PERFORMANCE EVALUATION OF HYDROPONICS SYSTEMS FOR DIFFERENT CROPS UNDER SOIL LESS MEDIA

M.Tech. (Agril. Engg.) Thesis

by

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Thesis

Submitted to the

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by

Khyati Jain

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CERTIFICATE – I

This is to certify that the thesis entitled "**Performance Evaluation of Hydroponics Systems for Different Crops Under Soil Less Media**" submitted in partial fulfillment of the requirements for the degree of **Master of Technology in Agricultural Engineering** of Indira Gandhi Krishi Vishwavidyalaya, Raipur, is a record of the bonafide research work carried out by **Khyati Jain** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma or certificate course. All the assistance and help received during the course of the investigations have been duly acknowledged.

Date: 22/07/2019

Chairman

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

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Member	**(Dr. A. K. Verma)**	....
Member	**(Dr. G. L. Sharma)**	....

CERTIFICATE – II

This is to certify that the thesis entitled **"Performance Evaluation of Hydroponics Systems for Different Crops Under Soil Less Media"** submitted by **Khyati Jain** to Indira Gandhi Krishi Vishwavidyalaya, Raipur, in partial fulfillment of the requirements for the degree of **Master of Technology in Agricultural Engineering** in the Department of Soil and Water Engineering has been approved by the external examiner and Student's Advisory Committee after oral examination.

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Date: 21/8/2019

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Faculty Dean ____________________ 22/8/19

Approved/Not approved

Director of Instructions ____________________

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Khyati

(Khyati Jain)

Place: Raipur

Date: 22.07.2019

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LIST OF SYMBOLS

Symbol	**Description**
%	Percent
&	And
Avg.	Average
et al.	Et alibi
etc.	Etcetera
i.e.	That is
Viz.	Namely
rpm	Revolution per minute
hp	Horse power
mm	Millimeter
cm	Centimeter
m	Meter
S.No	Serial number
Kg	Kilogram
1/min	Litres per minute
kJ/min	Kilo joule per minute
min	mintues

LIST OF ABBREVIATIONS

Abbreviation	Description
Agril.	Agricultural
Agril. Engg.	Agricultural Engineering
Dept.	Department
M. Tech.	Master of Technology
ICAR	Indian Council of Agricultural Research
FAE	Faculty of Agricultural Engineering
Engg.	Engineering
IGKV	Indira Gandhi Krishi Vishwavidyalaya
M. Tech.	Master of Technology
N:P:K	Nitrogen: Phosphorous: Potassium
CoE-PCPF	Center of Excellence on Protected Cultivation and Precision farming
Avg	Average
dai.	Daimeter
PVC	Polyvinyl Chloride
SVCAET & RS	Swami Vivekananda College of Agricultural Engineering and Technology & Research Station

THESIS ABSTRACT

Title of the thesis	:	Performance evaluation of Hydroponic systems for different crop under soil less media
Full name of the Student	:	Khyati Jain
Major Subject	:	Soil and Water Engineering
Name and Address of the major advisor	:	Dr. M. P. Tripathi Professor & Head, Dept. of Soil and Water Engineering, SVCAET & RS. Faculty of Agricultural Engineering, IGKV, Raipur (CG)
Degree to be awarded	:	M.Tech. (Agricultural Engineering)

Khyati

Signature of the Student

Signature of Major Advisor

Date: 22/07/2019

Signature of Head of the Department

ABSTRACT

Now days Hydroponic system of cultivation are gaining popularly in India because of it proved to be profitable system of cultivation in urban areas. In hydroponic system plant roots are submerged in nutrient solution and directly absorb it. This method of cultivation does not use soil, instead the roots are supported through some inert media like rock-wool, clay-pellets, coco-peat, and vermiculite. The use of hydroponic systems can be beneficial to small-scale farmers by enabling them to take advantage of favorable climatic conditions to improve productivity.

