STANDARDIZATION OF IRRIGATION REQUIREMENT OF SALAD CUCUMBER IN POLYHOUSE

By

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PROJECT REPORT

Submitted for the partial fulfillment of the requirement for the degree

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In

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Department of Irrigation and Drainage Engineering

KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY

TAVANUR-679 573, MALAPPURAM

2010

DECLARATION

We hereby declare that this project entitled "**Standardization of irrigation requirement of salad cucumber in polyhouse"** is a bonafide report work done by us during the course of project and that the report has not previously formed the basis for the award to us of any degree, diploma, associate ship, fellowship or other similar title of any other university or society.

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We bow our heads before God Almighty for the blessing bestowed on us.

Dedicated

to

GOD, Almighty

and

Farming community

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SYMBOLS AND ABBREVATIONS

ºC	:	Degree Celsius
cm	:	Centimeter
CD	:	Critical difference
cm^2	:	Square centimeter
DF	:	Degrees of freedom
et al	:	And others
Fig	:	Figure
gm	:	Gram
ha	:	Hectare
hr	:	Hour
IDE	:	Irrigation and Drainage Engineering
KCAET	:	Kelappaji College of Agricultural Engineering and Technology
Kg	:	Kilogram
LDPE	:	Low Density Poly Ethylene
Lph	:	Litre per hour
LSD	:	Least Significant Difference
m	:	Metre
MS	:	Mean sum of Squares
No	:	Number

PFDC	:	Precision Farming Development Centre
POP	:	Package of practices
%	:	Percentage
PVC	:	Poly Vinyl Chloride
Rs	:	Rupees
RBD	:	Randomized Block Design
SS	:	Sum of Squares
t	:	Tonne
MAP	:	Modified atmosphere packaging
O_2	:	Oxygen
CO_2	:	Carbon dioxide

Introduction

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CHAPTER I

INTRODUCTION

Irrigation system is one of the most important components affecting the yield and quality of agricultural produce. It is the application of water to soil which assist in the production of crops. Irrigation water is applied to supplement the water available from rainfall, soil moisture and the capillary rise of ground water. In many areas of the world, the amount and distribution of rainfall are not adequate and uniform to meet the water requirement of crops. Hence, successful crop production often requires adequate provision for irrigation. The objective of efficient irrigation is to increase agricultural production per unit volume of water, per unit area of cropped land in unit time.

Drip or trickle irrigation is an efficient irrigation method, which is becoming increasingly popular in areas of water scarcity and poor quality irrigation water. Drip irrigation is an efficient method of irrigation in which water is supplied directly to the root zone of the plant so as to maintain the soil moisture near the field capacity of soil for most of the time. Water is applied frequently to the soil through drippers attached to water delivery lateral line placed near the plant row .The principle of drip irrigation is to irrigate the root zone of the plant to get minimal wetted soil surface. Very high water application efficiency (90-95%) can be obtained through drip irrigation method. In drip irrigation, water is applied at a slower rate to keep the moisture content most favorable to plant growth. Excess of water applied reduces plant growth as it displaces the air at the root zone, required for plant growth. Small but frequent application of water enables the plant to grow well without any ill effect of the water stress periods between consecutive irrigations.

Drip irrigation system can be used for all wide-spaced crops, as in orchards, plantation, row crops and others. Water is applied continuously over a long period through a network of small diameter plastic pipes and water delivering devices like drippers. Water conservation is the most obvious advantage of this system. Losses are almost fully eliminated. This system of irrigation ensures uniform application of water throughout the field which results in uniform plant growth and yield. In recent years, considerable interest has been seen in drip irrigation as a means for increasing yield and irrigation efficiency, thereby reducing operation costs. Soil erosion is almost eliminated in steep hilly areas by the use of this method of irrigation. However, high initial cost of the system resulted in the reduced acceptance of drip irrigation in India.

Irrigation scheduling is the process of determining the time to irrigate and how much water is to be applied (irrigation depth) in each irrigation. Proper scheduling is essential for the efficient use of water and other inputs in crop production. Irrigation scheduling inside greenhouse is an important parameter for the appropriate design and successful operation, and management of drip irrigation system. It directly affects the quality and quantity of crop production system inside greenhouse. Scheduling water application is very critical to make the most efficient use of drip irrigation system, as excessive irrigation can reduce yield, while inadequate irrigation causes water stress and reduces production. On the other hand, the intensity of the operation requires the water supply to be kept at the optimum level to maximize the returns to the farmer. The optimal use of irrigation can be characterized as the supply of sufficient water according to plant needs in the rooting area, and at the same time, avoiding the leaching of nutrients into deeper soil levels. High-frequency water management by drip irrigation minimizes soil as a storage reservoir for water, provides at least daily requirements of water to a portion of the root zone of each plant, and maintains a high soil matric potential in the rhizosphere to reduce plant water stress.

The combination of greenhouse farming and drip irrigation can save water compared to the open drip irrigated farming system. Green house is a structure with transparent covering that is used for growing plants under controllable condition. With reasonable structure, easy to construct and maintain, it is becoming more and more popular because it can produce huge amount of vegetables and fruits and bring of plenty benefit for the farmers. In greenhouse cultivation, it is possible to control the weather parameters suitable for optimal crop growth. At the same time it provides an environment that maximizes the working efficiency and optimal use of natural resources. The main advantage of greenhouse farming is that the production can be obtained round the year even in adverse climatic conditions. An obvious advantage of greenhouses is the protection they provide from outside elements. Seeds planted indoors are not blown away by the wind, nor are they eaten by birds. Gusty winds and driving rain do not interfere with the growing pattern of greenhouse plants and bugs can be kept out, which often deliver diseases and can ruining a crop. Greenhouses provide the perfect shelter for gardens. And gardeners who plant in greenhouses can provide perfect growing conditions for their produce. Lighting can be placed and directed, timed and reduced. The temperature and humidity can be monitored and adjusted accordingly. Different soil types can be brought in and supplements added as needed with no risk of external pollution or pesticides.

The only way to reduce the consumptive use of water in the irrigated agriculture is to reduce evaporation by mulching and micro irrigation, to reduce the irrigated area, and to grow more drought tolerant crops. In the early stages of growth when plants are small the inter-plant area is completely exposed, resulting in large scale wastage of water due to evaporation. This loss of water from the field can be reduced by covering the inter-plant area with some materials. This process of covering the soil around the base of the plant with suitable materials is known as mulching.

Dry leaf, paddy straw, paddy husk, dry grass, saw dust, coconut husk, coconut leaves, etc., are some of the materials used for mulching. Besides these, plastic films such as Low Density Poly Ethylene (LDPE) films, Ethylene Vinyl Acetate films, etc., are used as mulches to reduce evaporation.

In mulching, the soil surface where crops are growing is covered directly by these materials, with a very thin air space between the cover and soil surface. Mulching helps in reducing evaporation by the physical presence of mulches on the soil that conserve the moisture in the soil profile. Mulching does so without affecting crop growth and yield. It also reduces weed growth and increase the water and fertilizer use efficiency. Mulching generally increases yield and improves product quality by modifying the microclimate of the plants. Temperature is an important environmental factor for plant growth. Soil and air temperature play an important role in the growth and development of vegetables. The temperature of the plant environment can be modified by covering the area between plants using plastic films. In order to improve the thermal environment of the soil, film mulching is widely used both in open fields and in green houses. The use of plastic materials for mulching is a very common practice for vegetable crops. Black and silver polyethylene is the most widely used due to its excellent properties and low cost. Silver plastic mulches are metallic reflective sheets of plastic, used primarily in commercial vegetable crops to increase yields and repel insects. Properly applied plastic mulches prevent weed growth and reduce moisture evaporation. Silver plastic mulch is particularly useful for reflecting heat away from the soil in climates where high summer temperatures make commercially successful agriculture difficult. Silver plastic mulch has been demonstrated to repel aphids and certain species of winged insects, called thrips, better than other mulches.

Cucumber (*Cucumis sativus*) is a common garden vegetable native to southern Asia, but cultivated as an annual in many parts of the world. Cucumbers belonging to the Cucurbitaceae family are commonly called cucurbits. Cucurbits are a big group of vegetables that include cucumber, bitter gourd, squash, bottle gourd, ridge gourd and snake gourd. Compared with other vegetables, cucumber occupies fourth place in importance in the world, following tomato, cole crops and onion. As other crops in the Cucurbitaceae family, cucumber also have many field problems such as insect pest attacks and diseases, deteriorated varieties and reduced fruit quality. However, cucumber is the highest export-processed product and its productivity is increasing annually. The cucumber plant is a hairy-stemmed vine that bears many tendrils. Its triangular leaves may have three pointed lobes. Cucumbers grow best in warm weather.

