IRRIGATION SCHEDULING STUDIES ON SOILLESS CULTURE MEDIA FOR POLYHOUSE CULTIVATION OF VEGETABLE CROPS

APARNA P V (2015-02-009)

KRISHNA (2015-02-026)

SILPA S JAYAN (2015-02-036)

PROJECT REPORT

Submitted in partial fulfillment of the requirement for the degree of

Bachelor of Technology

in

AGRICULTURAL ENGINEERING

Faculty of Agricultural Engineering and Technology

Kerala Agricultural University

DEPARTMENT OF IRRIGATION AND DRAINAGE ENGINEERING

KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY

Tavanur – 679 573, Malappuram

KERALA

2019

DECLARATION

We hereby declare that this project entitled **"Irrigation scheduling studies on soilless culture media for Polyhouse cultivation of vegetable crops"** is a bonafide record of project done by us during the course of academic programme in the Kerala Agricultural University and that report has not previously formed the basis for the award to us for any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Aparna P V (2015-02-009)

Place : Tavanur

Krishna (2015-02-026)

Date :

Silpa S Jayan (2015-02-036)

CERTIFICATE

Certified that this project report entitled **"Irrigation scheduling studies on soilless culture media for Polyhouse cultivation of vegetable crops"** is a bonafide record of project work jointly done by Aparna P V (2015-02-009), Krishna (2015-02-026) and Silpa S Jayan (2015-02-036) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship or other similar title of any other University or Society to them .

Dr. Rema K.P
Professor,
Department of Irrigation and Drainage Engineering,
KCAET, Tavanur

Tavanur
Date:

ACKNOWLEDGEMENT

We would like to express our deep sense of gratitude, utmost indebtedness and heartfelt thanks to our project guide **Dr. Rema K P**, professor, Department of Irrigation and Drainage Engineering, KCAET, Tavanur for valuable guidance, profound suggestions, constant backing, prolific encouragement and advice throughout the project work.

We are thankful to **Dr. Sathyan K. K,** Dean, KCAET, Tavanur for his support and co-operation during the course of work.

With deep respect we express our heartfelt gratitude to **Dr. Sasikala D,** professor and Head of the Department of IDE, KCAET, Tavanur for her immense support and advice during this work.

Our heartfelt thanks to E**r. Ajay Gokul** and **Sandhya M,** Farm Manager, KVK Malappuram for the timely help and support.

We are immensely thankful to **Aboobacker,** Farm superintendent, KCAET, Tavanur, and **Syam Prakash,** Farm Manager, KCAET, Tavanur for giving valuable suggestions and constant backing at all stages of this research work.

At this juncture, we would like to express our gratitude to **Shijila** Lab Assistant, KCAET, Tavanur, **Suresh,** Driver, KCAET, Tavanur for their sincere help and support.

We are immensely thankful to the **farmers** of Farm, KCAET for their support and cooperation during the period of study.

We fail on our part if we do not mention our friends **Deepthi S Nair, Joshila Mary J and Amrutha K** for their enthusiastic cooperation and support during the study.

We express our sincere thanks and gratitude to **Kerala Agricultural University** for providing this opportunity to do the project work.

We are greatly indebted to our **parents** for their love, blessings and support which gave strength to complete the study.

Last but not the least, we bow our heads before **God Almighty** for the blessings bestowed upon us to materialize this endeavour.

Aparna P

V

Krishna

Silpa S Jayan

DEDICATED TO OUR PROFESSION

CONTENTS

LIST OF TABLES

LIST OF FIGURE

LIST OF PLATES

SYMBOLS AND ABBREVIATIONS

ANOVA	Analysis of Variance
ALT-N	Alternating Nitrogen
B	Boron
Ca	Calcium
CDV	Critical Difference Value
cm	Centimetre
CMFRI	Central Marine Fisheries research Institute
CRD	Completely randomised Design
CRBD	Completely Randomised Block Design
Cu	Copper
EC	Electrical Conductivity
ETc	Crop evapotranspiration
et al	and others
FAO	Food and Agricultural Organisation
Fig	Figure
FYM	Farm yard manure
g	Gram
g/cc	gram per cubic centimetre
ha	Hectare
K	Potassium
KCAET	Kelappaji college of agricultural Engineering and Technology
Kc	Crop Coefficient
Kg	Kilogram
KNO_3	Potassium Nitrate
KVK	Krishi Vigyan Kendra

LH	Ladies Hostel
l/d	litre per day
Lph	litre per hour
M	Metre
m^2	Square metre
mg/l	milligram per litre
ml	Millilitre
mm	Millimetre
mm/d	millimetre per day
Mn	Manganese
N	Nitrogen
P	Phosphorous
PVC	Poly Vinyl Chloride
RGR	Relative Growth Rate
SCS	Soilless Culture System
SEM	Scanning Electron Microscope
TSS	Total Soluble Solids
t/ha	tonnes per hectare
viz	Namely
Wb	wet basis
W/m^2	Watt per square metre
WUE	Water Use Efficiency
Zn	Zinc
%	Percentage
µm	Micrometre
°C	Degree Celsius

INTRODUCTION

CHAPTER 1
INTRODUCTION

World population is predicted to reach 9.4 billion by 2050. The biggest challenge before the technocrats, agriculturists and farmers at present is to increase production enough to feed the entire population with quality food in the required quantities. Agriculture is the backbone of Indian economy. Agricultural production must increase in order to meet the ever increasing demand for food. Unsustainable use of natural production factors such as soil, biological diversity and water has caused degradation of 60 % of our ecosystem services. Agriculture is insufficiently prepared to cope with vagaries of monsoon, unpredictability and adaptation to climate change. Improved sustainable management of soil and ecosystems that soils provide could produce 50% more food. Technologies are improving day by day for increasing production. Different farming methods are developed from the traditional system of soil based farming to the hydroponics techniques.

Soil is a naturally occurring mixture of minerals, organic matter and air which has a definite structure and composition and forms on the surface of the land.Soil provides anchorage for roots. But presence of nematodes and disease causing organisms, undesirable soil reaction, unfavourable soil compaction, degradation due to erosion, poor drainage etc. are some of the limitations of soil based cultivation. Continuous cultivation of crops has created poor soil fertility, which reduces the natural soil fertility build up by microbes. Soil is less available for cultivation in industrial and urban areas and also there is a shortage of fertile cultivable arable lands in some places due to their unfavourable geographical or topographical conditions.

Conventional crop growing in soil is difficult because of the demand of cultivable land area, more space, large volume of water and lots of labour. Therefore soilless culture has been introduced to overcome this situation. Soilless culture systems (SCS) offer flexibility and intense farming, with high crop yield and high quality produce. This is the modern cultivation system for plants that use either inert organic or inorganic substrate through nutrient solution nourishment. SCS is to control soil-borne pests and diseases, which is especially suitable in the tropics, where its life cycles are uninterrupted and so is the threat of infestation. With SCS we can avoid the time consumption, costly works of soil sterilization and amelioration etc. Thus soilless culture in bags, pots or trays with light weight medium is a simple, easy and economical way of growing crops.

Polyhouse farming as well as other controlled environment cultivation has been evolved to create favourable micro-climates, conducive for crop production, making cultivation possible throughout the year or part of the year as required. Adopting soilless culture in protected cultivation with technical practices like fertigation, drip irrigation and climate control ensures better yield and water use efficiency. Therefore, studies over the last few decades have mainly focused on the development and rehabilitation of new or readily available systems especially aiming to provide more water and nutrient saving, increased yield and decreased waste of nutrients. Thus protected cultivation system control the growing environment through management of amount and composition of nutrient solution, weather factors and also the growing medium. Modern systems use manufactured media such as perlite, rock wool, expanded clay and other materials in plastic grow bags and containers. Certain organic products, such as coconut coir, rice hulls, saw dust, composted plant material and wood chips etc. also are used successfully for polyhouse soilless culture of vegetables.

Coir pith can be used in soilless cultivation especially in areas having water shortage, low fertility and poor soil drainage, unsuitable soil reaction, soil salinity, pest and other ecological problems. Due to its features like water holding capacity and enhanced aeration it can be used for various agricultural purposes. It is an excellent soil conditioner and is being extensively used as a soilless medium for agro-horticultural purposes such as planting lawns, parks and gardens, golf courses and planting vegetable gardens. Because of its sponge like structure it helps to improve aeration and retain water in the root zone. Similarly, The Krishi Vigyan Kendra, Ernakulam has developed a soil-less medium which is available as an alternative to soil in farming. This medium consists of composted press mud, a by-product from sugar mills along with coirpith, powdered cow dung, neem cake, Dolomite and bio control agents.

Water is considered as a critical resource for agriculture and supplying the right amount in the right time is essential for healthy plants and optimum productivity. This objective can be met only through scientific water management and judicious water application, which in turn requires proper scheduling of irrigation events. Irrigation scheduling is the process of determining when to irrigate and how much quantity of water to apply per irrigation. To schedule irrigation effectively, a farmer must know the atmospheric demand for surface water. In order to obtain profitable level of crop yield, soil water depletion level should not exceed the predetermined levels mainly during the critical period of crop. Application of excess or deficit amounts of water at the crop development stage causes crop damage and yield reduction.

Proper irrigation management is essential for improving the productivity and quality of crops grown in the greenhouse. The two important factors that influence the efficient irrigation management are exact time and the amount of irrigation. Mainly drip irrigation is used in soilless culture.Right selection of operating parameters and proper scheduling of irrigation can scientifically result in better yield in soilless production system. Scheduling water application is very crucial to make the most efficient use of drip irrigation system, as excessive irrigation can reduce yield, while inadequate irrigation causes water stress and reduced production.The correct amount of irrigation can be characterized as the supply of sufficient water considering the plant needs in the rooting area. Fertigation is a very important requirement in soilless culture and optimizing the fertigation levels to suit the requirements of media and crop can assure commendable results in soilless production.The composition of mineral solutions depends on the crop under cultivation. The commonly used soilless media are coco coir, rock wool, expanded clay pellets, potting soil and grow stones.

Advantages of soilless agriculture

- It does not require the use of toxic chemicals.
- It is ideal in urban areas where space is too limited for soil-based gardens.
- Nutrient and growing media loss is significantly reduced with soilless cultivation because the nutrient requirements for crops are determined in advance.
- Growing media are eco-friendly.
- The yield from soilless cultivation is significantly higher.
- Media are of very low bulk density.
- Can be shipped or transported to any place due to being light weight.
- Suitable combinations can be used.
- Suitable proportions can be tried for desirable results.

However some of the disadvantages are also observed for soilless agriculture. Crops cultivated using this approach is more prone to pathogen attacks as a result of high moisture levels. Crops are also more susceptible to rapid death as a result of their lower buffering capacity.Hence control of moisture levels, pH and EC levels of media are very important in cultivation using this method. Most of the studies on soilless media highlight the high water use efficiency and reduced water requirement for vegetable crops. Proper scheduling of irrigation with varied levels and frequencies of irrigation can ensure better moisture control and enhanced water use efficiency without compromising production. In order to analyse these aspects the present study on soilless media for poly house is proposed with the following objectives:

The specific objectives of the study are:-

- To study the effect of irrigation scheduling on soilless media for vegetable crops in polyhouse.
- To compare the crop growth and yield parameters under varied irrigation schedules on alternate media.

REVIEW OF LITERATURE

CHAPTER 2
REVIEW OF LITERATURE

Soilless culture is an artificial means of providing plants with support and a reservoir for nutrients and water. Soilless cultivation is intensively used in protected agriculture to improve control over the growing environment and to avoid uncertainties in the water and nutrient status of the soil. It also overcomes the problem of salinity and the accumulation of pests and diseases. Predominant progress has been made recently in the development of soilless media and economically viable soilless systems have evolved. A number of growers in different Mediterranean countries are using soilless culture commercially, but their usage varies, according to the level of education of the growers, the existing greenhouses facilities and their level of organization.

Some of the literature relevant to the study are reviewed and presented under the following sub headings.

2.1. MICROCLIMATE INSIDE POLYHOUSE AND ITS EFFECT ON CROP GROWTH

Rise in air humidity stimulates growth and photosynthesis and high humidity levels resulted in an increased photosynthetic rate (Bunce,1984). High humidity increased cucumber total yield, but did not affect the early yield fresh and dry weight, stem length and leaf area, and the final total cucumber yield was positively related to daytime humidity (Bakker *et al*.,1987).

Kavitha*et al*. (2003) carried out a study in polyhouse provided with solar module aided spinning disc sprayer and solar energy aided exhaust fan. By attaining specific climatic conditions in the poly-house the crop response could be varied in such a way that tomato shoot length was increased by 96% and yield was increased by 27% and for brinjal 55% increase in shoot length and 85% increase in yield were observed.

Greenhouse cooling is quite a difficult and complicated task, in case of buildings it even requires huge investment. The net solar radiation in the greenhouse, reaches 500-600 W/m^2 during summer. In order to obtain greenhouse air temperatures close to outside ones, a total of about 200-250 W/m^2 of sensible heat needs to be removed. Low cost methods such as forced ventilation, cooling pads, fog systems, screens, etc., or in most cases, a combination of the previous methods are used for the removal of heat energy. The most common methods used for greenhouse cooling in Mediterranean areas are natural or forced ventilation (Kittas*et al.*, 2005).

Tropical greenhouses require active evaporative cooling system such as pad and fan to assure a suitable microclimate for crop production. Excess heat causes inside the greenhouse results in increase in temperature which may results in damaging effects to crop growth and production. Jamaludin (2009) investigated temperature and relative humidity inside greenhouse at horizontal and vertical profiles.The result of the study showed that, in horizontal direction temperature increased from evaporative pad to exhaust fans while relative humidity shows inverse pattern from temperature and in the vertical direction, temperature increased, while relative humidity decreased from lower level to the upper level. The inside temperature with growing crops however, was slightly lower than the empty greenhouse.

