiration and evaporative cooling thereby lower canopy temperature than air temperature.

Further it was noticed that at the initial growth stage of plant ( $\Delta T_c$ ) values were more and decreased slowly as the advancement in age.



**Fig. 7 : Effect of fertilizer levels on canopy-air temperature differential.**

**Table 31 : Effect of fertilizer levels on canopy-air temperature differential**

<b>DAB*</b>	<b>T<sub>1</sub></b>	<b>T<sub>2</sub></b>	<b>T<sub>3</sub></b>	<b>T<sub>4</sub></b>	<b>T<sub>5</sub></b>	<b>Field</b>
30	- 4.80	- 4.71	- 4.18	- 4.10	-3.52	1.00
37	- 4.65	- 4.80	- 4.00	- 4.30	- 3.40	- 1.10
44	- 4.32	- 4.63	- 4.20	- 3.91	- 3.51	1.74
51	- 3.70	- 3.49	- 3.23	- 3.11	- 3.10	2.29
58	- 3.61	- 3.49	- 3.13	- 3.02	- 3.00	1.82
65	- 3.44	- 3.40	- 2.83	- 2.52	- 2.41	2.39
72	- 3.57	- 3.42	- 2.83	- 2.40	- 2.40	2.89
79	- 3.39	- 3.31	- 2.77	- 2.19	- 2.10	3.64
86	- 3.30	- 3.30	- 2.63	- 2.10	- 2.00	3.42
93	- 3.19	- 3.12	- 2.55	- 2.00	- 1.92	2.92
100	- 3.00	- 3.19	- 2.47	- 2.00	- 1.88	3.11
107	- 2.87	- 3.10	- 2.39	- 1.93	- 1.70	3.63
114	- 2.64	- 2.90	- 2.42	- 1.73	- 1.61	2.31
121	- 2.70	- 2.55	- 2.50	- 1.59	- 1.60	3.50
128	- 2.53	- 2.50	- 2.41	- 1.40	- 1.41	2.73
135	- 2.41	- 2.30	- 2.19	- 1.32	- 1.20	2.90

\* DAB – Days after Bending

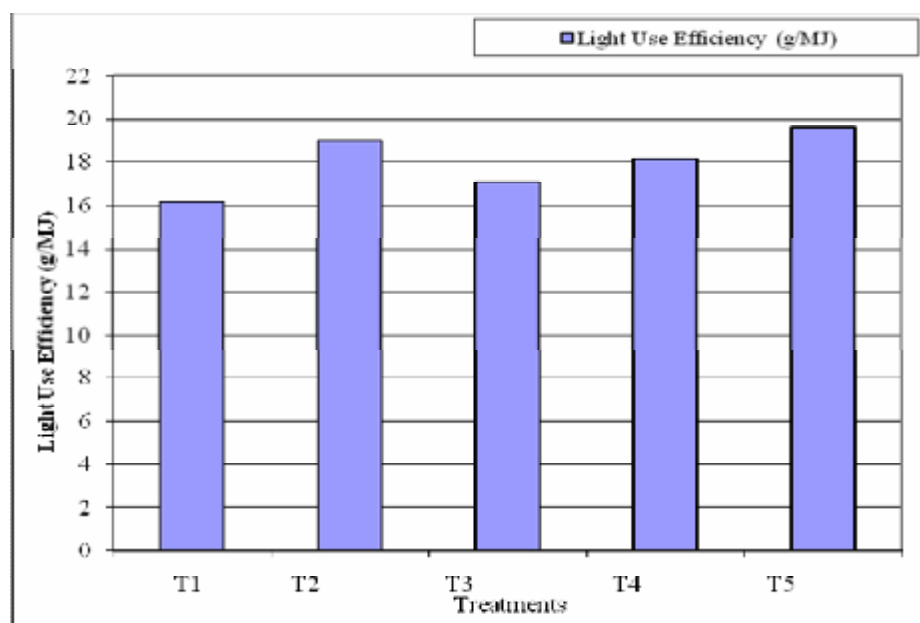
#### **4.5. Light use efficiency.**

##### **4.5.1. Green weight**

Cumulated absorbed radiation was converted from  $\mu\text{molm}^{-2}\text{s}^{-1}$  to  $\text{MJm}^{-2}$  by multiplication of factor 0.0188. Thus the data calculated on green weight light use efficiency was presented in Table-32, and represented in figure 8.