Packaging is one of the most important processes to maintain the quality of food products for storage, transportation and end-use. It prevents quality deterioration and facilitates distribution and marketing. The basic functions of packaging are protection, containment, information, and convenience. A good package can not only preserve the food quality but also significantly contribute to a business profit. Beyond the major functions of preservation, packaging also has secondary functions such as selling and sales promotion. However the main function of food packaging is to achieve preservation and the safe delivery of food products until consumption. During distribution the quality of food product can deteriorate biologically and chemically as well as physically. Therefore food packaging contributes to extending the shelf life and maintaining the quality and the safety of the food products

Modified-atmosphere packaging (MAP) of fresh fruits and vegetables refers to the technique of sealing actively respiring produce in polymeric film packages to modify the O_2 and CO_2 levels within the package atmosphere. It is often desirable to generate an atmosphere low in O_2 and/or high in CO_2 to influence the metabolism of the product being packaged, or the activity of decay-causing organisms to increase storability and/or shelf life. For some products, modifying both O_2 and CO_2 may be desirable, and indeed, altering the O_2 level automatically alters CO_2 level. In addition to atmosphere modification, MAP vastly improves moisture retention, which can have a greater influence on preserving quality than O_2 and CO_2 levels. Furthermore, packaging isolates the product from the external environment and helps to ensure conditions that, if not sterile, at least reduce exposure to pathogens and contaminants.

OBJECTIVES OF TRIAL

1. To standardize the irrigation requirement of salad cucumber.
2. To find out a suitable packaging practice.

Review of literature

CHAPTER II

REVIEW OF LITERATURE

In this chapter research and development efforts carried out at different parts of the world have been critically viewed regarding objectives of study under the following headings.

1. Water requirement of crops
2. Effect of drip irrigation
3. Comparison of drip and basin irrigation methods
4. Combined effect of drip and mulch
5. Effect of drip and mulch in greenhouse
6. Mulching
7. Modified atmospheric packing

2.1 WATER REQUIREMENT OF CROPS

Sivanappan *et al*. (1987) reported a drip system applying 32 cm of water giving a yield of 11,600 kg/ha of brinjal in addition to 10.0 cm rainfall. For the same experiment control plot required 90 cm of water besides 10.0 cm rainfall to give an yield of 10,690 kg/ha.

Water requirement, productivity and water use efficiency of a perennial aromatic grass, palmarosa, were studied by Singh *et al*., under different levels of irrigation for three years (July-June) during 1990 to 1993, on sandy loam soils under subtropical climate of Lucknow. Growth, herb and essential oil yield increased significantly up to 0.5 IW: CPE ratio. At 0.5 IW: CPE ratio palmarosa produced 47.3 tons of fresh herb and 227.3 kg of essential oil ha^{-1} yr^{-1}. Further increase in irrigation levels caused an adverse effect on growth and yield of palmarosa. Irrigation levels did not affect the quality of oil in terms of its geraniol and geranyl acetate contents. Water requirement of palmarosa was worked out to be 89.1 cm. The highest water use efficiency of 2.97 kg oil ha^{-1} cm^{-1} was recorded at 0.1 IW: CPE ratio.

An attempt was made by Singh *et al.* during 1996-1998 at Himachal Pradesh to study the effect of drip irrigation compared to conventional irrigation on growth and yield of apricot, and to work out its irrigation requirement. Drip water requirement for irrigation of apricot varied with the period of time depending upon the environmental conditions. During the summer season, greater amount of irrigation water was required compared to cold and rainy months of the year because of the higher evapotranspiration rates. During summer months, i.e., March, April, May and June correspondingly with active plant growth period, the irrigation water of 0.19, 0.32, 0.52 and 0.37m^3/plant/month respectively is required for better growth and fruit yield. During July, August, September, October and November, the respective irrigation water requirements are 0.25, 0.07, 0.10, 0.12, 0.22 m^3/plant/month.

Yield, water requirement and economics of drip irrigation were studied by Singh *et al.* in litchi orchards at farmer's field in Babar region of Uttar Pradesh. It was observed that amount of water applied through drip system for matured litchi crop was 282 mm compared to 670 mm under surface irrigation system. The higher yield of 14.0, 16.0 and 12.5 t/ha were reported in three consecutive years under drip irrigation system over 10 t/ha for surface method of irrigation. The water-use efficiency varied from 44.33 to 56.74 kg/mm for drip irrigation compared to 14.92 for surface method of irrigation. It was also seen that, additional area cultivated due to saving of water by drip system was 1.38 ha. The next extra income due to the drip irrigation system over conventional was Rs 200697, 257817 and 157857 per hectare for 1996, 1997 and 1998 respectively.

Locascio *et al.* (1996) studied the effect of amount of water application and mulches for 3 years on irrigated tomatoes by applying water at 0.00, 0.25, 0.50, 0.75 and 1.0 times pan evaporation in one application in per day. They found that fruit yield gets doubled with drip irrigation. The total yield was found highest with irrigation quantities of 0.75, 0.50 and 1.00 times pan evaporation and significantly lower with 0.25 and 0.50 times pan evaporation values.

Wang *et al.* (1999) studied the relationship between irrigation amount, yield and quality of cucumber in solar greenhouse. The seedlings were transplanted on 10th, January, 40 days after sowing. In 140 days growing period from transplanting to last harvest, five irrigation treatments with different water amount were designed. The yield increased with irrigation amount, but the quality slightly decreased. Water use efficiency (yield/irrigation quantity) declined with increase of irrigation quantity.

Xiaobo *et al*. (2002) studied the water requirement of cucumber of different cropping in solar greenhouse. The results indicated that inner light and temperature of solar greenhouse were varied with the cropping of winter-spring and autumn-winter. Water requirement was close at plantlet stage with about 0.55 mm/d, but it increased more quickly in winter-spring than in autumn-winter since early bloom. During fruit bearing stage water requirement kept over 2.0 mm/d in winter-spring while about 40% of this level at the same stage in autumn-winter. At plantlet stage water were scattered through evaporation and at fruit bearing through transpiration in solar greenhouse.

According to the measured soil moisture under the optimal soil water and fertilizer conditions, crop water requirements (ETc) of three vegetables were calculated by soil water budget model. Crop coefficients (Kc) of cauliflower, amaranth and spinach during growth period were evaluated based on the determined ETc and reference evapotranspiration (ET_0) by Penman-Monteith procedure. The crop water requirements for cauliflower, amaranth and spinach were 223.8 mm, 144.9 mm and 148. 1 mm separately; the mean Kc for above vegetables was 0.68, 0.94 and 0.65 mm separately; the Kc value has a logarithmic function to leaf area index for experimented crops except for amaranth. (Shuhua *et al.,* 2002).

Four different levels of drip fertigation equivalent to 100, 75, 50 and 25% of crop evapotranspiration (ET_c), based on Penman–Monteith (PM) method, were tested for their effect on crop growth, crop yield, and water productivity. Tomato (*Lycopersiconesculentum*, Troy 489 variety) plants were grown in a poly-net greenhouse. Results were compared with the open cultivation system as a control. Based on this, the actual irrigation water for tomato crop in tropical greenhouse could be recommended between 4.1 and 5.6 mm day^{-1} or equivalent to 0.3–0.4 l/plant/day. Statistically, the effect of depth of water application on the crop growth, yield and irrigation water productivity was significant, while the irrigation mode did not show any effect on the crop performance. Drip irrigation at 75% of ET_c provided the maximum crop yields and irrigation water productivity (Harmanto *et al*., 2004).

The effects of different water supply tension that is different soil moisture on the growth and development of greenhouse cucumber (*Cucumis sativus* L.) were studied. The result also indicates that the water demand increase with the growing process. The growth will be restricted and yield will be reduced with the shortage of water supply, increase the yield at terminal fruiting stage can be obtained by increasing soil water content at fruiting stage of cucumber. The above results indicate that the range of WST from 3-5 kPa are more suitable for greenhouse cucumber growth when the relative soil water content ranges from 67% to 81%. Reduce water supply at seedling stage, control water supply at flowering stage and increase water supply at fruiting stage of cucumber can increase yield and WUE. (Shao *et al*., 2010)

2.2 EFFECT OF DRIP IRRIGATION

Experiments were carried out by Hasan *et al.* for irrigation scheduling of cut flower rose (c.v First Red) grown inside climate controlled greenhouse with three treatments 100%, 80% and 60% ETc and three replications. The experiment was conducted at the project farm of Centre for Protected Cultivation Technology (CPCT) at the Indian Agricultural Research Institute (IARI). The study involved design and installation of drip irrigation system inside climate control greenhouse, field observation and sampling, analysis of soil, water and plant and determination of irrigation scheduling of rose crop grown under climate controlled greenhouse. Irrigation scheduling directly affected the cut flower yield of rose grown in climate controlled greenhouse. The maximum yield per plant was found to be 48 cut flowers per plant in the year 2004 with total amount of irrigation as 112 liter per plant and irrigation scheduling done with 100% ET. Irrigation was found to have direct effect on the cut flower yield of rose grown in climate controlled greenhouse.