2.2. POLYHOUSE VEGETABLE CULTIVATION

Growing vegetables in greenhouse is one of the most intense and demanding forms of all agricultural enterprises. The greenhouse offers the ability to manage the growing environment in order to increase control over productivity and quality.

Protected cultivation has a special importance in the agriculture of Turkey and occupies 42,000 ha, which accounts 50 % of the total land as glass and plastic greenhouses. Among that 95 % of them are vegetables, 4 % ornamentals and in the remaining seedlings and fruits are grown. Fertigation is the main fertilization system in modern commercial greenhouses. Excess fertilizer use is a very widespread practice, in especially conventional greenhouses (Anac. 2004).

Investigations on crop water requirement for drip irrigated tomatoes grown in tropical environment in greenhouse have been done in the past. Greenhouse farming system performed better than open farming systems in terms of crop yield, irrigation water productivity and fruit quality. The results revealed that greenhouse farming can save about 20-25 % of water compared to the open drip irrigated farming system (Harmantoa *et al*., 2004).

Plasticulture with soilless cultural systems could address several of the serious challenges faced by the vegetable industry in Florida and other areas of the world with similar climates. In analysing production systems in this area, it was possible to assume that similar production systems would work in the more humid, semi-tropical areas and countries such as India. Florida plasticulture systems could include the use of soilless culture for enhancing crop production and water use efficiency. Bag or container production using an inert media such as perlite, vermiculite, peat, or coconut fibre would be an example (Cantliffe *et al*., 2007).

According to Spehia (2015), the productivity of cucumber inside polyhouses was more than four times as compared to open field cultivation.

2.3. PHYSICO- CHEMICAL PROPERTIES OF DIFFERENT SOILLESS CULTURE MEDIA

Atiyeh *et al*. (2001) designed experiments to characterize the physical, chemical and microbial properties of a standard commercial horticultural, greenhouse plant medium (Metro-Mix 360), that had been substituted with a range of increasing concentrations (0 %, 5 %, 10 %, 25 %, 50 % and 100 % by volume) of pig manure vermicompost and to relate these properties to plant growth responses. The growth trials used tomatoes grown in the substituted media for 31 days under glasshouse conditions, with seedling growth recorded in 20 pots for each treatment. The percentage total porosity, percentage air space, P^H and ammonium concentrations of the container medium all decreased significantly, after substitution of Metro-Mix 360 with equivalent amounts of pig manure vermicomposting; whereas bulk density, container capacity, electrical conductivity, overall microbial activity and nitrate concentrations, all increased with increasing substitutions of vermicomposting. Some of the growth enhancement in these mixtures seemed to be related to the combined effects of improved porosity, high nitrate content of the substrate and aeration and water retention in the medium, which resulted in increased uptake of nitrogen by the plant.

Kannan *et al.* (2005) conducted a field experiment to study the influence of different organic N sources viz, FYM, Vermicompost and coir pith compost with bio fertilizers on the soil physical properties, nutrient availability and biological properties during December - May (2003-2004) with tomato (Lycopersicon esculentum. Mill). Application of different organics with azospirillum favourably enhances the soil physical, chemical and biological environment such as bulk density, water holding capacity, available nitrogen, organic carbon, beneficial bacterial and fungal population over the inorganics alone applied plot. Among the different organic N sources the application of 75 percent Vermicompost with azospirillum was found to be superior in bettering soil health over the other treatments.

Rasool *et al.* (2008) studied on the effects of vermicompost on soil physical and chemical properties in tomato field. The experiment was arranged in a CRBD design with four replications. Different amounts of vermicompost viz. 0, 5, 10, and 15 t/ ha were applied into the top 15 cm of soil. The soil sampling and measurements were carried out 3 months after the application of vermicompost in soil and the soil samples were collected from depth of 15 cm. The results showed that addition of vermicompost at rate of 15 t /ha significantly ($P < 0.05$) increased contents of soil total organic carbon, total N, P, K, Ca, Zn and Mn compared with control plots. The soils treated with Vermicompost had significantly increased EC and low P^H in comparison to unamend plots. The results of this experiment showed that addition of Vermicompost had significant ($P < 0.05$) positive effects on the soil chemical and physical properties.

Narendar *et al.* (2013) conducted the study to determine the effect of chemical treatment on the mechanical and water absorption properties of coirpith/Nylon/Epoxy sandwich composites. Multi-layered coir pith, nylon fabric, epoxy hybrid composites were fabricated by the hand lay-up technique. Coirpith was subjected to chemical treatment before processing and the fraction of coirpith was maintained in the range of 60 – 65 %. The effect of treatment was analysed by scanning electron microscope (SEM) and optical microscopy. The effects of layering and treatment on the mechanical and water transport nature of composite were analysed. The mechanical properties of the composite decreased on exposure to water. However, the retention of impact strength increased with chemical treatment of coirpith.

Coir pith is a mass of heterogeneous particles having broadened physical characteristics. Bulk density was found to be high in small particles (150 μm) and it decreased as particle size increased (2000 μm). In smaller particles, high bulk density of coir pith was found (0.11g/cc) which are low compared to soil. Total porosity and aeration porosity of the coir pith mass formed of specific particle size showed direct relationship with particle size whereas water holding porosity had a negative relation. High bulk density showed by big particles had a low total porosity which would cause reduction in growth and distribution of roots of the plants grown on it. Water absorptivity and particle size of coir pith showed a strong negative linear correlation. Smaller particles of coir pith which was compactly arranged and absorbed more water due to infinite micro pores than the coarser particles which contained larger but limited amounts of macro pores. Both surface area as well as specific surface area of coir pith particles decreased with the increase in the average size of the coir pith. As water retention in a medium depends mainly on the number and size of the pores and the specific surface area of the medium, it was observed to be higher in the smaller sized particles. (Maragatham *et al*., 2010)

Drainage is not allowed before planting the crop and the substrate is irrigated up to the point of saturation to ensure complete filling of the pores with nutrient solution (Savvas *et al*., 2013). Immediately after planting, full drainage has to be allowed to avoid hypoxic conditions in the root zone.

Duggan-Jones *et al.* (2013) investigated on the effect of physical characteristics of coir on the productivity of greenhouse tomatoes. Coir is a relatively new growing media; particle size significantly affects the physical properties of coir, particularly the air-water relationships. An experiment was designed to compare the yield, water use efficiency and RGR (relative growth rate) of a tomato crop grown in coir using a range of particle sizes. Seven treatments based on combinations of small (S), medium (M) and large (L) sized particles, together with a commercial ungraded coir dust were used. Two irrigation (low and high) frequencies were adopted. The seven treatments were based on particle size with differences in WHC.

2.4. ALTERNATE MEDIA FOR SOILLESS CULTURE

Dayananda *et al*. (2001) conducted an experiment to find out the desirable growing media and hydroponic system for cultivation of lettuce under controlled environment. The treatments included 3 growing systems viz nutrient flow system, non-circulating system and aggregate system and six growing medias used were coir dust, coir dust + tea refuse, tea refuse + partially burnt paddy husk, tea refuse, coir dust + partially burnt paddy husk and partially burnt paddy husk. Results revealed that the coir dust and paddy husk were proved to be the best growing media for better plant growth and yield. Hence combination of an aggregate system with either coir dust or partially burnt paddy husk or both would be ideal for cultivation of lettuce under protected environment.

Hochmuth *et al*. (2003) reported that the cucumber and tomato are grown successfully in perlite media. Although the study focuses on perlite media in layflat bags, most of the principles also pertain to other soilless media, such as peatmix bags and rockwool slabs.

Peat moss is the result of the decomposition of sphagnum, mosses, and sedges under acid and wet anaerobic conditions. Some of their characteristics are high water holding capacity, high cation exchange capacity, and good porosity (Gianquinto, 2005).

Parks *et al.* (2005) investigated the suitability of some locally available materials in Vietnam as soilless substrates as a part of an Australian aid project (AUSAID-CARD). For the production of cucumber and tomato, four media were used as substrates such as coir, or mixtures of three components including sugar cane waste, peanut husks, soybean, peat or volcanic rock. For both the tomato and cucumber crop yield was significantly increased by the use of coir as a substrate. The medium of sugar cane waste, peat and volcanic rock proved to be unfavourable for cucumber production as it produced fruit with lead levels above the maximum residue limit of 0.2 mg/kg in three out of five replicates.

Coirpith is a byproduct of the coir industry, produced more than 7.5 million tonnes annually in India. It can be used as fuel or in briquettes form. This study investigates different physical properties of coirpith with respect to its moisture content (10.1 to 60.2 % w.b.) and particle size (0.098 to 0.925 mm). Porosity and particle density varied from 0.623 to 0.862 and from 0.939 to 0.605 gm/cc respectively. Bulk density and static coefficient of friction against mild steel were in the range of 0.097 to 0.341 gm/cc and 0.5043 to 0.6332 respectively. Models were developed for the above properties (Neethi *et al.*, 2006).

Rajarathnam *et al*. (2007) carried out experiments with coirpith for its potential in serving as a growth substrate for the production of species of oyster mushroom. Amendment of coirpith with rice straw and horse gram plant residue greatly modified the physical characteristics of inoculated mushroom. Changes in cellulose, hemicellulose and lignin contents of coirpith amended with rice straw were studied. Cellulose, hemicellulose and protease enzyme activities in the amended coirpith substrate showed continuous increase from inoculation till the end of fructification, whereas laccase activity decreased during fructification, in consonance with decreased lignin degradation during fructification.

Albaho *et al*. (2013) investigated the suitability of some locally available materials in Kuwait. Four combinations of media were used as substrates viz. M1-35 % peat moss/40 % perlite/25 % vermicompost, M2-25 % peat moss/25 % perlite/25 % vermicompost/25 % coco peat, M3- 100 % coco peat and M4- 50 % perlite/50 % peat moss as control. Experiments were carried out in a cooled greenhouse. Experiments with cucumber and banana revealed that the growing media M1 and M2 are the best substrates for use in the growbag technique.

2.5. DRIP IRRIGATION AND FERTIGATION IN SOILLESS CULTURE

Harmsen, *et al.* (2002) assessed the pan evaporation method for scheduling irrigation of a sweet pepper (Capsicum annuum) crop grown on an Oxisol at the University of Puerto Rico Agricultural Experiment Station at Isabela, PR. Evaluation of the pan method for scheduling irrigation was based on comparison of ETpan with the Penman-Monteith-based evapotranspiration (ETc), estimates of deep percolation, measured vertical hydraulic gradients, and measured soil moisture distribution. A simulated irrigation schedule using the Penman-Monteith method resulted in even greater seasonal deep percolation (127.7 mm). Vertical hydraulic gradients were found to be downward throughout a significant portion of the season, and observed moisture content distributions below the root zone clearly showed that deep percolation was occurring.

Singandhupe *et al.* (2002) tested fertigation studies and irrigation scheduling in drip irrigation system in tomato crop ,response to urea fertilizer with drip irrigation and compared with conventional furrow irrigation for 2 years (1995 and 1996) at the Research Farm of Water Management Project, Mahatma Phule Agricultural University, Rahuri (Maharashtra), India. Application of nitrogen through the drip irrigation in ten equal splits at 8-days interval saved 20- 40 % nitrogen as compared to the furrow irrigation when nitrogen was applied in two equal splits (at planting and 1 month thereafter). Similarly, 3.7-12.5 % higher fruit yield with 31-37 % saving of water was obtained in the drip system. Water use efficiency in drip irrigation, on an average over nitrogen level was 68 and 77 % higher over surface irrigation in 1995 and 1996, respectively.

Miranda (2005) suggests that precise estimation of crop evapotranspiration (ETc) on a daily basis is critical for drip irrigation management in soils with limited water storage capacity. The objective of his study was to determine the evapotranspiration and crop coefficients for Tabasco pepper (Capsicum frutescensL.), in the Northeast region of Brazil. Crop ET was measured daily using a precision weighing lysimeter with a surface area of 2.25 m^2. Reference ET was estimated using the FAO Penman-Monteith equation. The total ETc observed throughout the 300 - day crop season was 888 mm, with maximum daily values of 5.6 mm d^{-1}. Average crop coefficients observed during the first harvest cycle were 0.3, 1.22 and 0.65 for the initial, mid-season and end of the late-season stages, respectively. During the second harvest cycle average crop coefficients were 1.08 and 0.60 for the mid-season and the late-season stages, respectively.

“Galia” muskmelons were grown in a passively ventilated greenhouse during three seasons in Gainesville, Florida using polyethylene-bag perlite culture. Nitrogen concentrations were applied with every irrigation at 80, 120, 160, 200, and 240 mg/l. An alternating N (ALT-N) treatment that followed the four growth stages was also included (120- 160- 200- 120 mg/l). In all three seasons, there were no differences among the N treatments for average fruit weights or soluble solids content. Petiole-sap NO_3-N concentrations during spring and fall 2001 suggested that optimal yields can be achieved if at least 3000 mg/l NO_3-N was maintained through fruit maturation. When petiole-sap concentrations were less than 2500 mg/l, as in the case of plants receiving 80 or 120 mg/l N, significantly lower yields were obtained (Rodriguez *et al*., 2005).

Bernstein *et al.* (2006) conducted a study to determine the effect of irrigation with treated sewage water on roses cultivated in two soil-less medium, perlite, an inert mineral medium and Coir (coconut fibres), an organic medium of high ion absorption capacity. Cl contents increased 47 % in perlite and 73 % in coir grown plants reaching levels characteristic of exposure to moderate salinity. Mn, Cu and B contents increased as well under cultivation in both perlite and coir under irrigation with treated sewage water.