**Table 32 : Green weight light use efficiency (g/MJ) at different fertilizer levels**

Treatments- NPK Levels (mg/pl/wk)	Absorbed radiation (MJ/m <sup>2</sup> growth period)	Biomass (Economic Yield+ Dry weight) g/m <sup>2</sup>	Light Use Efficiency (g/MJ)
T <sub>1</sub> - 400:400:400	43.41	701.29	16.16
T <sub>2</sub> - 450:400:400	44.86	850.77	18.96
T <sub>3</sub> - 500:400:400	46.62	795.56	17.06
T <sub>4</sub> - 550:400:400	48.9	886.17	18.12
T <sub>5</sub> - 600:400:400	50.35	985.32	19.57



**Fig. 8 : Green weight light use efficiency (g/MJ) at different fertilizer levels**

It was revealed from Table-32 that green weight light use efficiency was recorded maximum in T<sub>5</sub> (NPK @ 600:400:400 mg/pl/wk) (19.57 g/MJ) and lowest was observed in T<sub>1</sub> (NPK @ 400:400:400 mg/pl/wk) (16.16 g/MJ). Further, it was also observed that green weight

LUE increases with increase in fertilizer levels, thereby indicating good response of LUE of higher levels of fertilizer application.

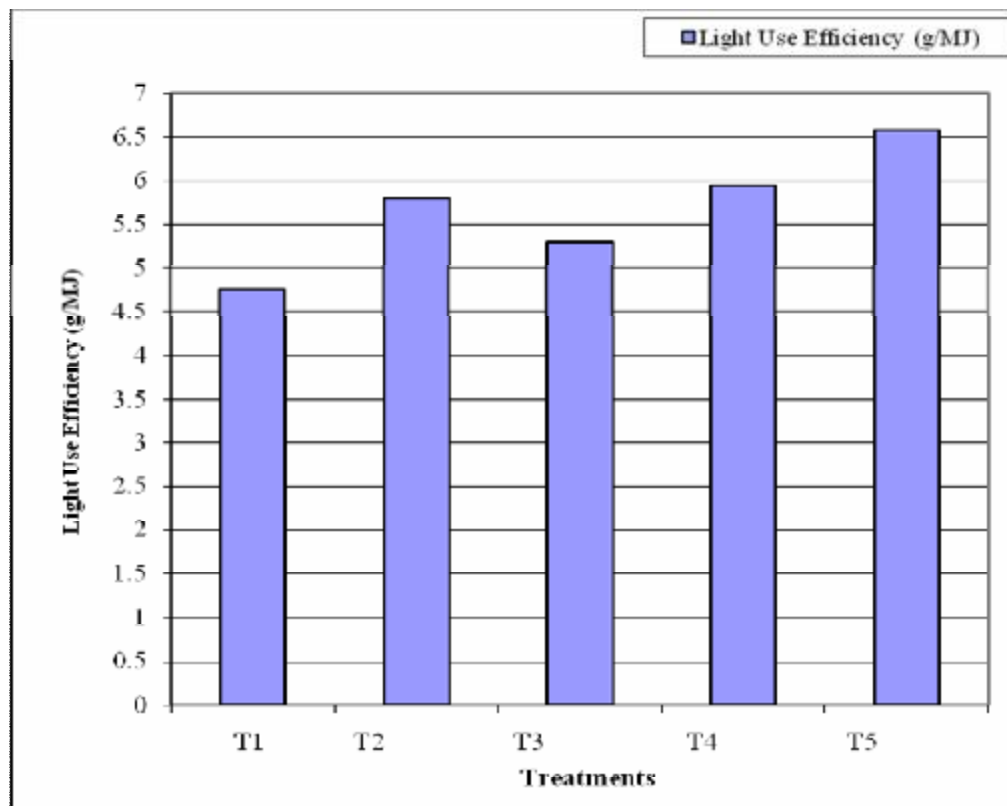
#### 4.5.2 Dry weight

Cumulated absorbed radiation was converted from  $\mu\text{molm}^{-2}\text{s}^{-1}$  to  $\text{MJm}^{-2}$  by multiplication of factor 0.0188. Thus the data calculated on green weight light use efficiency was presented in Table 33, and depicted in figure 9.