2.3 COMPARISON OF DRIP AND BASIN IRRIGATION METHODS

GilshaBhai (1997) conducted a study at K.C.A.E.T, Tavanur to find out the effect of drip Irrigation along with two colours of plastic mulching on the growth and yield of Brinjal. Two types of irrigation methods: drip and surface, and two colors of plastic mulches, black and transparent, were used in the experiment. The yield obtained was maximum in the black mulched drip irrigated plants (13.9 t/ha) the yield from unmulched surface irrigated plot was 7.90 t/ha. Drip irrigation along with mulching in summer Vegetable can reduce the cost of cultivation through efficient water management.

C. Sunil Kumar and U. Jai Kumaran (1997) conducted a study at Agricultural Research Station, Mannuthy, Thrissur, to find the yield and yield attributes of bhindi as influenced by mulching and methods of irrigation. The ten treatments comprised of combinations of three irrigation systems (drip irrigation with and without mulch and furrow irrigation with mulch) and three irrigation levels (irrigation at soil moisture tensions of 0.04, 0.06, 0.08 MPa) plus furrow irrigation at 0.06 MPa without mulch as one control. The depth of irrigation was 30 mm. Black LDPE sheets of 200 gauge were used as mulch material. The crop received 254.6mm rainfall during its growth in the field. There was no significant effect due to varying levels of irrigation once the crop was mulched. On an average, mulched and drip irrigated crop produced 22.70 tonnes fruits ha, where as mulched and furrow irrigated crop, produced fruits 20.95 t/ha, and the control crop produced12.86t/ha.

2.4 COMBINED EFFECT OF DRIP AND MULCH

Field experiments were conducted by Tiwari *et al*. on the lateritic sandy loam soils of Kharagpur, West Bengal, India during spring–summer (February–May) seasons for 3 years (1995–1997) to evaluate the economic feasibility of drip irrigation in combination with different types of mulches for an okra crop. The study indicated that 100% irrigation requirement met through drip irrigation along with black plastic mulch gave the highest yield (14.51 t ha^{-1}) with 72% increase in yield as compared to furrow irrigation. The net seasonal income, benefit–cost ratio and the yield per unit depth of water used were found to be highest for drip irrigation with black plastic mulch, drip irrigation alone and drip irrigation with black plastic mulch, respectively.

Experiments were conducted by Tiwari *et al*. on the lateritic sandy loam soils of Kharagpur, during middle of September–January for 3 years (1997–2000) to evaluate the economic feasibility of growing cabbage crop under drip irrigation with mulches. The average seasonal water requirement of crop was estimated to be 400 mm. The net profit per mm of water used was obtained to be highest in case of drip irrigation. The highest yield per unit quantity of water used was 427.04 kg ha^{-1} mm^{-1}. The study reveals that drip irrigation has a definite role in increasing the productivity of cabbage.

Experiments were conducted by Shrivastava *et al*. on the fine-textured heavy soils of Western India from 1989 to 1991. These sought to study the effect of drip, mulches and irrigation levels on tomato yield. In areas of high weed intensity, drip along with plastic mulch could be adopted. This treatment resulted in 95% reduction in weed infestation, 53% higher yield and 44% saving in irrigation water when compared with the surface flood without mulch treatment.

Experiments were conducted in the farmer's field on the loamy soil in coastal Orissa for two consecutive years, by Mishra *et al.* (2005-07) to evaluate the economic feasibility of drip irrigation with black LDPE mulch in a cashew plant planted during July 2000. The drip irrigation in combined with mulch significantly increased the yield of cashew as compared to drip irrigation and ring basin irrigation without mulch. The drip irrigation is observed to be economical and cost effective when compared with conventional basin irrigation. The use of drip either alone or in combination with mulching, can increase the cashew yield up to an extent of 108% over basin irrigation along with a saving of 20% of irrigation water. It was also observed that, 987mm of water would be required to irrigate one hectare of cashew crop with drip system in sub-humid agro-climatic conditions of Bhubaneswar.

2.5 EFFECT OF DRIP AND MULCH IN GREENHOUSE

An experiment was undertaken by Dayana *et al.* (2007) to study the effect of mulching and nutrient sources on the production of salad cucumber inside and outside naturally ventilated green house. Maximum yield inside the greenhouse was observed in the treatment with silver mulch and drip irrigation along with nutrient supply provided by neem cake, vermicompost and VAM. Significant reduction in weeds was observed in plots with mulches. Plants in the mulched plots showed earliness in flowering and fruiting compared unmulched plots. Inside the greenhouse the crop showed an early growth, flowering; fruiting compared to crop outside the greenhouse. The drip method of irrigation helped in the judicious application of water and it also helped to save water. Therefore the combination of drip irrigation along with mulching inside the greenhouse can give better yield and thereby reduced the cost of cultivation.

2.6 MULCHING

A field experiment was conducted by Kuruvilla *et al.* in a sandy loam soil of the Agronomic Research Station, Chalakudy, Kerala for four years from 1981 to 1985 to study the Response of irrigation and mulching on the growth and yield of pineapple. Both irrigation and mulching influenced the fruit yield significantly. Mulching with dry leaves during the first year exerted a positive and significant influence on fruit yield in the plant crop. Though favourable, the effect was not significant in the second ratoon. However, the increase in total fruit yield of the three seasons due to mulching over no mulching (20.86%) proved to be significant. The increase in yield might be due to the advantages like better conservation of soil moisture and suppression of weeds associated with mulching.

A study was undertaken by Jose *et al.* in the sandy loam soil of the Agronomic Research Station, Chalakudy during 1983-'84 and 1984-'85 to know the response of December-January planted amorphophallus to irrigation and mulching. Four treatments (no mulching and mulching with dried leaves, paddy waste and coir dust) were practiced. The study revealed the importance of mulching with organic waste materials like dried leaves, paddy waste and coir dust in boosting corm yield in irrigated amorphophallus. The corm yield increased significantly when mulched with all the three organic materials as compared to the unmulched crop. The yield increase was attributed to the better soil moisture conservation, soil temperature regulation and other related benefits like weed control achieved through mulching. The yield increases over the unmulched crop were 14.074, 10.923 and 8.175 t/ha respectively. The corresponding percentage increases were 62, 48, and 27.

The investigations were carried out at the Crop Production Farm, Department of Crop Production, Faculty of Agriculture, Luyengo Campus of the University of Swaziland Supplementary watering and mulching tomatoes using black polythene and grass increased plant height significantly. The number of fruits per plant was significantly increased by both mulching and supplementary irrigation. Highest yield per plant and total yield was obtained in tomatoes mulched with grass. Similarly, the harvesting duration was longest when tomatoes were mulched with grass. Supplementary irrigation and grass mulching in tomato production, therefore, can be used to increase yield, farm income and the lifespan of tomato plants. (Wahome *et al*., 2005)

The modern technique of drip irrigation was developed in Israel in 1959. This system of irrigation ensures uniform application of water throughout the field which results in uniform plant growth and yield.

2.7 MODIFIED ATMOSPHERIC PACKAGING

According to Lee *et al*. (1996) modified atmosphere (MA) technology improves the shelf life of a large number of fresh produce during distribution and storage. MA conditions can be realized through packaging by balancing produce respiration and gas exchange through package materials. Such systems, called modified atmosphere packaging (MAP), can be configured as bulk packaging containers, unit retail packages and individual produce coatings. MAP has an attractive potential as an alternative to low temperature storage for preserving fresh fruits and vegetables that possess a high respiration rate and are sensitive to chilling injury. However, there are still practical and theoretical difficulties limiting the commercial use of modified atmosphere packaging for fresh produce.

Atmosphere modification in MAP requires actively respiring plant tissue and a barrier through which gas exchange is restricted. The reduced O_2 and increases CO_2 that results from tissue respiration creates gradients across the film barrier that provides the driving force for gas movement into and out of the package. The levels of O_2 and CO_2 within a package depend on the interaction between commodity respiration and the permeability properties of the packaging film and/or micro perforations (Beaudry *et al*., 1992; Kader *et al*., 1997).