Metin *et al.* (2009) conducted a study to determine the optimal irrigation strategy for drip irrigated fresh market tomato grown in different soilless culture in a glasshouse in the Mediterranean Region of Turkey. Volcanic ash, peat and their mixture were used as growth media. Four different irrigation levels (WL1=75 %; WL2=100 %; WL3=125 % and WL4=150 % of Class A Pan evaporation) and two watering frequencies like once and twice daily applications were evaluated. Highest yield and fruit number were obtained from the ash+peat mixture (1:1) with twice a day watering at WL4 irrigation level. Soluble solids of tomato fruit decreased with increasing available water. The highest irrigation water use efficiency (IWUE) value of 121.4 kg/m^3 was obtained from once a day irrigation WL1 irrigation level with peat+ash (1:1). IWUE decreased in all treatments as the amount of irrigation water increased.

An EC based irrigation strategy was tested in two greenhouse soil-less cucumber crops. One of the crops was subjected to CO_2 enrichment using a dynamic control strategy, while the other one was not enriched. It is concluded that CO_2 enrichment combined to an EC based irrigation scheduling lead to synergistic beneficial effects on the overall water use efficiency of soilless greenhouse cropping systems and to a drastic reduction of the leaching fraction (Sanchez-Guerrero *et al*., 2009).

Serhat (2009) studied the effect of deficit irrigation on yield of pepper grown under unheated greenhouse condition. The research was carried out at Turkey, in 2007. In the study, water was applied to pepper as 100, 75, 50, 25 and 0% (as control) of evaporation from a Class A pan (K1cp 1.00, K2cp 0.75, K3cp 0.50, K4cp 0.25, K5cp 0.00- control) corresponding to 2 day irrigation frequency. Irrigation water applied to crops ranged from 65 to 724 mm, and water consumption ranged from 115 to 740 mm. The effect of irrigation water level on the yield, fruit height, diameter, weight and dry matter ratio were significant. Crop yield response factor (ky) was 1.07. The highest values for water use efficiency (WUE) and irrigation water use efficiency (IWUE) were 3.13 and 3.39 kg mm^{-1} for the K2cp treatment. Under the conditions that water resources are scarce, it can be recommended that K2cp treatment is most suitable as a water application level for pepper irrigation by drip irrigation under unheated greenhouse condition.

2.6. EFFECT OF GROWING MEDIA ON PLANT GROWTH PARAMETERS

A comparative study of coirpith and cowdung was done at Regional Agricultural Research Station, Jessore to show the performance of coirpith on growth and yield of summer tomato compared to cowdung. Five treatment combinations viz. T1, 10 t/ha coirpith; T2, 20 t/ha coirpith; T3, 10 t/ha cowdung; T4, 20 t/ha cowdung and T5, control were included in the study. Growth and yield of summer tomato was significantly influenced by the treatments. Maximum number of fruits per plant (30) was obtained from T2 treatment which was higher than T3 treatment (27). Similarly the highest single fruit weight (57 g) was measured in T2 treatment which was higher than T3 treatment (54 g). The highest marketable yield (32.59 t/ha) was recorded from the treatment T1 which was statistically similar to T3 treatment and the lowest marketable yield (13.31 t/ha) was recorded from control. Therefore, coirpith @ 10 t/ha with chemical fertiliser is suitable for summer tomato production at Jessore region in Bangladesh (Hossain *et al*., 2008).

An investigation was carried out for the evaluation of the effect of substrate and cultivar on growth characteristic of strawberry in soilless culture system. Experimental treatment consisted of three strawberry cultivars (Camarosa, Mrak and Selva) and six growing media (rice hull, sycamore pruning waste, cocopeat + perlite (50:50), vermicompost + perlite + coco peat (5:45:50), (15:40:45) and (25:35:40)). Measured factors were dry and fresh weight of root and shoot, runner number, petiole length, leaf area, total biomass and root/shoot ratio. Physical and chemical characteristics of different substrate consisting of pH, EC, porosity, bulk density, particle density, % organic material and % inorganic material were tested. According to results of this experiment, for better growth and consequently higher yield, suitable substrate that will have high water holding capacity, suitable bulk density and better porosity must be chosen. Among the cultivars, Camarosa, which is a short day plant, consequently had high vegetative growth, while Mrak, day neutral, had high yield. Also, M4 and M5 were the best in the measured properties. Mrak in M4 had the highest yield (Atefe *et al*., 2012).

Norrizah *et al*. (2012) conducted an experiment on characterization of plant growth, yield and fruit quality of Rockmelon cultivars planted in soilless culture. In this experiment, three different rockmelon cultivars were selected for the study. Seed morphology, plant growth, yield and fruit quality of rockmelon cultivars (Glamour, Honeymoon and Champion) planted in cocopeat were evaluated. Plants were irrigated through fertigation technique and grown under rain shelter. Afterfive weeks, fruit was harvested and tested.All three rockmelon cultivars were able to survive and grow using soilless culture system. Rockmelon cv. Glamour showed the best seed morphology and plant growth performance.Other than that, highest fruit fresh weight seemed to be influenced by the high fruit diameter because cv. Honeymoon produced heaviest and largest fruit diameter. Rockmelon cv. Champion showed the best fruit preferences with high quality as the fruit mesocarp was thick and nutritive containing large amount of vitamin C and TSS.

2.7 STUDIES ON IRRIGATION SCHEDULING FOR SALAD CUCUMBER

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. Hence water use efficiency (yield/irrigation quantity) declined with increase of irrigation quantity.

Xiaobo*et al*. (2002) studied the water requirement of cucumber in solar greenhouse. The results indicated that inner light and temperature of solar greenhouse varied with the cropping seasons 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 was 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 was lost through evaporation and at fruit bearing stage through transpiration in solar greenhouse.

Polyhouse cultivation of cucumber using soilless media has most benefit than open field condition, in terms of yield, quality, water use efficiency, fertilizer use efficiency and benefit cost ratio. The treatment peat: vermicompost: sand was found to have a positive influence on plant height, flower characters, and yield per hectare. The highest yield (113.89 t/ha) was registered in peat: vermicompost: sand. The supreme performance of cultivation of cucumber under polyhouse in soilless media can be attributed to the prevalence of optimum microclimatic conditions created by the protected structure as well as the ideal growing medium (Janapriya *et al*., 2010).

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

MATERIALS AND METHODS

CHAPTER 3
MATERIALS AND METHODS

Soilless culture offers a valuable substitute for soil based vegetable cultivation and it has been widely adopted by specialist growers of greenhouse crops in the world. The problems associated with soil based production such as pests and diseases, salinity, lack of arable soil and water etc. have led to the development of substrate media for soilless cultivation.

3.1 LOCATION OF THE STUDY AREA

The field experiment was planned to be conducted inside the naturally ventilated polyhouse in the research plot of Department of Irrigation and Drainage Engineering situated near the LH KCAET, Tavanur. The area lies in the cross point of 10.85^0 N latitude and 75.98^0 E longitude.

3.2 CLIMATE OF THE STUDY AREA

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 average maximum temperature of study area is 31ºC and the average minimum temperature is 26ºC.

3.3 FIELD EXPERIMENT

Growth and yield parameters of salad cucumber and okra with alternate growing systems and three irrigation schedules were studied. The experiment was conducted inside the naturally ventilated polyhouse during 2018 (October 24th) – 2019 (January 23th) and the crop duration was three months(91 days). The polyhouse was oriented east–west with an area of $208m^2$(26 m length and 8 m width). A view of the polyhouse is shown in Plate 3.1.

3.3.1 Field Preparation

Land preparation was done inside the naturally ventilated polyhouse. Poly house was divided into two parts and one portion was used for cultivation of okra crop and other portion was used for salad cucumber. Six raised beds of 10m length, 0.25m height were made for cultivation of each crop. Layout of the field experiment is shown in figure 3.1 and plate 3.2.

Plate 3.1 View of the poly house

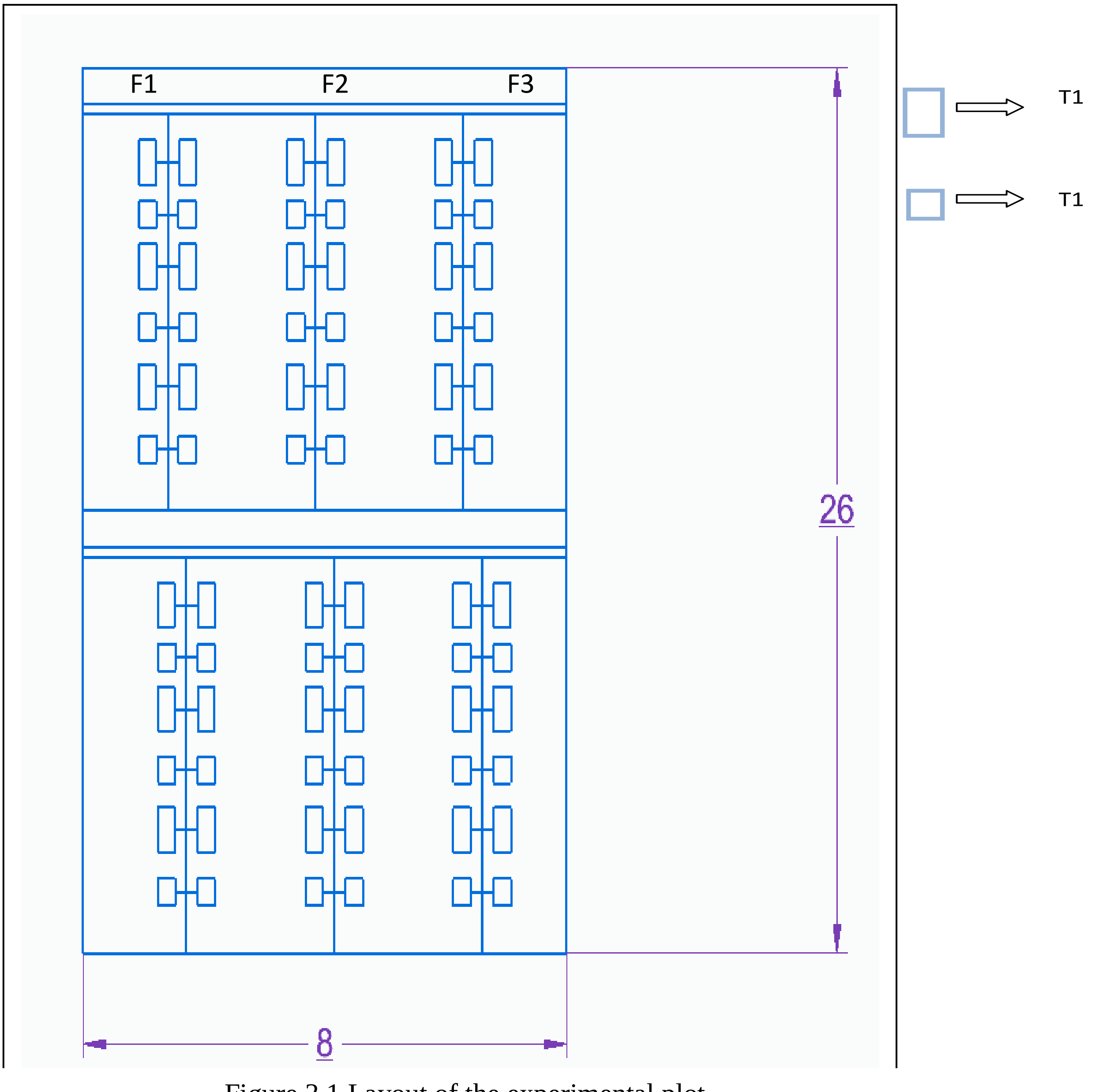

Figure 3.1 Layout of the experimental plot

The substrate media adopted for soilless cultivation are:

1. The soil-less medium developed by the Ernakulam KVK, functioning under the CMFRI, is composed of composted pressmud a by-product from sugar mills along with coir pith, powdered cow dung, neem cake, dolomite and biocontrol agents.
2. The soilless media consisting of coirpith, perlite and vermiculite which is mixed in the proportion of 3:1:1

In the present study coir pith and press mud were selected as the major substrate media since they are light weight, environmentally friendly and has high water-holding capacity. The high air filled porosity of coir pith results in very high seed germination rates and produces seedlings with stronger and more fibrous roots. Commercial hydroponic growers worldwide are producing excellent quality and high-yielding vegetable and cut flower crops using coir pith. The most commonly available substitute for soil in Kerala is coirpith. There are several reasons for the popularity of coir pith as potting mixture. It is easy to handle and there is no interaction between the medium and the nutrients hence offering more availability of nutrients to plants. It provides better physical and chemical properties suitable for plant growth and also a pathogen free growing environment. It also enables incorporation of microorganisms used as bio pesticide and bio nutrients, thus reducing the use of chemicals. This experiment studies the effect of alternate growing soilless media and irrigation schedules for soilless culture of Salad Cucumber and Okra.

3.3.2 Preparation of Alternate Growing Systems

Preparation of soil less media

36 grow bags were filled with media that consisted of coir pith, vermiculite and perlite mixture and other 36 grow bags were filled with Ernakulum KVK soilless media.Prior to media filling, growbags were filled with pebbles at the bottom to ensure proper drainage.

Plate 3.2 Poly house after land preparation

Plate 3.3 Soilless media filled grow bags

3.3.3 Nursery

Salad cucumber variety *Hilton and* Okra variety *Varsha Upahar* were chosen for cultivation. Seeds were sown in pro trays and fifteen days old seedlings were transplanted to the main field. Plate 3.4 shows the seedling of salad cucumber and okra before transplanting.

Plate 3.4 Seedling of salad cucumber and okra before transplanting.

3.3.4 Transplanting

Transplanting was done on 24th October 2018. There were 6 plants in each bed. The total plant population was 72 numbers. The view of the plot after transplanting is given in Plate 3.5.