It was revealed from Table-33 that dry weight light use efficiency was recorded maximum in  $T_5$  (NPK @ 600:400:400 mg/pl/wk) (6.57 g/MJ) and lowest was observed in  $T_1$  (NPK @ 400:400:400 mg/pl/wk) (4.75 g/MJ). Further, it was also observed that dry weight LUE increases with increase in fertilizer levels, thereby indicating good response of LUE of higher levels of fertilizer application.

**Table 33 : Dry weight light use efficiency (g/MJ) at different fertilizer levels**

<b>Treatments- NPK Levels (mg/pl/wk)</b>	<b>Absorbed radiation (MJ/m<sup>2</sup> growth period)</b>	<b>Biomass (Economic Yield+ Dry weight) g/m<sup>2</sup></b>	<b>Light Use Efficiency (g/MJ)</b>
$T_1$ - 400:400:400	43.41	206.24	4.75
$T_2$ - 450:400:400	44.86	260.08	5.8
$T_3$ - 500:400:400	46.62	246.62	5.29
$T_4$ - 550:400:400	48.9	290.66	5.94
$T_5$ - 600:400:400	50.35	330.67	6.57



**Fig. 9 : Dry weight light use efficiency (g/MJ) at different fertilizer levels**

## 5. SUMMARY AND CONCLUSION

### 5.1 SUMMARY

The research experiment “Study of variations in crop canopy temperature and light use efficiency due to different fertilizer levels in rose under polyhouse condition during kharif and winter season” was undertaken during the year 2008-09 at Hi-tech Floriculture and Vegetable Project, College of Agriculture, Pune - 41105. The present research was carried out with the following objective.

1. To study the variations in canopy temperature due to different fertilizer levels under polyhouse conditions.
2. To study the variations in light use efficiency due to different fertilizer levels under polyhouse conditions.
3. To study the effect of N, P, K levels on the growth yield and quality in relation to meteorological parameters.

The experiment was laid out in Randomized Block Design with six treatments and four replications.

T<sub>1</sub> – NPK @ 400:400:400 mg/pl/wk

T<sub>2</sub> - NPK @ 450:400:400 mg/pl/wk

T<sub>3</sub> - NPK @ 500:400:400 mg/pl/wk

T<sub>4</sub> - NPK @ 550:400:400 mg/pl/wk

T<sub>5</sub> - NPK @ 600:400:400 mg/pl/wk

Observation in respect of growth, yield and flower quality were recorded. The result of present investigation are briefly summarized in this chapter.

## **Growth**

The treatment T<sub>5</sub> was the earliest to sprout (4.37 days) followed by T<sub>4</sub> (4.39 days) and both were nearly on par. It was followed by T<sub>3</sub> and T<sub>2</sub> (4.95 and 5.11 days respectively). Treatment T<sub>5</sub> and T<sub>4</sub> were significant over treatments T<sub>1</sub> and T<sub>2</sub> and T<sub>3</sub>.

Days required for flowering were significantly influenced by fertilizer levels. Late flowering was recorded in treatment T<sub>1</sub>, T<sub>2</sub> and T<sub>3</sub> (45.41, 36.45 and 35.05 days respectively), whereas the treatment T<sub>4</sub> was the earliest (31.34 days) for flowering, which was followed by T<sub>5</sub> (32.08 days).

Number of leaf pairs per flowering shoot were maximum in treatment T<sub>5</sub> (20.07) followed by T<sub>4</sub> (19.10), T<sub>3</sub> (18.19) and T<sub>2</sub> (16.8). All these treatments were found to be significantly superior over Treatment T<sub>1</sub> (16.41).