Hong *et al*. (2004), Storage quality of minimally processed (MP) bunched onions, as affected by plastic film packaging, was investigated to determine the optimum packing method for this vegetable product. Five different packaging treatments, including two passive modified atmosphere packaging (MAP), two active MAP and a moderate vacuum packaging (MVP), were used for MP bunched onions. Quality attributes of the samples were evaluated periodically in terms of weight loss, colour, decay ratio, microbial counts and sensory properties during storage at 10 °C for 28 days. Various sealed-packaging treatments did not significantly influence changes in colour of white stem and green leaf tissues, flesh weight loss and microbiological populations including mesophiles, psychrotrophs and lactic acid bacteria. However, sensory attributes and disease incidence were affected by packaging type. MVP with a gas-permeable plastic film retained better quality bunched onions, with reduced microbial decay and visual sensory aspects, as compared with the other packages.

MAP is a dynamic system where the respiration of the packaged product and the gas permeation through the packaging films take place simultaneously. At equilibrium, the respiration rate of commodity equals the permeation rate of packaging films and it retains the desired atmosphere. The attainment of equilibrium state depends on proper design of MAP (S.Mangaraj and T.K.Goswami., 2009).

The optimum temperature for the storage of guava fruits was 6 ^{0}C and 90 to 95% relative humidity for maintaining highly acceptable sensory quality. At this temperature the fruits had attractive colour pleasant flavour and acceptable quality and can be stored up to 2-3 weeks with a post-storage shelf life of 3 days at 20 to 21 ^{0}C and 65 to 70% relative humidity (Mahajan *et al*., 2009).

The principle of MAP involves the removal of air from the pack and its replacement with a single gas or mixture of gases by either passive or active methods, depending upon the type of product.

Chung *et al.* suggested that MAP with a polypropylene or microperforated antifogging oriented polypropylene (MiA-OPP), films at 4°C provides an effective means to prolong the shelf-life and to keep the weight and sensory quality of Aster glehni and Aruncusdioicus var. kamtschaticus produced from Ulleungdo, Korea.

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The materials used and methodology adopted for conducting experiment is presented in this chapter. A field experiment was conducted to standardize the irrigation requirement of salad cucumber by different combinations of drip and controlled irrigation methods. The experiment was conducted from November 2009 to August 2010.

3.1 LOCATION AND CLIMATE

The experiment was conducted inside the naturally ventilated green house of 100 m^2 area located near to the Precision Farming Development Center (PFDC), Kelappaji College of Agricultural Engineering and Technology, Tavanur. The place is situated at 10° 52' 30" North latitude and 76° East longitude. It is situated in the east-west direction.

Agro-climatically, the area falls within the border line of northern zone and central zone of Kerala. Most part of the rainfall received in this region is from south- west monsoon. The average annual rainfall varies from 2500 mm to 2900 mm. The detailed rainfall data during the period of trial is given in the Appendix 1. The climatological data of the experimental area is shown below.

- Mean maximum monthly temperature: 32.5°C
- Mean minimum monthly temperature: 22°C
- Average monthly relative humidity: 83%
- Average annual rainfall: 2500 mm

3.2 EXPERIMENTAL DETAILS

The experiment was conducted during 2009(November)-2010(August) and the crop duration was three months. The first trial was from November (2009) to February (2010) and the second trial was from May (2010) to August (2010).The objective was to standardize the irrigation requirement of salad cucumber. The soil where the experiment conducted was well drained laterite type. In this experiment, the land was leveled and beds were raised. The experiment was laid out in randomized block design. The plot was divided into thirty rectangular sections having five treatments with six replications. Two irrigation methods, mainly drip irrigation in 24 plots and basin irrigation in 6 plots were practiced inside green house. Three salad cucumber (C*ucumis sativus*) seeds of the variety Long Green were sown in each bed. Fertilizers as per Package of Practices (POP) recommendations were applied with different combinations of irrigation methods. Plant protection measures were also applied. The yield obtained from each plot was noted.

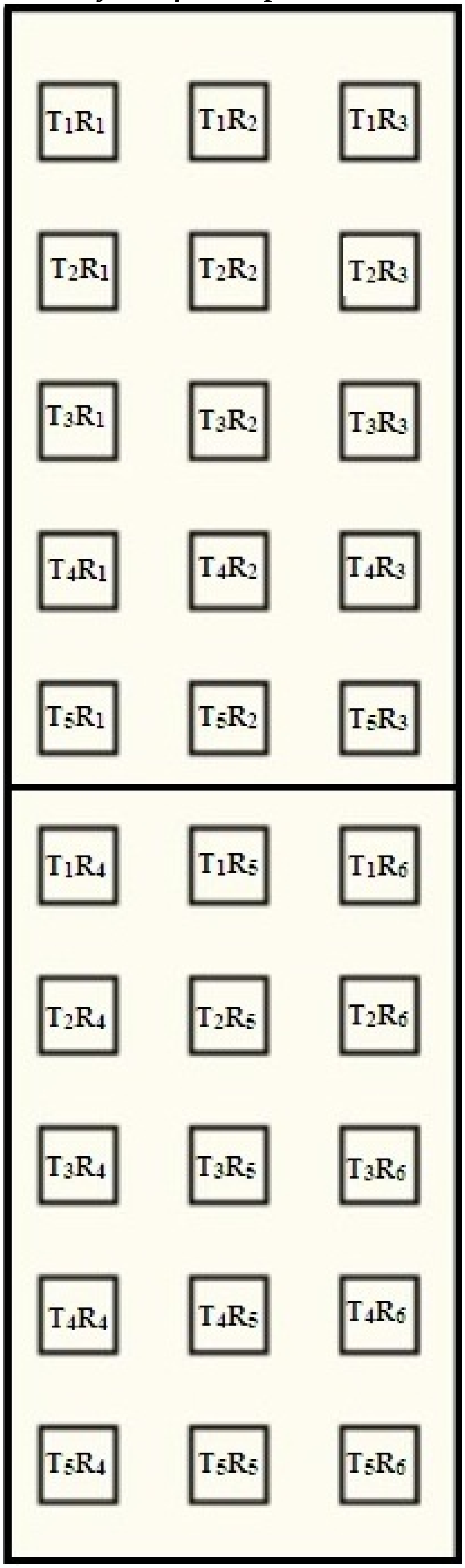
3.2.1 Land Preparation

The land preparation was done. Cucumber is a heavy consumer of fertilizer so soil improvement using manures was done during land preparation for the early nourishment of

Plate 1: Plot after planting

the plant. Farm Yard Manure was mixed to the soil at a rate of 20 t/ha. Thirty beds of 70 cm length and 70 cm width were prepared. The bed was raised to a height of 10 cm.

3.2.2 Layout of the experiment



T1: Drip irrigation with 1 l/plant/day

T2: Drip irrigation with 1.5 l/plant/day

T3: Drip irrigation with 2.0 l/plant/day

T4: Drip irrigation with 2.5 l/plant/day

T5: Control plot with 2.5 l/plant/day

Fig. 1 Layout of the experiment

The treatments in the experiments were

T1: Drip irrigation with 1 l/plant/day

T2: Drip irrigation with 1.5 l/plant/day

T3: Drip irrigation with 2.0 l/plant/day

T4: Drip irrigation with 2.5 l/plant/day

T5: Control plot with surface irrigation of 2.5 l/plant/day

3.2.3 Method of irrigation

The field was prepared and the drip system was installed in the field. Laterals of 12 mm were used in the experimental plot. Each plant was irrigated with an emitter having capacity 8 lph. The irrigation for all other plots were done using basin method.

3.2.4 Mulch spreading and planting

Silver colored mulch sheets of 30 micron thickness were used for all treatments. Position of each treatment plot and position of plants in each plot were marked as per the layout.

For sowing the seeds, small holes were made in the polyethylene sheets as per the spacing required after spreading the mulch sheets in respective plots. Seeds were sown at the corresponding hole position in the polyethylene sheet. The ends of the sheets were covered with soil to prevent the blowing off by wind. Three days after seeding, the seeds are expected to emerge.

3.2.5 Fertilizer application

Recommendations in the POP were followed to find out the quantities of fertilizers required for the chemical fertilizer. Nitrogen was applied as urea, phosphorus as rajphos and potassium as muriate of potash. Fertilizers were applied as basal dose.