Plate 3.5 Plot after transplanting

3.4. EXPERIMENT DESIGN

The experiment was designed under Factorial completely randomized block design. The design details are as furnished in the Table 3.1 and 3.2.

Table 3.1. Experiment Design Details

Crop variety	Salad Cucumber : *Hilton* Okra : *VarshaUpahar*
Experiment design	Factorial CRD
Factors	**F - Growing media** F1- Coirpith:vermiculate:perlite - 3:1:1 F2- KVK formulated media **T - Irrigation schedules** T1-Daily irrigation T2- Alternate day irrigation T3- Once in three Day irrigation
No. of replications	3
No of treatment combinations	6

Table 3.2. Treatment details

F1T1	Crop in growing media 1 with daily irrigation
F1T2	Crop in growing media 1 with alternate day irrigation
F1T3	Crop in growing media 1 with irrigation once in 3 days
F2T1	Crop in growing media 2 with daily irrigation
F2T2	Crop in growing media 2 with alternate day irrigation
F2T3	Crop in growing media 2 with irrigation once in 3 days

3.5 IRRIGATION SYSTEM

Irrigation water source was filter point well from which water was pumped to an overhead tank and conveyed through the main line of 63 mm diameter. PVC sub main of 50 mm diameter was connected to the main line to which, Low density polyethylene laterals of 12 mm diameter were connected. End caps were provided at the end of laterals. Each lateral was provided with individual cut off valves for controlling irrigation. Along the laterals, micro tube of 6 mm diameter and length 75 cm were connected with thin connector and online drippers of 4 lph were fixed at the other end of micro tubes. Plate 3.6 depicts the irrigation system layout in the poly house.

The irrigation applied to the plant was in higher rate than the actual requirement in order to ensure drainage and considering other losses. In the case of okra application rate of 0.65L/day/plant against standard value of 0.6L/day /plant was given. During the mid-season stage the plant requires more water than initial stage. So the water applied increased from 0.65 to1 L/day/plant. In the late season water application rate was reduced to 0.8L/day/plant according to studies conducted by Akshaya *et al.* (2018).In the case of salad cucumber at the initial stage water application rate was 0.5L/day/plant. During the development stage the plant requires more water than initial stage. So the water applied was increased from 0.5 to 1 L/day/plant. After mid stage water application rate was increased to 1.5 L/day/plant as the water uptake by plants increases during late stage according to Sabeena*et al.* (2015).

The polyhouse was kept under temperature control using solar operated fogger (Plate 3.7) during afternoon.

Plate 3.6 Drip irrigation system layout in the poly house.

Plate 3.7 A view of fogger

Plate 3.8 Stock solution tank

Plate3.9 Fertigation pump

3.6 FERTIGATION

In all modern soilless systems, fertilization and irrigation are integrated into one system which enables supply of fertilizers and water at the same time (fertigation). Once it became evident that all nutrients essential for crops (macro- and micronutrients) could be supplied through hydro soluble fertilizer salts, systems were developed with fertilizers dissolved at relatively high concentrations in special stock solutions.

Both macro and micro nutrients were applied as water soluble fertilizers from two tanks (tank A and tank B as shown in Plate 3.8) through fertigation system with fertilizer tank and fertigation pump(shown in Plate 3.9). Tank A having macro nutrients and tank B having micro nutrients. Same quantities of fertilizers were applied in each treatment by maintaining electrical conductivity.

Stoke solution was prepared by dissolving the following minerals in 50 litres of water.

Tank A

Calcium Nitrate	: 4.125 kg
Potassium Nitrate	: 0.85 kg

Tank B

Mono potassium phosphate	: 0.925 kg
Sulphate of potash	: 1.180 kg

(Source: RijkZwaan seeds)

Stoke solution was injected at the rate of one litre in 100 litres of water. Tank A and Tank B solutions were applied based on the water requirements during the initial stage, mid-season and late stage of the crops in the evening.

3.7 PEST AND DISEASE MANAGEMENT

Cucumber yields are frequently reduced due to sucking insects and pests. Common problems for polyhouse salad cucumber are aphids, thrips, white flies, downy mildew etc. Seedlings have little tolerance to insect attack and relatively small numbers can cause economic damage. Crop protection consisted of controlling the incidence of pest and disease. Aphids damage cucumber plants by feeding on plant sap, which may get spreaded and cause important viral diseases like cucumber mosaic. Small soft bodied insects on underside of leaves and/or stems of plant which are usually in green or yellow in colour were observed. Tatamida was sprayed at the rate of 3ml/10 litres of water on the leaves for controlling sucking insects like aphids, white fly and thrips. Okra yield is also usually reduced due to sucking insects and pests. Common problems for polyhouse okra are aphids mealy bugs, scale, thrips, white flies and stem borer. Tatamida was sprayed at the rate of 1ml/3litres of water on the leaves for controlling sucking insects and along with that neem soap at a rate of 5g/l twice during the crop period was applied.

3.8 FIELD OBSERVATIONS

3.8.1 Microclimate Inside the Poly house

Minimum temperature, maximum temperature, relative humidity and light intensity inside the polyhouse during the crop season were measured using the Equinox Digital Temperature and Humidity meter (plate 3.10 (a)) and Equinox digital light meter(plate 3.10 (b))at 8 am, 2 pm, and 5 pm every day at crop canopy level.

Plate 3.10 (a) Plate 3.10 (b)

(a)Equinox digital temperature and humidity meter (b)Equinox digital light meter

3.8.2 DETERMINATION OF CHEMICAL PROPERTIES OF THE MEDIA

Plate 3.11 Water analyser toolkit

A limitation of EC is that it indicates only the total concentration of the solution and not the individual nutrient components. Higher EC will prevent nutrient absorption due to osmotic pressure and lower EC severely affect plant health and yield. When plants take up nutrients and water from the solution, the total salt concentration, i.e., the EC of the solution changes. If the EC is higher than the recommended range, fresh water must be added to reduce it and EC can be increased by adding KNO_3.

Variations in the EC values of the media were monitored during the crop growth period at mid-stage and late stages of the crop.

3.8.3 Plant Growth and Yield Parameters

Three plants from each treatment were selected at random and tagged for observations on growth and yield characters.

3.8.3.1 Plant Height

The height of the plant from base level of shoot to the tip was measured at ten days interval and expressed in centimetres for each treatment.

3.8.3.2 Number of Leaves

Number of leaves per plant was noted at ten days intervals in selected plants.

3.8.3.3 Flowering

Days to first flowering per plant was recorded at ten days intervals in both the crops.

3.8.3.4 Yield Parameters

Okra

In the case of okra, harvesting was started forty days after transplanting at an interval of two or three days. The weight of fruits harvested was noted from the tagged plants for each harvest. The fruit weight per plant was accordingly computed from the data of all harvests. Total twenty harvests were done and total yield was taken.

Salad Cucumber

Harvesting was started seventy five days after transplanting at an interval of two or three days. The number of fruits obtained and weight of fruits harvested were noted from the tagged plants for each harvest. The average value of fruit number per plant and fruit weight per plant was accordingly computed from the data of all harvests. Total five harvests were done and total yield was taken. The crop period was not over and harvest was continuing when the experiment was stopped. The results reported are upto the first five harvest of the crop.

3.9 DETERMINATION OF IRRIGATION 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.

WUE=Y/W.A =

Where,

WUE = Water Use Efficiency (kg/ha mm^{-1}) of water used

Y = Yield of the crops (kg ha^{-1})

W.A = Total water applied (mm)

3.10 STATISTICAL ANALYSIS

Statistical analysis was carried out to study the effects of alternate growing media, irrigation interval and their interaction effect on crop growth and yield parameters. The experiment was laid as factorial CRD design with three replications and the data collected were analyzed statistically as 2 × 3 factorial experiment. WASP 2.0 software was used to analyze data. Analysis of variance (ANOVA) was computed from WASP 2.0 software. Critical differences values (CDV) were used to compare the significant differences among mean of the treatments at 0.05 level of probability ie. at 5% level of significance.

RESULTS AND DISCUSSIONS

CHAPTER 4
RESULTS AND DISCUSSION

Results obtained from the field trials on the effect of alternate growing media and irrigation schedules for soilless culture of Salad Cucumber and Okra were analyzed and details are discussed under various headings in this chapter.

4.1 CLIMATIC PARAMETERS INSIDE THE POLYHOUSE

During crop growth period microclimate inside the poly house was recorded. Temperature, relative humidity and light intensity were recorded. They were recorded as per the procedure detailed in section 3.10.1.

Fig 4.1 shows weekly mean values of temperature inside poly house during the crop growing season. Maximum and minimum temperatures recorded were 36.95 and 27.20^{0}C in seventh and sixth week respectively and the minimum temperature ranges from 24 to 27^{0}C in the polyhouse. From the figure 4.1 it is understood that the temperature recorded was high in afternoon compared to morning and evening. In the fourth week the highest temperatures were recorded. In the sixth week a drastic drop in the temperature was recorded due to a change in climate caused by a rainfall event and hence the relative humidity was high and low light intensity was recorded.

In this study the high temperature inside polyhouse compared to open field was found to be an advantage as it benefitted the early maturity and yield. Cheema et al. (2004) reported that the early and higher yield of different vegetable crops inside the polyhouse was mainly because of better microclimate such as higher temperature (4-9°C more than the nearby open field) observed during winter months.

Fig 4.2 shows variations of weekly mean relative humidity inside the poly house during crop growing season. From the figure it can be seen that the relative humidity was lower at noon hours and, higher relative humidity was recorded during morning and evening hours. For poly house conditions, maximum and minimum relative humidity values were 63.21 and 43.76 percent during first week and eleventh week respectively.

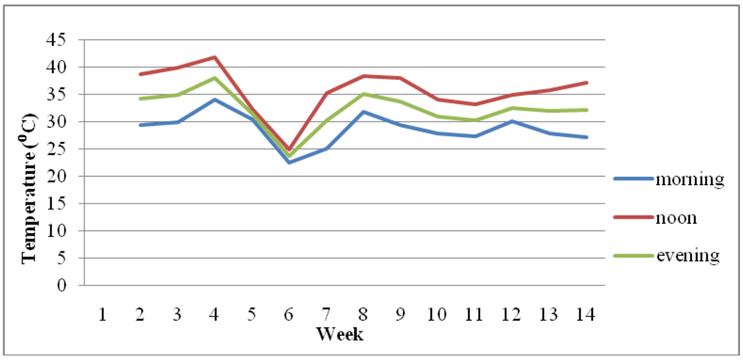

Fig.4.1 Temperature variation observed inside the polyhouse during the crop period

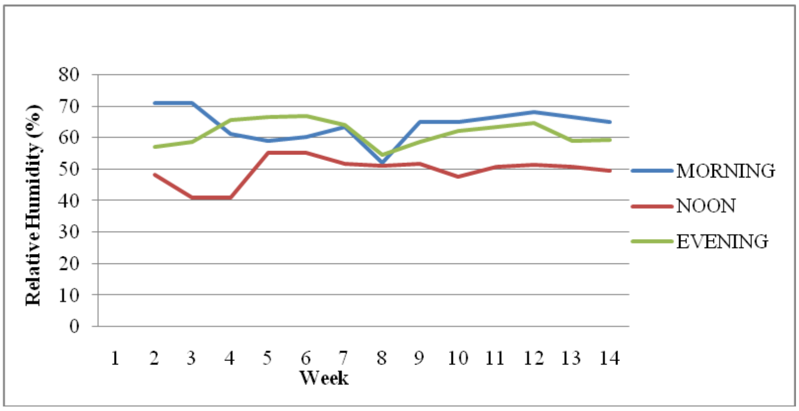

Fig. 4.2 Relative humidity variation recorded inside the polyhouse during the crop period

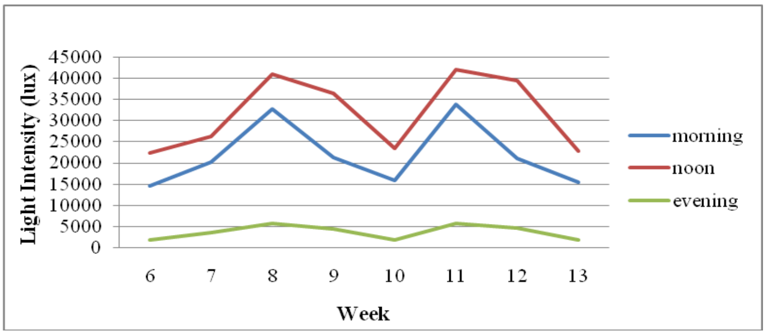

Fig 4.3 Weekly mean values of light intensity

The RH inside the polyhouse was always 5-10 % lower than that of the nearby open field. Parvej*et al.* (2010) had reported that better growth, development and yield of crop inside polyhouse were attained due to the higher (optimum) temperature and lower relative humidity during the winter months (December to February), which positively influenced the morpho-phenological and physiological events. In this study also, higher temperature and lower humidity were experienced inside polyhouse which benefitted crop growth positively.

Fig 4.3 shows weekly mean values of light intensity inside polyhouse during the crop growing season. Maximum and minimum light intensity recorded values were 7638.40 and 4208.42 lux in eleventh and sixth week respectively. In a poly house, the intensity of light can range from as much as 130,000 lux on a clear summer day to less than 3,000 lux on overcast winter days. It is recommended that in a polyhouse at least 4000 lux light intensity is required for photosynthesis process in plants.

4.2 OBERVATIONS ON CROP GROWTH AND YIELD PARAMETERS

Data on observations viz, number of leaves, plant height, days to first flowering and yield per plant for each treatment were observed during different stages of crop growth. The data were statistically analysed and the results are enumerated under the various headings.

The influence of alternate growing systems and irrigation interval on the crop growth and yield parameters are discussed in the following sections.