## **Yield**

Result of the present investigation show that number of flowering shoot produced per plant and yield of flowers per plant were positively correlated with each other. It was observed that increased in flowering shoot per plant resulted in growth of total yield of flowers per plant. Treatment T<sub>5</sub> was produced significantly more number of flowering shoots per plant (5.27). Hence it produced highest number of flowers (9.58) than rest of treatments. Treatment T<sub>1</sub> produced the least number of flowering shoots (3.68 per plant) followed by T<sub>2</sub> (4.19) and T<sub>5</sub> (4.38).

## **Quality**

Different fertilizer levels influenced quality parameters such as length of shoot, diameter of flower bud and length of flower bud. Treatment T<sub>4</sub> (NPK @ 550:400:400 mg/wk/pl.) was superior with maximum diameter of flower bud (2.30 cm) and length of flower bud (2.86 cm). It was followed

by T<sub>5</sub> with 2.21 cm diameter of flower bud and 2.82 cm length of flower bud. Treatment T<sub>1</sub> was inferior in all respects of quality. Treatment T<sub>5</sub> (64.39 cm) had significantly highest shoot length among the treatments. It was followed by the treatment T<sub>4</sub> (63.52 cm) which was followed by treatment T<sub>3</sub> (61.16 cm).

### **Radiation**

Radiation was measured in  $\mu\text{molm}^{-2}\text{s}^{-1}$  all treatments with the help of line quantum sensor (LICOR) and data logger (LI 1000).

### **Incident radiation**

It was noticed that, weekly mean incident radiation under open condition was  $942.81 \mu\text{molm}^{-2}\text{s}^{-1}$  which was 69.32 % more than weekly mean incident radiation under polyhouse condition  $289.25 \mu\text{molm}^{-2}\text{s}^{-1}$ .

Thus it can be concluded that, UV stabilized 200 micron polythene film reduces the incident radiation by 69.32 %.

### **Reflected radiation**

It was noticed that, weekly mean reflected radiation under open condition was  $85.81 \mu\text{molm}^{-2}\text{s}^{-1}$  which was 71.09 % more than weekly mean reflected radiation under polyhouse condition  $24.80 \mu\text{molm}^{-2}\text{s}^{-1}$ . Further it was revealed from table. 11 and 12 that as fertilizer levels increases, amount of reflected radiation decreases.

Thus it can be concluded that, UV stabilized 200 micron polythene film reduces the reflected radiation by 71.09 %.

### **Transmitted radiation**

It was noticed that, weekly mean transmitted radiation under open condition was  $134 \mu\text{molm}^{-2}\text{s}^{-1}$  which was 31.76 % more than weekly mean transmitted radiation under polyhouse condition  $91.44 \mu\text{molm}^{-2}\text{s}^{-1}$ . Further it was revealed that as fertilizer levels increases, amount of transmitted

radiation decreases. Thus it can be concluded that, UV stabilized 200 micron polythene film reduces the transmitted radiation by 31.76 %.

### **Absorbed radiation**

It was noticed that, weekly mean absorbed radiation under open condition was  $713.56 \mu\text{molm}^{-2}\text{s}^{-1}$  which was 75.93 % more than weekly mean absorbed radiation under polyhouse condition  $171.77 \mu\text{molm}^{-2}\text{s}^{-1}$ . Further it was revealed from table. 18 and 19 that as fertilizer levels increases, amount of absorbed radiation increases.

Thus it can be concluded that, UV stabilized 200 micron polythene film reduces the absorbed radiation by 75.93 %.

### **Albedo (Reflectivity)**

The albedo in all different fertilizer levels under polyhouse and open condition maximum, minimum and average value of albedo (percentage) are given in Table: 22. Under polyhouse showed that decrease in albedo with increase in fertilizer levels table 21. The highest albedo (12%) and lowest albedo (5.98 %) were observed in the treatment T<sub>4</sub> (NPK @ 550:400:400 mg/pl/wk). From the comparison between open field and polyhouse it showed that open field have more albedo (9.12 %) than polyhouse (8.41 %).