Plate 2: Crop at the flowering stage

3.2.6 Pests

Several insect pests of cucumber are present throughout the year but thrips, aphids, are prevalent**.**

Plate 3: Harvested salad cucumber

Aphids (*Aphis gossypii)* **–** Aphid**s** is an insect pest that attack cucumber and can produce their offspring in the absence of male, so they rapidly multiply in a short period. The young and adult aphids suck the sap of the plant initially on the leaves. Under severe condition, they suck the sap of the vines. Some species are vectors of plant diseases.

Thrips *(Thripstabaci lindeman)* – Thrips is a sucking pest of cucumber. It sucks the sap of the leaf resulting in a papery appearance of the surface and undersurface of the leaf.

3.2.7 Plant protection

To prevent the plant from pest attack, pesticide Ekalux was sprayed @1000ml/ha in all plots once in three weeks. For the effective control of fruit fly; banana fruit traps were used which was coupled with the removal of and destruction of infested fruits. It is seen to be more

Plate 4: Pheromone trap

efficient than the spray with insecticides. The trap was prepared by pouring carbofuran granules at the cut end of ripened banana fruits, which were placed inside the coconut shell. Traps were set at a distance of 2 m after a border row and replaced after 7 to 9 days. Pheromone traps were also used to prevent the attack of fruit fly.

3.2.8 Harvesting

Harvesting was started 55 days after sowing at an interval of two days. A pair of scissors was used to cut the cucumbers from the vine. This avoids damaging the plant and makes for ease of harvesting.

3.2.9 Post harvest handling of salad cucumber

Suitable packaging for salad cucumber was tried with different treatments. The treatments involved are:

Plate 5. Salad cucumber packed in polythene pack kept in deep freezer and at room temperature

1. T1: Packed with polythene kept inside deep freezer
2. T2: Without polythene kept inside deep freezer
3. T3: Packed with polythene at room temperature
4. T4: Without polythene at room temperature

3.2.10 Packaging of fruits

After harvesting, 24 salad cucumbers were selected and 4 treatments were done on it, as mentioned above. The treatments T1 and T3 have polythene packing and it consisted of packing the cucumber in perforated polythene cover, having 240 holes (10% perforation) in it. For treatment T1, three packets each having two cucumbers were placed inside the deep freezer at 13˚C. For treatment T2, six cucumbers were placed inside the deep freezer without polythene cover. Treatment T3 included three packets of two cucumbers each which were placed at room temperature. The other six cucumbers were placed at room temperature without polythene packing, for treatment T4.

Plate 6: Salad cucumbers kept at room temperature and inside deep freezer

3.2.11 Texture analysis

The importance of texture on the overall acceptability of the foods is well known and directly affects the liking of the consumer. Texture includes those qualities that can feel with fingers, tongue, the palate or the teeth. Texture of the product was analyzed by texture analyzer shown in plate 7. It is an instrument that measures the response of a sample to a compressive or tensile force. This can be done by measuring force or by applying a force and measuring movement, both as function of time. The texture analyzer is a microprocessor controlled texture analysis system. The probe carrier contains a very sensitive load cell. Compression platens were used for conducting the test. Size of the probe used was 5 mm at test speed of 2 mm/s.

Plate 7: Texture Analyzer

3.2.12 Parameters recorded

Observations on the number of fruits and yield were taken. Weight, diameter, length and number of fruits harvested from each plot were recorded. Soil temperature, atmospheric temperature and moisture content were recorded.

3.2.13 Soil temperature and atmospheric temperature

Soil temperature and atmospheric temperature was recorded at 8.30 am and at 2.30 pm, using a thermometer. The soil temperature at 5 cm depth was measured by inserting the sensing probe into the soil up to this depth.

3.2.14 Determination of moisture content

In order to analyze the variation in soil moisture content, the gravimetric method of moisture content determination was made.

In the gravimetric method basic measurements of soil moisture are on samples of known weight. Soil samples were collected with sampling tube. The samples were taken at the desired depth 10 cm they were collected in airtight aluminum containers. Soil samples were weighed and they were dried in an oven at about 105°c for about 24 hours, until all the moisture was dried off. After removing from oven, they were cooled slowly to room temperature and weighed again. The difference in weight is the amount of moisture in the soil.

The percentage of moisture content was found out by the following formula.

Moisture content (%) = $((w_2 - w_3) / (w_3 - w_1)) \times 100$

w_1 = weight of empty container with lid

w_2 = weight of container with lid and moist soil

w_3 = weight of container with lid and dry soil

Using the above procedure the moisture content in percent was determined.

3.2.15 Determination of water use efficiency

Water use efficiency was calculated for each treatment. It is the ratio of yield of crop in kg/ha and total water applied in mm.

Ew = Y/Wu

Where,

Ew = Water use efficiency (kg/ha mm)

Y = Yield of the crop in kg/ha

Wu = Total water applied in mm

3.2.16 Statistical analysis of experimental data

The results obtained during the experiment were statistically analyzed by analysis of variance and multiple comparisons. Post-hoc tests (post-hoc comparison tests) were used at the second stage of the analysis of variance (ANOVA).

Multiple comparisons are used in the same context as analysis of variance (ANOVA) - to check whether there are differences in population means among more than two populations. In contrast to ANOVA, which simply tests the null hypothesis that all means are equal, multiple comparisons procedures helps to determine where the differences among the means occur.

Result and Discussion

CHAPTER IV

RESULT AND DISCUSSION

Results obtained from the experiment "Standardization of irrigation requirement of salad cucumber in polyhouse" are presented and discussed in this chapter after analyzing the observations taken during the course of work. The first season experiment was laid out during November (2009) to February (2010) and was vitiated due to soil problem hence was repeated in the next season from May (2010) to August (2010).

From the first season's observations, drip irrigation with 1.5 l/plant/day recorded highest yield. The plants with drip irrigation of 0.5 l/plant/day could not survive during yielding stage, so it was omitted in the second season's experiment. The treatment wise yield data of the first trial is given below in table 1.

Table 1. Yield data from first trial

Irrigation treatments (l/plant/day)	Average yield (g)	Average no. of fruits
0.5	1075.00	4.50
1.0	1563.33	4.66
1.5	1703.50	5.00
2.0	1362.57	5.00
2.0	1382.85	4.71

RESULT AND DISCUSSION OF SECOND TRIAL

The second trial of the experiment was laid out during May to August (2010). The results obtained from the second trial of the experiment are as follows:

4.1 EFFECT OF TREATMENTS ON YIELD

Crop yield is always an important effective and economic index consideration in the crop development. The aim of planting any crop is to get the highest yield and highest quality. The average yield obtained from various treatments is shown in Table 2. According to analysis of variance (Table 3) yield difference amongst different treatments was not significant; however there is possibility of water saving of 20-60% by adopting any of the drip irrigations over surface irrigation.

Table 2. Average yield and water use efficiency of various treatments						
Irrigation treatments (l/plant/day)	Average Yield (kg/plant)	Average yield (kg/ha)	Increase in yield (%)	Water used (mm)	Water saving (%)	Water use efficiency (kg/ha mm)
1.0	1.58	15830		104	60.0	152.21
1.5	1.89	18860	19.14	156	40.0	120.89
2.0	1.98	19830	25.26	208	20.0	95.34
2.5	2.44	24350	53.82	260		93.65
2.5(control)	2.10	20980	32..53	260		80.69
CD (5%)	NS					

Table 3. RBD analysis of yield of various treatments						
Source	DF	SS	MS	F-ratio	Table value	Remarks
Block	5	909480	181896	0.27	2.71	NS
Treatment	4	3639360	909840	1.37	2.87	NS
Error	20	13249020	662450			
Total	29	17797860				

When a multiple comparison was made using Post Hoc test, yield from treatment with 1.0 l/plant/day (T1) was comparatively low. There is no significant difference between other treatments (Appendix 2).The yield from treatment T2 (Drip irrigation with 1.50 l/plant/day) is on par with yield from other treatments. These studies indicate that T2 enables to save water up to 40% and increases yields by 19.14%. So if water availability is a major problem then drip irrigation with 1.5 l/plant/day is highly suitable for salad cucumber grown in polyhouse. If water is not a criterion then T4 gives maximum yield, since this treatment gives a yield increase of 53.82% over T1.The experiment also reveals that water saving is achieved in crops irrigated through drip irrigation over the conventional surface method of irrigation.

The water use efficiency of different treatments was calculated and is given in Table 2. The highest water use efficiency was noted for the treatment 1 (Drip irrigation with 1 l/plant/day) with a value of 152.21 kg/ha mm. Water use efficiency is the highest not because the yield was maximum but because of lower value of water used. And the lowest water use efficiency of 80.692 kg/ha mm was recorded for the plot with surface irrigation (Control plot with 2.5 l/plant/day). So it is clear that the drip irrigation has higher water use efficiency than conventional surface method of irrigation. According to Simonne *et al.* (2009) Crop water requirements depend on crop type, stage of growth, and evaporative demand. According to him the crop water requirement of salad cucumber vary during different growth stages. So it is necessary to study the crop water requirement of salad cucumber in different growth stages.