4.2.1 Okra

4.2.1.1 Plant height

Table 4.1 Effect of alternate growing systems and irrigation schedules on plant height (cm) during different growth stages

Treatment combinations	**10 DAT**	**20 DAT**	**30 DAT**	**40 DAT**	**50 DAT**	**60 DAT**	**70 DAT**	**80 DAT**	**90 DAT**
T1F1	17.67	22.33	26.33	30.67	49.00	71.67	105.00	105.00	**107.67**
T1F2	19.67	26.00	31.00	33.00	50.00	60.00	78.33	78.33	**85.50**
T1F3	22.00	28.66	31.50	32.67	42.33	57.33	62.67	62.67	**73.33**
T2F1	18.33	24.33	25.00	28.33	31.67	33.33	47.33	47.33	50.83
T2F2	18.67	22.00	21.83	23.00	37.00	42.33	50.67	50.67	52.00
T2F3	22.67	26.66	27.33	29.67	25.67	40.00	43.33	43.33	48.67
CDV (T*F)	5.55	6.61	7.46	12.02	25.88	31.97	28.78	34.86	36.64

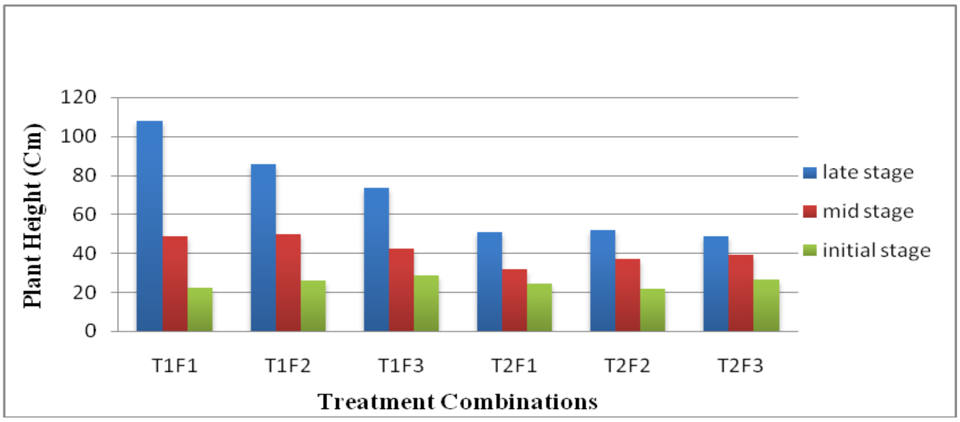

Fig 4.4 Growth stage wise variations of Okra height for different treatment combinations

4.2.1.2 Number of Leaves

From the Table 4.1 and Fig 4.4, it can be observed that plant height increased with crop growth and reached a maximum value of 107.67cm in T1F1 which is coirpith ,vermiculite and perlite media and in daily irrigation followed by 85.5 cm in the same media with alternate day irrigation and T1F3 which is also having greater okra height that is not significantly different. In the initial stage plant height was on par for all the treatments. but towards the later stages plant height was better in T1F1 and T1F2 than all the treatments usingErnakulum KVK media.

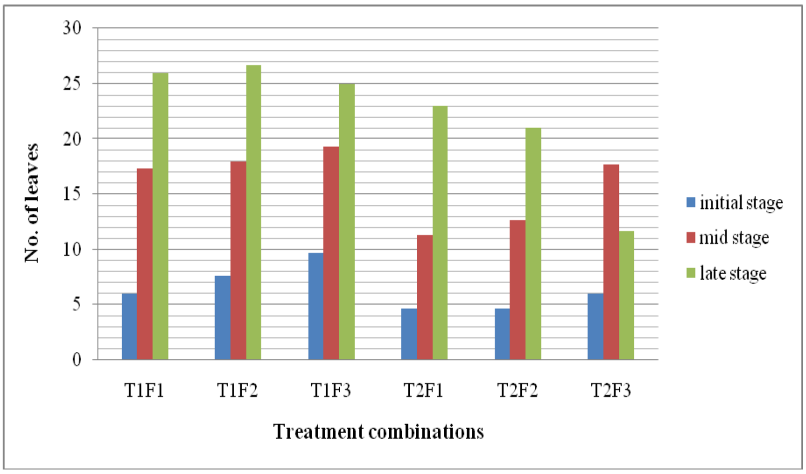

Fig 4.5 Growth stage wise variations of number of leaves in Okra for different treatment combinations

Table 4.2 Effect of alternate growing systems and irrigation interval on number of leaves during different growth stages

Treatment combinations	**10 DAT**	**20 DAT**	**30 DAT**	**40 DAT**	**50 DAT**	**60 DAT**	**70 DAT**	**80 DAT**	**90 DAT**
T1F1	4	6	8	13	17	18	26	24	**26**
T1F2	3	7	10	14	18	19	21	17	**27**
T1F3	3	9	13	17	19	18	21	20	**25**
T2F1	3	4	4	7	11	17	21	22	**23**
T2F2	3	4	5	10	12	13	20	20	**21**
T2F3	3	6	8	13	18	16	19.	20	**21**
CDV (T*F)5%	0.86	3.38	6	7.63	8.35	5.05	9.142	14.23	12.65

Table 4.2 and Fig 4.5 shows the variation of number of leaves of Okra during different growth stages. It is clear that T1F2 is on par with other treatment combinations. The number of leaves at the initial stages was almost equal and in late stages, plants grown in coirpith, vermiculite and perlite media was found to have more leaves than those in KVK media. The statistical results indicated that the number of leaves at different growth stages did not differ significantly with respect to alternate growing systems and all the treatments seemedto be on par.

4.2.1.3. Days to first flowering

In polyhouse with Ernakulum KVK media the earliest flowering was observed in T2F3 after 16 days of transplanting and T1F2 was late by six days. Remaining treatments have no significant difference in first flowering. Crop in the flowering stage is shown in Plate 4.1.

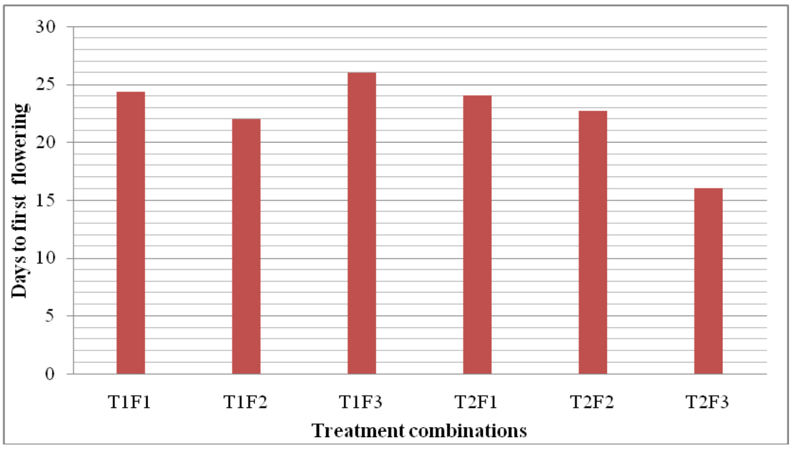

Fig 4.6 Variations of days to first flowering in various stages of crop growth

Plate 4.1 Okra at flowering stage

4.2.1.4 Crop yield per plant

Table 4.3 Effect of alternate growing systems and irrigation schedules on total yield per plant.

TREATMENT COMBINATION	**CROP YIELD (kg)/plant**
T1F1	0.02
T1F2	0.09
T1F3	0.03
T2F1	0.07
T2F2	0.07
T2F3	0.10
CDV(T*F) 5%	0.06

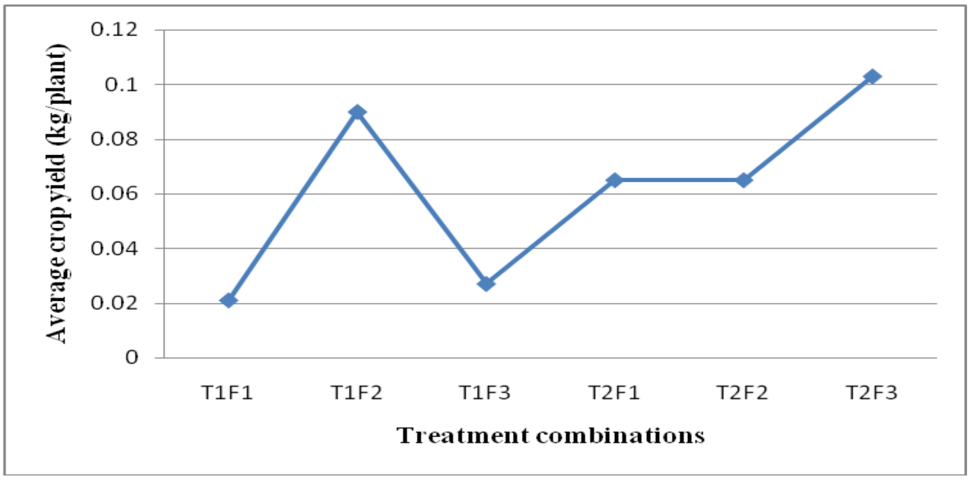

Fig 4.7 Variations of crop yield in various treatment combinations

The highest yield was for T2F3 (0.1kg/plant) followed by T1F2 (0.09kg/plant). The next higher value was for T2F1 and T2F2. There is not much significant difference in the yield obtained from T1F2 and T2F3 but much higher yield was obtained from Ernakulum KVK media. Okraat harvesting stage is shown in Plate 4.2.

Plate 4.2 Okra at harvesting stage

4.2.2 Salad cucumber

4.2.2.1 Plant height

Table 4.4 Effect of alternate growing systems and irrigation interval on plant height (cm) during different growth stages

Treatment means	**10 DAT**	**20 DAT**	**30 DAT**	**40 DAT**	**50 DAT**	**60 DAT**	**70 DAT**	**80 DAT**
T1F1	38.67	125.33	206.66	0.00	0.00	23.66	91.66	92.00
T1F2	34.17	89.67	160.00	195.00	305.0	187.66	221.66	**310.30**
T1F3	19.00	31.00	58.66	76.70	86.70	133.33	211.66	**276.60**
T2F1	12.00	44.33	135.00	0.00	0.00	26.33	86.66	87.00
T2F2	13.33	46.67	103.33	128.3	125.0	135.00	190.00	**241.60**
T2F3	14.00	18.66	47.66	81.70	101.60	123.33	178.33	**216.60**
CDV(T*F)	18.07	65.32	130.84	80.5	89.50	139.51	92.89	160.00

From the Table 4.4 and Fig 4.9, it can be observed that plant height increased with crop growth and reached a maximum value of 310.3cm in T1F2 which is coirpith, vermiculite and perlite media and in alternate day irrigation followed by 276.6cm in the same media with once in three day irrigation. In the initial stage, plant height was significantly higher for T1F1 and T1F2 treatments. But in the later stages plant height was better in T1F2 and T1F3 than all the treatments of KVK media.

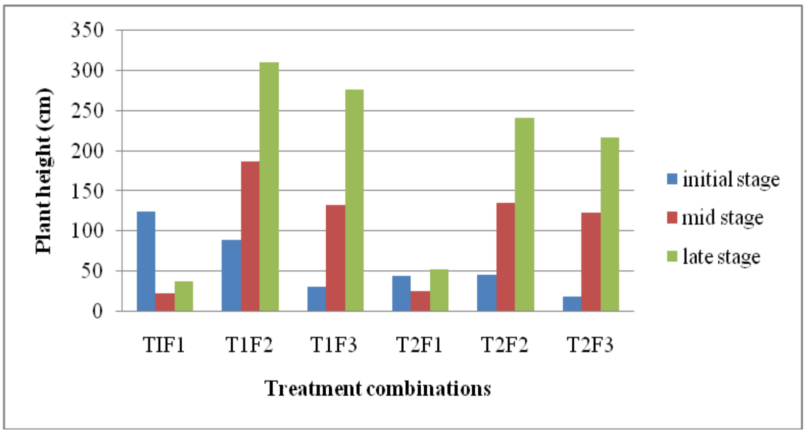

Fig 4.8 Variations of salad cucumber height in various stages of crop growth

4.2.2.2 Number of Leaves

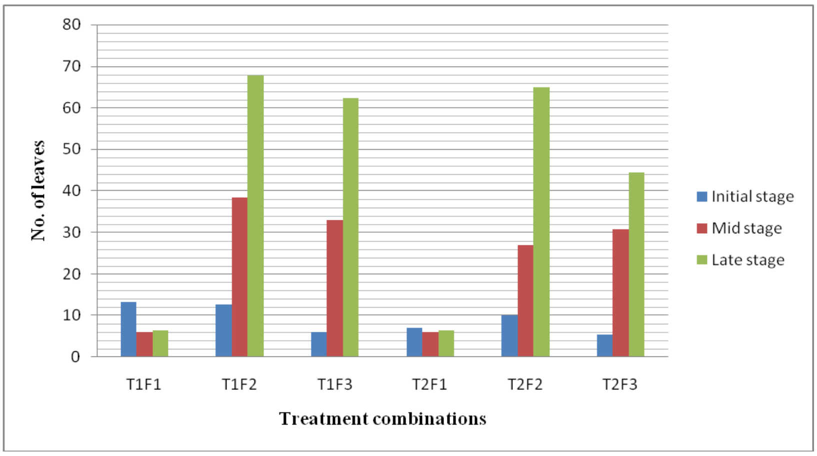

Fig 4.9 Variations of number of leaves in salad cucumber under various stages of crop growth

Table 4.5 Effect of alternate growing systems and irrigation schedules on number of leaves during different growth stages

Treatment means	**10 DAT**	**20 DAT**	**30 DAT**	**40 DAT**	**50DAT**	**60 DAT**	**70DAT**	**80 DAT**
T1F1	6	13	33	0	0	6	8	10
T1F2	5	12	16	13	14	38	49	**67**
T1F3	3	6	8	7	28	33	53	**62**
T2F1	3	7	21	0	0	6	12	13
T2F2	5	10	13	15	15	27	53	**65**
T2F3	1	5	9	8	24	30	39	44
CDV (T*F)	3.18	5.22	16.35	5.67	10.29	36.87	45	23.27

Table 4.5 and Fig 4.10, shows the variation of number of leaves during different growth stages. It is clear that T1F2 has higher number of leaves when compared with other treatment combinations. The number of leaves at the initial stages was almost equal and in late stages, coirpith, vermiculite and perlite media was found to have more leaves than Ernakulum KVK media. The statistical analysisresults indicated that the number of leaves at different growth stages did not differ significantly at 5% level of significance with respect to alternate growing systems and all the treatments seemed to be on par except in the case of T1F1 and T2F1. In T1F1 and T2F1 treatment combinations the plants were replanted due to fungal disease in the root zone.