### **Transmissivity**

It was noticed that maximum, minimum and average values of transmissivity (percentage) was more in polyhouse than open condition. Under polyhouse showed that decrease in transmissivity with increase in fertilizer levels table 23. The highest transmissivity was observed in the treatment T<sub>1</sub> (NPK @ 400:400:400 mg/pl/wk) (49.85 %) while lowest transmissivity observed in treatment T<sub>5</sub> (NPK @ 35:25:85 mg/pl/wk) (20.41 %). In general under polyhouse transmissivity was much higher (32.45 %) than open field condition (15.04 %) because of directionality effect of

radiation i.e. under polyhouse conditions direct radiation was less and diffused radiation was more than open conditions.

### **Absorptivity**

It was noticed that maximum, minimum and average values of absorptivity (percentage) was more in polyhouse than open condition. Under polyhouse showed that increase in absorptivity with increase in fertilizer levels table 25. This might be due to development of dense crop canopy. The highest absorptivity was observed in the treatment T<sub>5</sub> (NPK @ 600:400:400 mg/pl/wk) (72.51 %) while lowest absorptivity observed in treatment T<sub>1</sub> (NPK @ 400:400:400 mg/pl/wk) (40.64 %). From the comparison between open field and polyhouse it showed that open field have more absorptivity (75.8%) than polyhouse (59.33 %).

### **Canopy-air temperature differential ( $\Delta T_c$ )**

Canopy-air temperature differential ( $\Delta T_c$ ) values were negative for all fertilizer levels under polyhouse conditions and positive for open field conditions.

### **Light use efficiency**

Cumulative absorbed radiation for 135 days was converted from  $\mu\text{molm}^{-2}\text{s}^{-1}$  to  $\text{MJm}^{-2}$  by conversion factor of 0.0188.

The highest green weight light use efficiency (19.57 g/MJ) was recorded in T<sub>5</sub> (NPK @ 600:400:400 mg/pl/wk) and lowest was observed in T<sub>1</sub> (NPK @ 400:400:400 mg/wk/pl) (16.16 g/MJ).

The highest dry weight light use efficiency (6.57 g/MJ) was recorded in T<sub>5</sub>(NPK @ 600:400:400 mg/wk/pl) and lowest was observed in T<sub>1</sub>(NPK @ 400:400:400 mg/wk/pl) (4.75 g/MJ).

## 5.2 CONCLUSTIONS

### 5.2.1 Canopy-air temperature differential

Canopy air temperature differential ( $T_c - T_a$ ) was negative under polyhouse and treatment  $T_5$  (NPK @ 600:400:400 mg/pl/wk) showed significantly lower negative values followed by  $T_4$  (NPK @ 550:400:400 mg/pl/wk) . It might be due to thicker canopy and more absorption of radiation where as maximum negative value was observed in  $T_1$  (NPK @ 400:400:400 mg/pl/wk). However, positive canopy air temperature differential was recorded under open field condition.

From the observations it is concluded that canopy was cooler than ambient air due to sufficient availability of water to meet transpiration requirement. Sufficient availability of water for absorption by plants resulted in higher transpiration and evaporative cooling thereby lower canopy temperature than air temperature and in field condition there was observed that canopy is warmer than ambient air temperature.

Further it was noticed that at the initial growth stage of plant  $\Delta T_c$  values were more and decreased slowly as the advancement in age.

### 5.2.2 Light use efficiency

Application of treatment  $T_5$  found to be beneficial. The highest green weight and dry weight light use efficiency were recorded in treatment  $T_5$  (NPK @ 600:400:400 mg/pl/wk) followed by treatment  $T_4$  and  $T_3$ , while lowest green weight and dry weight light use efficiency were observed in observed in treatment  $T_1$  (NPK @ 400:400:400 mg/pl/wk).

It was revealed from above observation that increase in crop canopy due to increase in fertilizer levels which results in increasing light use efficiency.

### **5.2.3 Effect of different fertilizer levels in relation to meteorological parameters.**

From the above results, it could be concluded that fertilizer application T<sub>5</sub> (NPK @ 600:400:400 mg/pl/wk) proved to be the best dose of fertilizer in promoting growth, increasing yield and improving flower quality parameters of rose in relation to meteorological parameters.

The experiments need to be reported for two to three years for confirmation of results and derive a concrete conclusion to give recommendation to the farmers.

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## 7. VITA

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