4.2 EFFECT OF TREATMENTS ON FRUIT CHARACTERISTICS

The various fruit characteristics i.e. the number of fruits, average length and diameter of the fruits, obtained in the treatment are given in the Table 4.

Table 4. Effect of quantity of irrigation water treatments on fruit characteristics

Treatments (l/plant/day)	Average no. of fruits	Average length of fruits (cm)	Average diameter of fruits (cm)
1	5.58	20.24	14.96
1.5	7.44	20.41	15.04
2.0	7.03	21.32	14.71
2.5	7.67	21.97	14.21
2.5(control)	9.06	21.98	14.41
CD (5%)	NS	1.37	NS

4.2.1 Number of fruits

The number of Fruits per plant is an important determinant of yield in salad cucumber. Variation in number of fruit with different treatments of irrigation is shown in the Table 4. From the observations, treatment T1 (drip irrigation with 1 l/plant/day) shows least no of fruits. From the analysis of variance there is no significant difference among the five treatments tested (Table 5).

Table 5. RBD analysis of number of Fruits of second trial

Source	DF	SS	MS	f-ratio	Table value	Remarks
Block	5	33.94	6.79	0.97	2.71	NS
Treatment	4	37.62	9.40	1.34	2.87	NS
Error	20	139.94	7.00			
Total	29	211.50				

The detailed comparison among the treatments by multiple comparisons shows that treatment with 1.0 l/plant/day (T1) gives the least number of fruits. Fewer number of fruits is one of the predominant reasons for least yield in T1 (Drip irrigation with 1l/plant/day). The other treatments T2, T3, T4 and T5 are at par, so they do not have any effect on number of fruits. So it is evident that treatment T2 gives more number of fruits with least quantity of irrigation water. Thus it is clear that during rainy season 1.5 l/plant/day is enough for producing maximum number of fruits in salad cucumber grown in polyhouse.

4.2.2 Fruit length

Average fruit lengths obtained from various treatments are shown in table 2. The results obtained after statistical analysis on fruit length in various treatments are given in the Table 6.

Table 6. RBD analysis of fruit length of various treatments of second trial

Source	DF	SS	MS	f-ratio	Table value	Remarks
Block	5	17.17	3.43	2.66	2.71	NS
Treatment	4	16.58	4.14	3.21	2.87	*
Error	20	25.81	1.29			
Total	29	59.56				
CD = 1.37						

Analysis of variance shows significant difference in fruit length among treatments. The least length is observed for the fruits from the treatment with 1 l/plant/day (T1). T1 shows significant difference with T4 and T5. The analysis also shows that the T3, T4 and T5 are at par. From this it is clear that T3 (2.0 l/plant/day) gives fruits with maximum length by using minimum quantity of water. So irrigation level has significant role in fruit length.

4.2.3 Fruit diameter

The diameter of fruits obtained in various treatments is shown in the Table 2. The statistical analysis of the data by analysis of variance is shown in the Table 7. The analysis shows that there is no significant difference in fruit diameter among the treatments. All the fruits have almost same diameter. So irrigation treatments have no effect on fruit diameter

Table 7. RBD analysis of Fruit diameter of various treatments of second trial

Source	DF	SS	MS	F-ratio	Table value	Remarks
Block	4	2.660	0.665	0.058	0.993	NS
Treatment	25	288.658	11.546			
Total	29	291.318				

4.3 TEMPERATURE

4.3.1 Soil temperature inside polyhouse

Soil temperature plays an important role at the critical growth stages of salad cucumber. Soil temperature measurements were taken at 8.30 am and 2.30 pm at 5 cm depth inside polyhouse. As far as salad cucumber is considered the main critical growth stages are germination stage, flower initiation stage and fruiting stage. The value of soil temperature at germination stage is very important for the germination of seeds. Temperature measured inside the polyhouse during morning (8.30 am.) and peak hot hour of the day (2.30 pm.) are shown in fig.2.

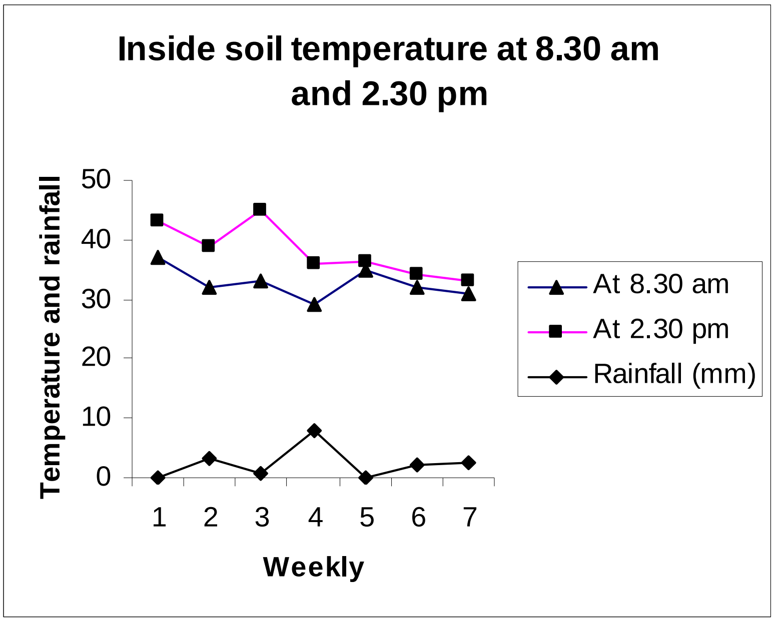


Fig.2: Variations in soil temperature at 8.30 am and 2.30 pm inside polyhouse

Inside polyhouse soil temperature at peak hot hour (2.30 pm.) of the day shows a slight increase than at morning (8.30 am.). So black silver mulching inside the polyhouse has significant effect on soil temperature. The rise in soil temperature inside polyhouse, during rainy season ranges from 1˚C to 6˚C. Hallidri (2005) reported an increase in soil temperature with black mulch. Black mulch does not transmit all the light and solar energy into the soil. It also prevents the loss of heat energy from the soil. Silver mulch also prevents the loss of heat energy from the soil. Thus the soil temperature inside the polyhouse increases significantly. This slight increase in soil temperature in the root zone was advantageous to the crop. The figure shows the minimum value of soil temperature at maximum rainfall and vice versa. So it is clear that rainfall has a great influence on soil temperature and the microclimate of the crops inside the polyhouse. Since soil temperature plays an important role at the critical growth stages of salad cucumber, the rainfall has a great significance.

4.3.2 Atmospheric temperature at 8.30 am.

Atmospheric temperature inside and outside the polyhouse during morning are shown in fig 3. The atmospheric temperature inside the polyhouse shows a slight increase during 8.30 am than outside. The rise in atmospheric temperature inside polyhouse ranges from 0.5˚C to 3.0˚C. So the polyhouse is effective in increasing the inside temperature. The temperature shows lower value at high rainfall, and a high temperature is observed at minimum rainfall. So the rainfall is a major factor affecting the microclimate of the crop.

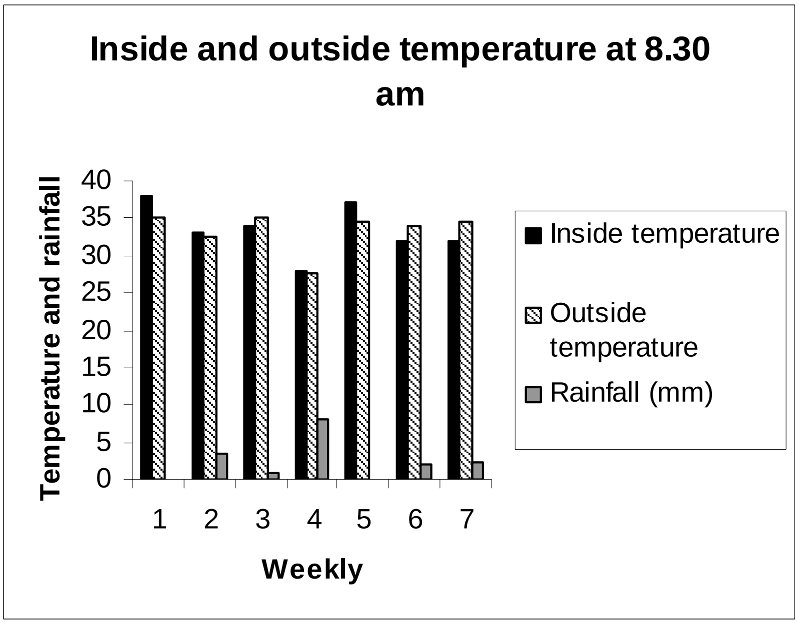


Fig.3: Variations in atmospheric temperature inside and outside the polyhouse at 8.30 am.