4.2.2.3. Days to first flowering

In polyhouse the earliest flowering was observed in T2F3 after 26 days of transplanting and T2F2 was late by two days ie in KVK media. But not much significant difference in days to first flowering is observed. Crop at the flowering stage is shown in Plate 4.3.

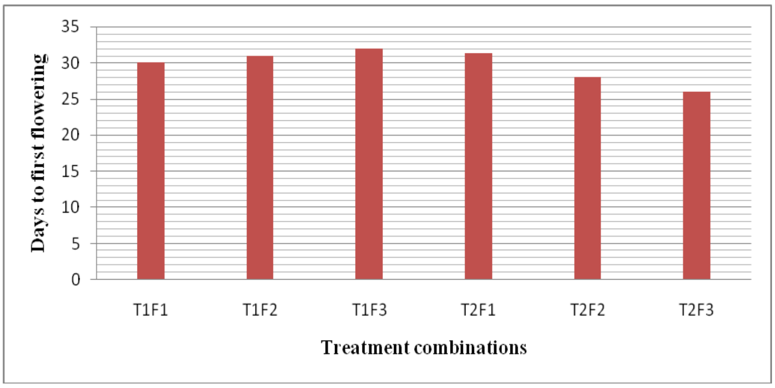

Fig 4.10 Variations of days to first flowering in various treatment combinations

Plate 4.3 Crop at flowering stage

Plate 4.4 Crop at harvesting stage

4.2.2.4 Crop yield

Table 4.6 Effect of alternate growing systems and irrigation schedules on yield per plant after five harvest.

Treatment combinations	Crop yield (kg/plant)
T1F1	0
T1F2	0
T1F3	0.25
T2F1	0
T2F2	0.06
T2F3	0.18

Variability of yield of salad cucumber was taken up to five harvests that were observed from 19th to 22nd January 2019.The data collection was stopped at that stage due to time limit and only data upto five harvests is included in the comparison. The highest yield was for T1F3 (0.25kg/plant) followed by T2F3 (0.18kg/plant). The yield is not obtained in treatment combinations T1F1, T1F2 and T2F1 up to the 19th January and the harvest was still expected. From the experimental study it was not able to conclude which media is better in terms of yield. So within our experimental limits we can say both the media is good but coirpith, perlite, vermiculite media proved to be more superior.Salad cucumberat harvesting stage is shown in Plate 4.4.

So the overall analysis in case of okra on the effect of alternate growing systems reveals that all the vegetative parameters was found to be better in T1 treatment that is coirpith, vermiculite and perlite media whereas yield of crops was found to be better in T2 treatment that is Ernakulam KVK media. Compared to crops under daily and once in three days irrigation alternate day irrigation resulted in best performance in all the growth parameters and yield. The growth parameters were found to be better in crops under once in three days irrigation compared to daily irrigation except number of flowers and yield.

In case of salad cucumber, within our experimental limits we can say both the media is good but T1 treatment that is coirpith, perlite, vermiculite media proved to be more superior in terms of vegetative parameters.From the experimental study it was not able to conclude which media is better in terms of yield but highest yield was obtained in T1 treatment.

4.3 CHEMICAL PROPERTIES OF SOILLESS MEDIA

4.3.1 Electrical conductivity

Variation of media EC value during crop growth period (Okra)

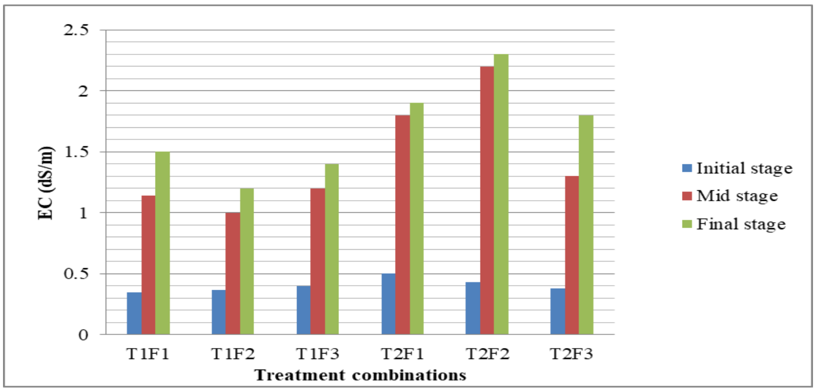

Fig.4.11 Variation of EC for different stages of okra

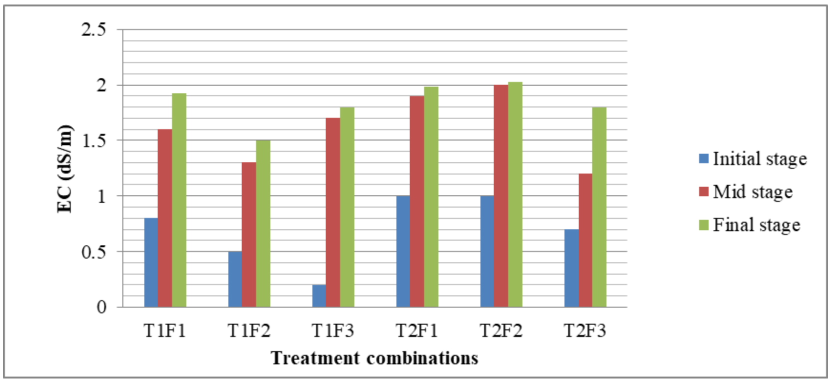

Fig 4.12 Variation of EC for different stages of Salad_cucumber

Table 4.7 Variation of EC (dS/m) for different stages of Okra

Treatment combinations	Initial stage	Mid stage	Final stage
T1F1	0.35	1.14	1.5
T1F2	0.37	1	1.2
T1F3	0.4	1.2	1.4
T2F1	0.5	1.8	1.9
T2F2	0.43	2.2	2.3
T2F3	0.38	1.3	1.8

Fig 4.11 shows the fluctuation of electrical conductivity (dS/m) during crop growing season. The highest EC (dS/m) was observed in T2F2 (2.3) in final stage. In this treatment EC was high in the initial stage also and the amendment with fresh water had to be given. The lowest EC was obtained in T1F2 (1.2) and T1F1 (0.35) in initial stage.

The optimum level of EC for okra was 2-2.4 dS/m. Higher EC will prevent nutrient absorption due to osmotic pressure and lower EC severely affect plant health and yield (Aatif et al., 2014). From the Table 4.7 it is clear that almost all the values of EC for all treatments during different crop growth stages were within the ideal range.

Variation of media EC (dS/m) value during crop growth period (Salad cucumber)

Table 4.8 Variation of EC (dS/m) for different stages of crop

Treatment combinations	Initial stage	Mid stage	Final stage
T1F1	0.8	1.6	1.92
T1F2	0.5	1.3	1.5
T1F3	0.2	1.7	1.8
T2F1	1	1.9	1.98
T2F2	1	2	2.03
T2F3	0.7	1.2	1.8

Fig 4.12 shows the fluctuation of electrical conductivity (dS/m) during crop growing season. The highest EC (dS/m) was observed in T2F2 (2.03) in the final stage. The lowest EC was obtained in T1F2 (1.5) . The optimum level of EC for salad cucumber was 0.8 (initial stage), 1.2 (flowering stage) and 1.5 or 1.8 (fruiting stage). From table 4.8 it is clear that almost all the values of EC for all treatments during different crop growth stages were within the ideal range.

4.3.2 Irrigation Water Use Efficiency (IWUE)

Variation of IWUE value during crop growth period (Okra)

Fig 4.13 shows the water use efficiency values obtained under the various treatments. Water use efficiency is greatly improved by scheduling irrigation when plants can utilize the water more effectively.

From the Fig 4.13 and Table 4.9 it is seen that irrigation scheduling significantly affected irrigation water use efficiency (IWUE). The highest IWUE in okra crop was for T2F3 (41.63 kg/ ha.mm) with once in three days irrigation and lowest was T1F1(2.88 kg/ ha.mm) with daily irrigation. In an area with water shortage as well as problematic soil, cultivation using Ernakulum KVK media with once in three days irrigation can be suggested as WUE was observed very high for the crops under once in three days irrigation compared to other treatments. Even though crops under alternate day irrigation were identified with remarkable yield, once in three days irrigation can be suggested in the areas experiencing water shortage.

The soilless culture demands 10 times less water than traditional cultivation for the same yield (Melgarejo and Martinez., 2007).

Table 4.9 Variation of irrigation water use efficiency (kg/ha.mm) for different treatments

Treatments	Yield (kg/ha mm)	Water applied (mm)	WUE(kg/ha mm)
T1F1	3703.7	1284.7	2.88
T1F2	4745.37	642.36	7.38
T1F3	11226.85	428.125	26.22
T2F1	15277.77	1284.7	11.89
T2F2	11226.85	642.36	17.47
T2F3	17824.07	428.125	41.63

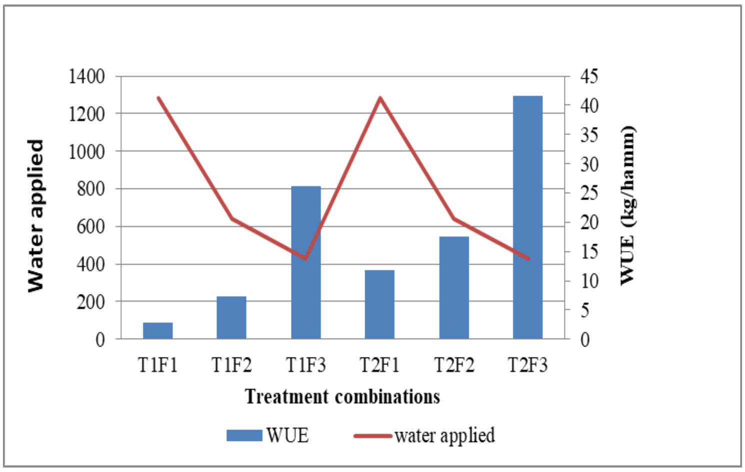

Fig 4.13 Variation of irrigation water use efficiency for different treatments

<u>Variation of IWUE value during crop growth period (Salad cucumber)</u>

Fig 4.14 shows the water use efficiency values obtained under the various treatments. Water use efficiency is greatly improved by scheduling irrigation when plants can utilize the water more effectively.

From the Fig 4.14 and Table 4.10 it is seen that irrigation scheduling significantly affected irrigation water use efficiency (IWUE). The highest IWUE was for T1F3 (75.4kg/ ha.mm) with once in three days irrigation and in some of the treatment combinations yield data was not complete but the harvest is still continuing. Following T1F3 is T2F3 hence both the media is good in terms of water use efficiency but better is coirpith, perlite and vermiculite media in the case of salad cucumber.

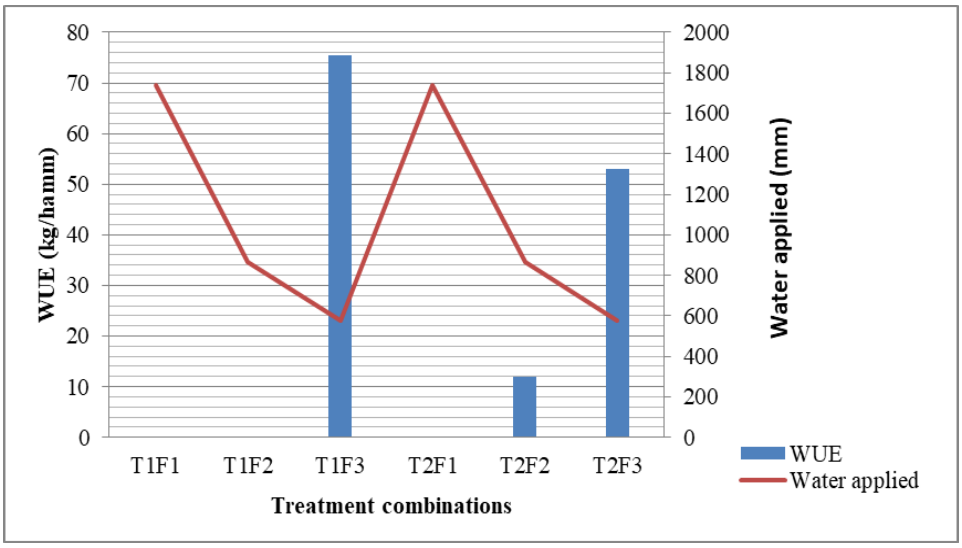

Fig 4.14 Variation of irrigation water use efficiency for different treatments

Table 4.10 Variation of irrigation water use efficiency (kg/ha.mm) for different treatments at the end of five harvests

Treatments	Yield (kg/ha mm)	Water applied (mm)	WUE(kg/ha mm)
T1F1	0	1736.11	0
T1F2	0	868.05	0
T1F3	43634.26	578.64	75.4
T2F1	0	1736.11	0
T2F2	10416.66	868.05	12
T2F3	30671.29	578.64	53

The following table shows the consolidated data on the effect of alternate growing systems and irrigation schedules on crop performance

Table 4.11 Consolidated data on the effect of alternate growing systems and irrigation schedules on performance of Okra

Treatment combinations	Height (cm)	No. of leaves	Yield (g/plant)	Days to first flowering	WUE (kg/ha mm)
T1F1	107.67	26	21.33	24.33	2.88
T1F2	85.50	27	88	22	7.38
T1F3	73.33	25	27.33	26	26.22
T2F1	50.83	23	64.66	24	11.89
T2F2	52.00	21	64.66	22.66	17.47
T2F3	48.67	21	102.66	16	41.63

So the overall analysis of the effect of alternate growing systems and irrigation schedules on okra reveals that in terms of vegetative growth, coirpith, vermiculite and perlite media in daily irrigation scheduling was found to be best than other treatment combinations. The alternate day irrigation and three days once irrigation treatments were not significantly different from daily irrigation which shows that even with three days once irrigation, vegetative growth is not seriously affected. In case of Ernakulum KVK media, it is a novel growing media as more crop yield was obtained. The vegetative growth parameters were found to be better in crops under daily irrigation and alternate irrigation compared to once in three days irrigation except number of flowers and yield.