Rainfall during the crop duration has a major role in the soil temperature, atmospheric temperature and hence in the crop water requirement since the rate of evaporation depends on the temperature. At high rainfall the inside and outside temperature shows almost same value. The temperature inside the polyhouse has shown higher value than outside temperature on days without rainfall. During rainy days the outside temperature shows a slight higher value than inside temperature at 8.30 am.

4.3.3 Atmospheric temperature at 2.30 pm.

Atmospheric temperature inside and outside the polyhouse during the peak hot hour (2.30 pm.) of the day are shown in fig.4. In rainy season temperature inside the polyhouse shows a significant effect during the peak hot hour of the day. It shows a maximum rise in temperature up to 4.0˚C and minimum of 1.0˚C. Polyhouse has a great role in determining the micro climate of the crop. The temperature shows least value at maximum rainfall and the maximum temperature is observed at minimum rainfall. At 2.30 pm the inside temperature is always higher than outside temperature irrespective of rainfall. So inside temperature of polyhouse is always greater than the outside temperature during peak hot hour of the day.

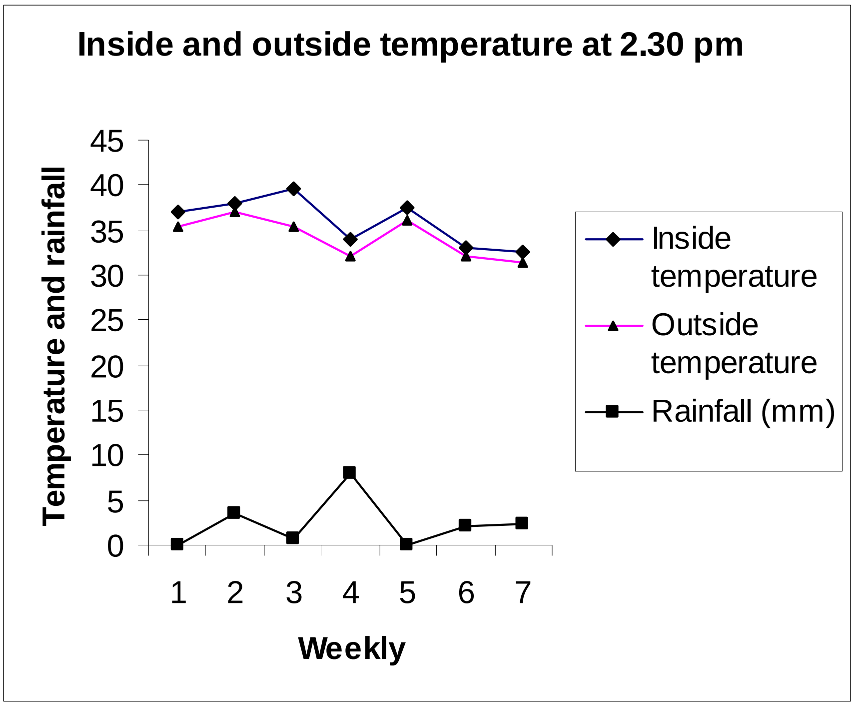


Fig 4: Inside and outside temperature of polyhouse at 2.30

4.4 MOISTURE CONTENT OF SOIL

The moisture content (%) of all the treatments before and after irrigation is shown in fig. 5. A marked decrease in the soil moisture content is observed in all the treatment, 24 hour after irrigation. The moisture content in all the treatments taken 30 minutes after irrigation shows larger values with large decline after a day. Among the treatments there is no significant difference in soil moisture content, 30 minutes after irrigation. So all the treatments have almost same moisture content while analyzing 30 minutes after irrigation.

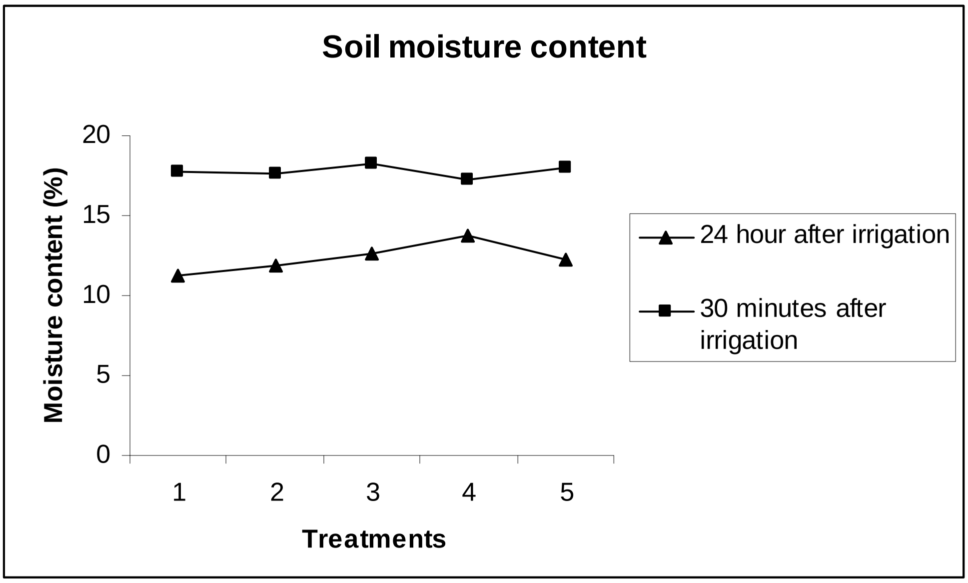


Fig. 5: variation in soil moisture content

While the analysis of moisture content a day after irrigation shows variation in all the treatments. The plots with drip irrigation shows larger soil moisture content a day after irrigation, while the conventional surface irrigation has least soil moisture content. So it is clear that drip irrigation conserves more soil moisture than the conventional surface irrigation with increase in soil moisture with quantity of irrigation water.

4.5 EFFECT OF PACKING

Four treatments were conducted to find the suitable packaging of salad cucumber. Salad cucumbers kept at room temperature without polythene cover (T4) began to perish after three days. After ten days those in control treatment were completely perished. Those kept in polythene cover at room temperature (T3) began to perish after six days, and completely perished after 11days. In deep freezer four cucumbers in polythene cover (T1) were retained after 14 days. While only two were retained without polythene cover in deep freezer (T2). So perforated polythene packaging along with deep freezing at 13˚C will extend the shelf life of salad cucumber to 15 days.

Table 8: Shelf life of salad cucumber under various treatments	
Treatments	**Shelf life in days**
Fruits kept in deep freezer packed with polythene	15
Fruits kept inside deep freezer without packing	12
Fruits packed with polythene kept at room temperature	6
Fruits without packing at room temperature	3

4.5.1 Texture analysis

The textures of the salad cucumbers were measured with the help of TA.XT plus texture analyzer (Stable micro systems Ltd.). The texture analyzer is a microprocessor controlled

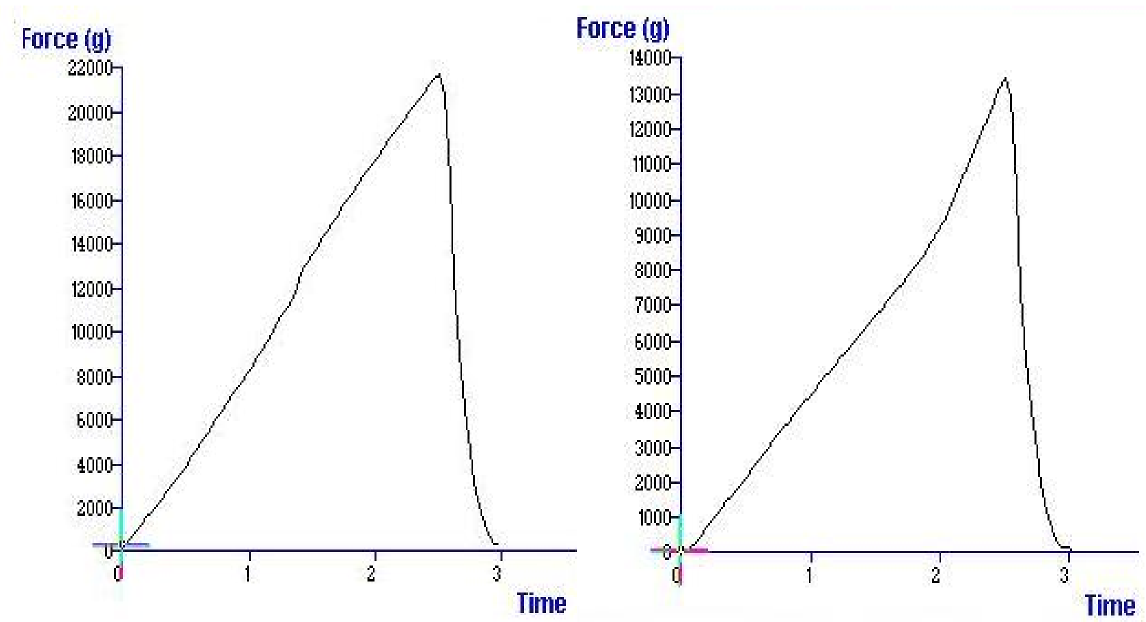


Fig. 6. Result of texture analysis of packed salad cucumber and fresh salad cucumber

texture analysis system. It measures force, distance and time, thus providing three dimensional product analyses. Analysis on texture pointed that the fresh sample of salad cucumber showed resistance to a maximum force of 8.9 g at a distance of 60.432 mm, but the salad cucumber packed in perforated polythene cover and kept at 13˚C could withstand a maximum force of 222.9 g at a distance of 55.85mm.This shows that the salad cucumber kept inside the deep freezer packed with polythene cover has a pronounced effect to resist larger force.

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

A study was conducted to standardize the irrigation requirement of salad cucumber grown in polyhouse. The experiment was done near to the PFDC building.

The experiment was laid out in randomized block design and the entire area was divided into 30 plots having 5 treatments with 6 replications for each treatment inside the polyhouse. Here different levels of irrigation were practiced by drip irrigation for 24 plots. Basin irrigation was done for 6 plots.

From the observation it was found that drip irrigation has a positive effect on growth and yield of crop. Crops drip irrigated with 1.5 l/plant/day performed well with a water use efficiency of 121.

Drip irrigation in comparison with the surface irrigation has given higher yield throughout the crop period. And also drip irrigation has shown larger soil moisture content a day after irrigation, while the conventional surface irrigation has least soil moisture content.

The experiment reveals that the soil temperature inside the polyhouse has a direct relation with rainfall, since the temperatures show maximum value at minimum rainfall, and vice versa. Since soil temperature plays an important role at the critical growth stages of salad cucumber, the rainfall has a great significance.

Packaging is one of the most important processes to maintain the quality of food products for storage, transportation and end-use. It prevents quality deterioration and facilitates distribution and marketing. A study was conducted to find the suitable packaging for salad cucumber. This study was done with four treatments. Perforated polythene packaging of salad cucumber along with deep freezing at 13˚C was found to be effective for extending the shelf life up to 15 days.

From our study the major observations obtained can be concluded as below

- The crop inside the polyhouse with drip irrigation of 1.5l/plant/day performed well during the experiment with a water use efficiency of 121.
- Crop performance with drip irrigation, in comparison to conventional surface irrigation has consistently shown higher yield.

- Drip irrigation shows larger soil moisture content a day after irrigation, while the conventional surface irrigation has least soil moisture content.
- The soil temperature inside the polyhouse increased with the minimum rainfall and vice versa and it was a important finding since soil temperature plays an important role at the critical growth stages of salad cucumber.
- Packaging is one of the most important processes to prevent quality deterioration of salad cucumber.
- The deep freezing of salad cucumber at 13˚C along with 10% perforated polythene packing was found to be effective for extending the shelf life up to 15 days.

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Appendices

APPENDIX 1

Rainfall data during the crop period

Date	Rainfall (mm)	Date	Rainfall (mm)
18/05/2010	39.00	19/07/2010	43.80
19/05/2010	29.00	20/07/2010	22.60
20/05/2010	1.80	21/07/2010	8.00
22/05/2010	16.20	22/07/2010	39.00
08/06/2010	12.50	23/07/2010	2.00
09/06/2010	64.00	24/07/2010	2.40
10/06/2010	27.00	26/07/2010	3.00
11/06/2010	22.00	27/07/2010	21.40
12/06/2010	146.80	28/07/2010	39.00
13/06/2010	104.20	29/07/2010	51.00
14/06/2010	67.10	30/07/2010	84.30
15/06/2010	54.20	31/07/2010	1.80
16/06/2010	5.60	01/08/2010	10.60
17/06/2010	16.80	02/08/2010	5.00
18/06/2010	11.80	03/08/2010	7.00
19/06/2010	7.80	04/08/2010	35.00
20/06/2010	3.40	05/08/2010	1.70
21/06/2010	0.80	06/08/2010	21.00
23/06/2010	15.40	07/08/2010	2.00
24/06/2010	32.40	08/08/2010	23.20
25/06/2010	26.60	09/08/2010	6.20
26/06/2010	24.80	16/08/2010	16.20
27/06/2010	41.80	17/08/2010	23.00
28/06/2010	56.80	18/08/2010	1.20
29/06/2010	52.00	21/08/2010	5.40
30/06/2010	63.00	26/08/2010	29.00
01/07/2010	25.00	27/08/2010	7.40
02/07/2010	16.80	28/08/2010	6.20
03/07/2010	33.00	29/08/2010	3.80
04/07/2010	17.60	30/08/2010	8.00
05/07/2010	53.40		
06/07/2010	18.60		
07/07/2010	19.80		
09/07/2010	8.00		
14/07/2010	3.80		
15/07/2010	9.00		
16/07/2010	12.20		
17/07/2010	90.20		
18/07/2010	9.00		

APPENDIX 2

Multiple comparisons of data from second trial

Dependent	Variable	(I) Treatment	(J) Treatment	Significance
Yield	LSD	1	2	0.099
			3	0.294
			4	0.075
			5	0.018
		2	1	0.099
			3	0.525
			4	0.888
			5	0.419
		3	1	0.294
			2	0.525
			4	0.439
			5	0.155
		4	1	0.075
			2	0.888
			3	0.439
			5	0.503
		5	1	0.018
			2	0.419
			3	0.155
			4	0.503
Fruits	LSD	1	2	0.127
			3	0.255
			4	0.111
			5	0.031
		2	1	0.127
			3	0.683
			4	0.941
			5	0.482
		3	1	0.255
			2	0.683
			4	0.629
			5	0.270
		4	1	0.111
			2	0.941
			3	0.629
			5	0.529
		5	1	0.031
			2	0.482
			3	0.270
			4	0.529

Length	LSD	1	2	0.976
			3	0.179
			4	0.027
			5	0.026
		2	1	0.976
			3	0.189
			4	0.029
			5	0.028
		3	1	0.179
			2	0.189
			4	0.344
			5	0.336
		4	1	0.027
			2	0.029
			3	0.344
			5	0.987
		5	1	0.026
			2	0.028
			3	0.336
			4	0.987
Diameter	LSD	1	2	0.960
			3	0.780
			4	0.866
			5	0.928
		2	1	0.960
			3	0.741
			4	0.906
			5	0.888
		3	1	0.780
			2	0.741
			4	0.655
			5	0.850
		4	1	0.866
			2	0.906
			3	0.655
			5	0.796
		5	1	0.928
			2	0.888
			3	0.850
			4	0.796

Abstract

ABSTRACT

Present project was to standardize the irrigation requirement of salad cucumber grown in polyhouse and to find the suitable packaging for extending the shelf life of salad cucumber. The experiment had five irrigation treatments with six replications. Two types of irrigation-basin and drip were practiced. The plot having basin irrigation with 2.5 l/plant/day was taken as the control plot.

The crop inside the polyhouse with drip irrigation of 1.5 l/plant/day performed well during the experiment with a water use efficiency of 121. Drip irrigation in comparison with the surface irrigation has given higher yield throughout the crop period.

Drip irrigation has shown larger soil moisture content a day after irrigation, while the conventional surface irrigation had least soil moisture content.

The experiment reveals that the soil temperature inside the polyhouse has a direct relation with rainfall, since the temperatures show maximum value at minimum rainfall, and vice versa. Since soil temperature plays an important role at the critical growth stages of salad cucumber, the rainfall has a great significance.

Packaging is one of the most important processes to prevent quality deterioration of salad cucumber. In the experiment, the deep freezing of salad cucumber at 13^{o}C along with 10% perforated polythene packing was found to be effective for extending the shelf life up to 15 days.