This study revealed that okra *Varsha Upahar* variety with once in three days irrigation in Ernakulum KVK media provided us with a remarkable yield but in terms of vegetative growth coirpith, vermiculite and perlite media in daily and alternate irrigation scheduling were found to be better. Even crops under alternate day irrigation provided remarkable yield and for an area with water shortage cultivation using Ernakulum KVK media with once in three days irrigation can be suggested. The WUE was observed very high for the crops under once in three days irrigation compared to daily and alternate day irrigation. In an area with sufficient amount of water alternate day irrigation can be suggested.

Table 4.12 Consolidated data on the effect of alternate growing systems and irrigation schedules on performance of salad cucumber

Treatment combinations	**Height (cm)**	**No. of leaves**	**Yield (g/plant)**	**Days to first flowering**	**WUE (kg/ha mm)**
T1F1	92.00	10	0	30	0
T1F2	**310.3**	**67**	0	31	0
T1F3	276.6	62	**251.33**	32	**75.4**
T2F1	87.00	13	0	31.33	0
T2F2	241.6	65	60	28	12
T2F3	216.6	44	176.66	**26**	53

The overall analysis of salad cucumber was done based on the yield obtained up to five harvests, that was from 19th Jan 2019 and the harvest was continuing. The table shows that the effect of alternate growing systems reveals that in terms of vegetative growth coirpith, vermiculite and perlite media in alternate irrigation scheduling was found to be better than other treatment combinations. Ernakulum KVK media is a novel growing system when three days once irrigation is given. The vegetative growth parameters were found to be better in crops under daily irrigation and alternate irrigation compared to once in three days irrigation except number of flowers and yield. This study revealed that salad cucumber *Hilton* variety with once in three days irrigation in coirpith, vermiculite and perlite media provided us with a remarkable yield and in terms of vegetative growth daily and alternate irrigation scheduling in the same media were found to be better. The WUE was observed very high for the crops under once in three days irrigation compared to daily and alternate day irrigation. In an area with sufficient amount of water alternate day irrigation can be suggested.

SUMMARY AND CONCLUSIONS

CHAPTER 5
SUMMARY AND CONCLUSION

Field experiment on the effect of alternate growing media and irrigation schedules for soilless culture of Okra and Salad Cucumber under drip irrigation were conducted inside the naturally ventilated polyhouse in the research plot of Department of Irrigation and Drainage Engineering situated near the LH KCAET, Tavanur, during October 2018 to January 2019. In the present study, data on climatic, plant morphological, chemical and yield parameters were recorded. The summary of the results obtained from the experiments and the conclusions drawn out of field experimentation are presented in this chapter.

Experiment location lies in the cross point of 10.85^0N latitude and 75.98^0E longitude and the area of the poly house is 208 Sq. m (Length=26 m, Width=8 m). In this experiment, the land was levelled and beds were raised. Okra variety *Varsha Upahar* and salad cucumber variety *Hilton* were chosen for cultivation. The experiment was laid out in factorial completely randomized design. The plot was divided into 2 parts with okra on one half and salad Cucumber on other half having three treatments with three replications and two factors. Two factors were two types of growing media viz. coirpith, vermiculite and perlite mixture (F1) and Ernakulam KVK media (composted pressmud along with coir pith, powdered cow dung, neem cake, dolomite and biocontrol agents)(F2). Six okra and salad Cucumber plants were planted under each replication. Treatment details consisted of T1F1 (coirpith, vermiculite and perlite mixture with daily irrigation), T1F2 (coirpith, vermiculite and perlite mixture with alternate day irrigation), T1F3 (coirpith, vermiculite and perlite mixture with once in 3 days irrigation), T2F1 (KVK media with daily irrigation), T2F2 (KVK media with alternate day irrigation), and T2F3 (KVK media with once in 3 days irrigation).

Fertigation is the supply of fertilizers and water at the same time. All nutrients essential for crops could be supplied through hydro soluble fertilizer salts from two tanks (tank A and tank B) through fertigation pump. Same quantities of fertilizers were applied in each treatment by maintaining electrical conductivity. The fluctuations of electrical conductivity (dS/m) during crop growing season were observed using water analyser toolkit. In the case of okra highest EC (dS/m) was observed in T2F2 (2.3) in final stage. In this treatment EC was high in the initial stage also and the amendment with fresh water had to be given. The lowest EC was obtained in T1F2 (1.2) and T1F1 (0.35) in initial stage. The optimum level of EC for okra was 2-2.4 dS/m. Higher EC will prevent nutrient absorption due to osmotic pressure and lower EC severely affect plant health and yield (Aatif et al., 2014). In the case of salad cucumber the highest EC (dS/m) was observed in T2F2 (2.03) in the final stage whereas lowest EC was obtained in T1F2 (1.5).The optimum level of EC for salad cucumber was 0.8 (initial stage), 1.2 (flowering stage) and 1.5 or 1.8 (fruiting stage).

The data on micro climate such as temperature and relative humidity were periodically recorded in polyhouse. Higher humidity was observed inside the polyhouse during morning hours and value gradually decreased in the afternoon because of increase in temperature. Maximum and minimum temperature recorded values were 36.995 and 27.2^{0}C in seventh and sixth week respectively. Data on vegetative parameters like height, number of leaves, days to first flowering and total yield per plant were observed during 10 day interval. Statistical analyses of the results were carried out using WASP 2 software. In case of okra crop maximum vegetative growth was found in coirpith, perlite and vermiculite mixture whereas remarkable yield was obtained in KVK media. In salad cucumber *Hilton* variety with once in three days irrigation in coirpith, vermiculite and perlite media provided us with a considerable yield and in terms of vegetative growth daily and alternate irrigation scheduling in the same media were found to be better.

So the overall analysis in case of okra on the effect of alternate growing systems reveals that all the vegetative parameters was found to be better in T1 treatment that is coirpith, vermiculite and perlite media whereas yield of crops was found to be better in T2 treatment that is Ernakulam KVK media. Compared to crops under daily and once in three days irrigation alternate day irrigation resulted in best performance in all the growth parameters and yield. The growth parameters were found to be better in crops under once in three days irrigation compared to daily irrigation except number of flowers and yield.

In case of salad cucumber, within our experimental limits we can say both the media is good but T1 treatment that is coirpith, perlite, vermiculite media proved to be more superior in terms of vegetative parameters. From the experimental study it was not able to conclude which media is better in terms of yield but highest yield was obtained in T1 treatment.

REFERENCES

REFERENCES

Aatif, H., Kaiser, I., Showket, A., Prasanto, M., and Negi, A. K. 2014. A review on the science of growing crops without soil (Soilless Culture) – A novel alternative for growing crops. Int. J. Agric. Crop. Sci. 11:833-842.

Abad, M., Noguera, P., Puchades, R., Maquieira, A., and Noguera, V. 2001. Physico-chemical properties of some coconut coir dusts for use as a peat substitute for containerised ornamental plants. Bioresour. Technol. 82(3): 241-245.

Abou-Hadid, A.F., El-Shinawy, M.Z., El-Oksh, I., Gomaa, H., and El-Beltagy, A.S. 1994. Studies on water. Acta Hort. 366(45): 365-372.

Albaho, M., Bhat, N., Thomas, B.N., Isathali, S., George, P., and Ghloum, D. 2013. Alternative Growing Media for Production of Cucumber Cultivar „Banan" for Soilless Culture in Kuwait. Acta Hort. 1004: 115-122.

Ali, A. G. 2013. Simulation of Peanut (Arachis hypogaea L.) with Cropwat Model in Irrigation Condition and Rainfed. J. Sci. Agric. 2(3): 54-59.

Allen, R.G., Pereira, P.L., Raes D., Smith, M., 1998. Crop Evapotranspiration on-Guidelines for Computing Crop Water Reguirements. FAO Irrigation and Drainage Paper 56.

Anaç, D. 2004. Nutrient Management in the Protected Agriculture of Turkey. IPI regional workshop on Potassium and Fertigation development in West Asia and North Africa, Rabat, Morocco.

Atefe, A., Ali, T., Mahmoud, S., and Gholam, H. 2012. Effect of substrate and cultivar on growth characteristic of strawberry in soilless culture system. Afr. J. Biotechnol. 11(56): 11960-11966.

Atiyeh, R. M., Edwads, C. A., Subler, S., and Metzger, J. D. 2001. Pig manure vermicompost as a component of a horticultural bedding plant medium: 122 effects on physical properties and plant growth. *Bioresour. Technol*. (78):11-20.

Ayse, G., Funda, K., and Dileka. 2007. Effect of nutrient sources on cucumber production in different substrates. *J. Sci. Hortic.* 113(2): 216-220.

Bunce A. 1984. Effects of Humidity on Photosynthesis. *Journal of Experimental Botany*, Volume 35, Issue 9, September 1984, Pages 1245–1251,https://doi.org/10.1093/jxb/35.9.1245

Bernstein, N., Bar, T. A., and Friedman, H. 2006. Application of treated waste water for cultivation of roses (Rosa hybrida) in soil-less culture. *Sci. Hortic*.108:185–193.

Cantiffe, D. J., Funes, J., Jovicich, E., Paranjpe, A.,Rodriguez, J., and Shaw, N. 2007. Media and containers for greenhouse soil less grown cucumbers, melons, peppers and strawberries. *Acta Hort*. 614: 199-203.

Dayananda, M. A. I. and Wahundeniya, W. M. K. B. 2001. Effect of different systems and media on growth of lettuce (Lactuca sativa) under protected culture.

Duggan, D. I., Nichols, M. A., and Woolley, D. J. 2013. Effect of Physical Characteristics of Coir on the Productivity of Greenhouse Tomatoes. *Acta. Hort*. 1004p.

Enujeke, E. C. 2013. Growth and yield responses of cucumber to five different rates of poultry manure in Asaba area of Delta state, Nigeria. *J. Int. Res.* 3(11): 369-375.

Francisco, M. A. and Maria, D. G. 2010. Agronomical response and water use efficiency of sweet pepper plants grown in different greenhouse substrates. *Hortic. Sci*. 44(3): 810-814.

Harmantoa, V.M., Salokhea, M.S. Babelb., and Tantau, H. J. 2004. Water requirement of drip irrigated tomatoes grown in greenhouse in tropical environment. Agric. Water Manag. 71:225–242.

Harmsen, E., Joel, C .T., Carmen, L. A., and Dionel, C. R. 2002. Evaluation of percolation and nitrogen leaching from a sweet pepper Crop grown on an oxisol soil in northwest Puerto Rico. *J. Trop. Agric. Res.* Vol.39.

Hochmuth, G. and Hochmuth, R. 2003. Open-field Soilless Culture of Vegetables. University of Florida Cooperative Extension Service, *Inst. Food and Agric. Sci,* EDIS.

Hossain M. F., Uddin, M. R., and Ara Nand, M. S. (2012) Comparative study of coirpith and cowdung on growth and yield of summer tomato, *Bull. Inst. Trop. Kyushu Univ*. 35: 47-51.

Jamaludin, D. 2009. Effect of Temperature and Relative Humidity on Crop Yield in Tropical Greenhouse with Evaporative Cooling System, University Putra, Malaysia.

Janapriya, S., Palanisamy, D., and Mohanalakshmi, M. 2010. Evaluation of soil less media on growth parameters of cucumber (Cucumis satvus L.) under naturally ventilated polyhouse. Green Farming. 3(1): 5-7.

Jose, A. M., Daniel, F.C., Leonardo, O. M., Leonardo, D. B., and Carlos, P. 2013. Growth analysis and yield of tomato crop under different irrigation depths. *Revista Brasileira de Eng. Agríc. e Ambient*. 17: 926-931.

Kannan, P., Saravanan, A., Krishnakumar and S. Natarajan 2005. Biological Properties of Soil as Influenced by Different Organic Manures. Res. J. Agric. and Biol. Sci. 1(2): 181-183.

Kavitha, E. R., Vijayaraghavan, N., and Tajuddin. A. 2003. Response of Vegetable Crops in a Solar aided Poly-house Ecosystem. J. Inst. Eng. India. 84: 52-55.

Kittas, c., Karamanis, M., and katsolas, N. 2005. Air temperature regime in a forced ventilated

Maragatham, D. and Samuel, P. R. 2010. Physical characteristics of coirpith as a function of its particle size to be used as soilless medium. *Am. Eur. J. Agric. And Environ. Sci*. 8(4): 431-437.

Metin, S. S., gulendam, C., Attila, y., Servet, T., and Burcak, K. 2010. Effect of irrigation management on yield and quality of tomatoes grown in different soilless media in a glasshouse. *Sci. Res. Essay*. 5(1): 41-48.

Miranda, F. R., Gondim, R. S., and Costa, C. A. G. 2005. Evapotranspiration and crop coefficients for tabasco pepper (*Capsicum frutescens* L.). *J. Agric. Water. Manag.* 82: 237-246.

Narendar , R and K. Priya, D. 2013. Effect of Chemical Treatment on the Mechanical and Water Absorption Properties of Coirpith/Nylon/Epoxy Sandwich Composites. *Int. . Polymer. Anal. Charact.*, 18: 369–376.

Neethi, M. and Subramanian, P. 2006.study of physical properties of coirpith. *Int. J. Green. Energy*. 3: 397- 406.

Norrizah, J. F., saiyidah, N. H., Yaseer, S. M., and Shamsiah, A. 2012. Chararacterization of plant growth, yield and fruit quality of rock cultivars planted on soilless culture. *J. Plant Sci. 7: 186-193.*

Parks, S., Newman, N., Pham, L.M., and Tran, T.K..2005. Exploratory data for improving food safety in Vietnam using soilless vegetable production. *Acta Hortic*. 648: 129-133.

Rajarathnam,S .and Shashirekha,M.N. 2007. Bioconversion and biotransformation of coirpith for economic production of Pleurotus florida: chemical and biochemical changes in coirpith during the mushroom growth and fructification. *World. J. Microbiol. Biotechnol*. 23: 1107 -1114.

Rasool, A., Mousa, T. G., and Rahim, D. T. 2008. Influence of vermicompost on soil chemical and physical properties in tomato (Lycopersicum esculentum) field. *Afr. J. Biotechnol.* 7 (14): 2397-2401.

Rodriguez, J. C., Cantlifee, D. J., and Shaw, N. L. 2006. Soilless media and containers for greenhouse production of „Galia" type muskmelon. *Hortic. Sci.* 41(5):1200-1205.

Sabeena, S. and Megha, P. 2012. Crop water requirement and irrigation scheduling of K.C.A.E.T. Instructional farm using CROPWAT model. B.Tech.(Ag) project. Kerala Agricultural University, Thrissur,104p.

Sanchez-Guerrero, M.C., Lorenzo, P., Medrano, E., Baille, A., and Castilla, N. 2009. Effects of EC-based irrigation scheduling and CO2 enrichment on water use efficiency of a greenhouse cucumber crop. *Agric. water manag.* 96: 429 – 436.

Savvas, D., Giotis, D., Chatzieustratiou, E., Bakea, M., Patakioutas, G., 2009. Silicon supply in soilless cultivations of zucchini alleviates stress induced by salinity and powdery mildew infections. J. Biol. Environ. Sci. 65: 11–17.

Spehia R S. 2015. Status and impact of protected cultivation in Himachal Pradesh, India. Current Science, 108, 2254-2257.

Serhat, A. and Çigdem, D. 2009. Deficit irrigation effects on pepper (*Capsicum annuum* L. Demre) yield in unheated greenhouse condition. *J. Food, Agric. & Environ.*7: (3&4) : 989-993.

Shahnaz, S., Yoshikazu, K., Masanobu, E., Tomoya, K., and Akira N. 2008. Effect of Fertigation Management and the Composition of Nutrient Solution on the Yield and Quality of High Soluble Solid Content Tomatoes. *J.Japan. Soc. Hortic. Sci*. 77 (2): 143–149.

Shao Guang-Chenga, Zhang Zhan-Yua, Liu Nac, Yu Shuang-Ena, and Xing Weng-Gang. 2010. Comparative effects of deficit irrigation (DI) and 128 partial root zone drying (PRD) on soil water distribution, water use, growth and yield in greenhouse grown hot pepper. *Sci. Hortic.* 119: 11–16.

Singandhupe, *R.* B., Rao, G. G. S. N., Patil, N. G., and Brahmanand, P. S. 2002. Fertigation studies and irrigation scheduling in drip irrigation system in tomato crop (*Lycopersiconesculentum* L.). *Eur. J. Agron*. 19: 327-340.

Takela, G. and Desalegn, C. 2009. Effect of drip irrigation level and planting method on water use efficiency, Irrigation uniformity and yield in green pepper (Capsicum annum L.) in Bako, Ethopia. *J.agwat.* 96: 11-96.

Wang, X.,, Li Dengshun and Zhang, X. 1999. Relationship between irrigation amount and yield of cucumber in solar greenhouse. *J. China Veg.*

Xiao, Z., W. Jiang, H. Yu and M. Wang. 2009. Substrate water content and nitrogen interactions in growing media: yield, fruit quality, water consumption and water use efficiency on tomato. *Acta Hort.* 843:57-64.

Xiaobo, P., Zhang, F., and Gao, L. 2002. Study on water requirement of cucumber of different cropping in solar greenhouse. *J. Chin. Agric. Sci. Bull.*

Zabihoah, R., Abdolhossein, A., Abdolrasoul, Z. 2013. Comparison of different medium for production of Sweet pepper transplant. *Int. Res. J. Appl. Basic. Sci.* 4(2): 307-310.

APPENDICES

APPENDIX I

Micro climate inside polyhouse

Week	Max RH	Max Temp	Min RH	Min Temp	Light
1	63.21	31.75	61.1	31.17	
2	58.01	39.66	56.47	33.65	
3	56.5	35.9	54.14	34.77	
4	59.76	31.07	55.37	29.74	
5	61.8	24.66	58.9	27.34	
6	59.8	28.3	56.3	27.2	4208.425
7	56.407	36.955	49.6	35.28	5096.14
8	54.6	35.45	51.403	34.6	6229.7
9	55.71	35.09	54.22	34.63	7287.85
10	56.01	34.41	52	36.02	5803.57
11	50.037	36.428	43.716	36.1915	7638.4
12	53.903	37.2	46.72	35.407	6226.28
13	50.2	36.9	46	35.4	5504.6

APPENDIX II

Annova table of Salad Cucumber height for 10 days interval

10 Days

Critical Difference Values		
-	CD 5%	CD 1%
Factor A	10.437	14.845
Factor B	12.783	18.181
Treatments/(AxB)	18.077	25.712

20 Days

Critical Difference Values		
-	CD 5%	CD 1%
Factor A	37.714	53.642
Factor B	46.19	65.698
Treatments/(AxB)	65.322	92.911

30 Days

Critical Difference Values		
-	CD 5%	CD 1%
Factor A	75.545	107.451
Factor B	92.523	131.601
Treatments/(AxB)	130.848	186.111

40 Days

Critical Difference Values		
-	CD 5%	CD 1%
Factor A	110.417	167.272
Factor B	110.417	167.272
Treatments/(AxB)	156.153	236.558

50 Days

Critical Difference Values		
-	CD 5%	CD 1%
Factor A	123.185	186.616
Factor B	123.185	186.616
Treatments/(AxB)	174.211	263.914

60 Days

Critical Difference Values		
-	CD 5%	CD 1%
Factor A	80.549	114.568
Factor B	98.651	140.317
Treatments/(AxB)	139.514	198.438

70 Days

Critical Difference Values		
-	CD 5%	CD 1%
Factor A	53.632	76.283
Factor B	65.685	93.427
Treatments/(AxB)	92.893	132.126

80 Days

Critical Difference Values		
-	CD 5%	CD 1%
Factor A	70.294	106.489
Factor B	70.294	106.489
Treatments/(AxB)	99.41	150.598

90 Days

Critical Difference Values		
-	CD 5%	CD 1%
Factor A	334.512	614.043
Factor B	334.512	614.043
Treatments/(AxB)	473.072	868.388

APPENDIX III

Annova table of Okra height for 10 days interval

20 Days

Critical Difference Values		
-	CD 5%	CD 1%
Factor A	3.821	5.434
Factor B	4.679	6.656
Treatments/(AxB)	6.618	9.413

30 Days

Critical Difference Values		
-	CD 5%	CD 1%
Factor A	4.31	6.131
Factor B	5.279	7.509
Treatments/(AxB)	7.466	10.619

40 Days

Critical Difference Values		
-	CD 5%	CD 1%
Factor A	6.94	9.87
Factor B	8.499	12.089
Treatments/(AxB)	12.02	17.096

50 Days

Critical Difference Values		
-	CD 5%	CD 1%
Factor A	14.947	21.259
Factor B	18.306	26.037
Treatments/(AxB)	25.888	36.822

60 Days

Critical Difference Values		
-	CD 5%	CD 1%
Factor A	16.617	23.636
Factor B	20.352	28.948
Treatments/(AxB)	28.782	40.938

70 Days

Critical Difference Values		
-	CD 5%	CD 1%
Factor A	18.46	26.257
Factor B	22.609	32.158
Treatments/(AxB)	31.974	45.478

80 Days

Critical Difference Values		
-	CD 5%	CD 1%
Factor A	20.129	28.631
Factor B	24.653	35.066
Treatments/(AxB)	34.865	49.591

90 Days

Critical Difference Values		
-	CD 5%	CD 1%
Factor A	21.158	30.095
Factor B	25.914	36.858
Treatments/(AxB)	36.647	52.126

APPENDIX IV

Salad Cucumber no. of leaves for 10 days interval

Treatment combinations	10 D	20 D	30 D	40 D	50 D	60 D	70 D	80 D	90 D
T1F1R1	6	14	40			6	5	10	
T1F1R2	7	10	18			6	10	0	
T1F1R3	6	16	42			6	10	9	
T1F2R1	3	11	10	0	0	6	14	70	
T1F2R2	8	18	20	28	14	54	80	60	
T1F2R3	5	9	20	11	0	55	55	73	
T1F3R1	4	8	11	11	55	55	85	50	
T1F3R2	5	5	9	7	19	24	40	67	
T1F3R3	0	5	5	4	10	20	35	70	
T2F1R1	5	7	17			6	11	5	
T2F1R2	4	10	34			6	15	0	
T2F1R3	0	4	13			6	11	14	
T2F2R1	4	12	23	26	26	60	80	65	
T2F2R2	6	10	10	7	4	15	31	50	
T2F2R3	6	8	8	12	0	6	50	80	
T2F3R1	1	6		10	26	26	38	35	
T2F3R2	0	5	9	7	32	45	50	68	
T2F3R3	0	5	10	8	14	21	29	30	

ABSTRACT

IRRIGATION SCHEDULING STUDIES ON SOILLESS CULTURE MEDIA FOR POLYHOUSE CULTIVATION OF VEGETABLE CROPS

APARNA P V (2015-02-009)

KRISHNA (2015-02-026)

SILPA S JAYAN (2015-02-036)

ABSTRACT

Submitted in partial fulfillment of the requirement for the degree of

Bachelor of Technology

in

AGRICULTURAL ENGINEERING

Faculty of Agricultural Engineering and Technology

Kerala Agricultural University

DEPARTMENT OF IRRIGATION AND DRAINAGE ENGINEERING

KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY

Tavanur – 679 573

Malappuram

KERALA

2019

ABSTRACT

Field study on the effect of alternate growing systems and irrigation schedules for soilless culture of salad cucumber and okra under drip irrigation was conducted inside the naturally ventilated polyhouse in the research plot of Department of Irrigation and Drainage Engineering situated near the LH KCAET, Tavanur, during October 2018 to January 2019. In the present study coirpith, perlite and vermiculite (3:1:1) and Ernakulam KVK media are selected as substrate media and data on climatic parameters, plant morphological parameters, chemical properties and yield parameters were recorded.

In this experiment, the land was levelled and beds were raised. Okra variety *Varsha Upahar* and salad cucumber variety *Hilton* were chosen for cultivation. The experiment was laid out in factorial completely randomized design. The plot was divided into 2 parts with okra on one half and salad cucumber on other half having three treatments with three replications and two factors. Fertigation in coirpith, perlite and vermiculite and Ernakulam KVK media include both macro and micro nutrients applied as water soluble fertilizers from two tanks (tank A and tank B) through fertigation system with venturimeter. Data about vegetative parameters for each treatment were observed during different stages of crop growth. The results on the effect of alternate growing systems used, irrigation frequency and their combined effect on crop growth and yield parameters were statistically analyzed. Analyzing the effect of alternate growing systems, it was found that in okra crop maximum vegetative growth was found in coirpith, perlite and vermiculite mixture whereas higher yield was obtained in KVK media. The highest yield was for Ernakulam KVK media in once in three day irrigation (102.66 g/plant) followed by coirpith, perlite and vermiculite media in alternate day irrigation (88g/plant). In salad cucumber with once in three days irrigation in coirpith, vermiculite and perlite media provided us with a considerable yield and in terms of vegetative growth daily and alternate irrigation scheduling in the same media were found to be better. The highest yield was for once in three days irrigation in coirpith, vermiculite and perlite media (251.33g/plant) followed by Ernakulam KVK media in once in three day irrigation (176.66 g/plant).

Irrigation interval significantly affected irrigation water use efficiency (IWUE). In okra the highest IWUE was for Ernakulam KVK media in once in three day irrigation (41.63kg/ha.mm) and lowest was for coirpith, perlite and vermiculite media in daily irrigation (2.88kg/ha.mm) whereas in salad cucumber highest IWUE was for coirpith, perlite and

vermiculite media in once in three days irrigation (75.3 kg/ ha.mm). Even though crops under alternate day irrigation were identified with remarkable yield, once in three days irrigation can be suggested in the areas experiencing water shortage. The results of this experiment showed that it is possible to obtain satisfactory yields of okra and salad cucumber variety grown under polyhouse conditions in two different media under varying irrigation schedules. The KVK media is nutrient rich soilless media so fertigation required was less whereas inert growing media like coirpith demands full fertigation with all macro and micro nutrients.