X

Present study was carried out for performance evolution of hydroponic systems for different crops under soil less media at the Centre of Excellence on Protected Cultivation and Precision Farming (CoE-PCPF), IGKV Raipur (C.G.) during the year 2018-19. The experiment was laid out with four treatments T_1 (A-frame structures Clay-pellets media), T_2 (A-frame structures Coco-peat media), T_3 (U-shaped structures Clay-pellets media), T_4 (U-shaped structure Coco-peat media) of hydroponic systems.

Performance of hydroponic system was evaluated by transplanting Two vegetable crops (Pak-choi and Leafy-garlic) and two flower crops (Chrysanthemum and Petunia) in two different media i.e. coco-peat and clay-pellets. In this system irrigation was applied to the crop by ebb and flow system. Nitrogen, Phosphorus, and Potassium was mixed in water at right balance to make the nutrient solution. Different concentration of nutrient solution was made for different plant growth stages for optimizing the nutrient solution..

Results of this study revealed that the yield of pak-choi was found to be more in coco-peat media as compared to clay-pellets media. On the other hand yield of chrysanthemum crop was recorded to be more in clay-pellets media as compared to coco-peat media. Further, Petunia crop yielded higher in clay-pellets media however yield of leafy-garlic was found to be also more in coco-peat media as compared to clay-pellets. At the present investigation we found that fibrous roots crop growth rate is high in coco-peat media, but tap-roots crop growth rate is high in clay-pellets media.

In hydroponic cultivation high water use efficiency can be achieved with comparatively lesser area. Under protected cultivation with less cultivated area, more number of plants can be grown as that is more beneficial to small or marginal farmer can earn more profit. In the present study it can be revealed that if hydroponic system of cultivation under protected condition is done one can plant 1.5 times more plants as compared to over land cultivation, because vertical farming is possible in case of hydroponic system of cultivation. This system requires per plant less unit area for planting. On the basis of this study it can be concluded that hydroponic system is very much helpful in cultivation of high value crop like vegetable and flower under protected condition for increasing the farmer income. The present studies are very helpful to do cultivation in hydroponic systems in commercially or any such things to do in future.

शोध सारांश

शोध का शीर्षक	:	मिट्टी के बिना विभिन्न फसल के लिए हाइड्रोपोनिक प्रणालियों का प्रदर्शन मूल्यांकन
छात्र का पूरा नाम	:	ख्याति जैन
प्रमुख विषय	:	मृदा एवं जल अभियांत्रिकी
प्रमुख सलाहकार का नाम और पता	:	डॉ. एम. पी. त्रिपाठी प्राध्यापक एवं विभागाध्यक्ष, मृदा एवं जल अभियांत्रिकी विभाग, एस.वी.सी.ए.ई.टी. एवं आर.एस. , कृषि अभियांत्रिकी संकाय, इंदिरा गांधी कृषि विश्वविद्यालय, रायपुर (छत्तीसगढ़)
सम्मानित किया जाने वाला डिग्री	:	एम.टेक. (कृषि अभियांत्रिकी)

Khyati

छात्रा का हस्ताक्षर

प्रमुख सलाहकार का हस्ताक्षर

दिनांक ...22/07/2019 विभाग के प्रमुख का हस्ताक्षर

सारांश

अब भारत में खेती की हाइड्रोपोनिक प्रणाली लोकप्रिय हो रही है क्योंकि यह शहरी क्षेत्रों में खेती की लाभदायक प्रणाली साबित हुई है। हाइड्रोपोनिक प्रणाली में पौधे की जड़ें पोषक तत्व के घोल में डूब जाती हैं और इसे सीधे अवशोषित करती हैं। खेती का यह तरीका मिट्टी का उपयोग नहीं करता है, इसके बजाय जड़ों को रॉक ऊल मिट्टी के छर्रों, कोको.पीट और वर्मीकलाइट जैसे कुछ निष्क्रिय मीडिया के माध्यम से सहारा

के लिए कृषको और लघु उघमियों को सक्षम बनाकर करके छोटे पैमाने के किसानों को हाइड्रोपोनिक प्रणालियों का उपयोग किया जाता है तो उनके लिए फायदेमंद हो सकता है।

वर्ष 2018-19 के दौरान संरक्षित खेती और परिशुद्धता खेती, रायपुर पर उत्कृष्टता के केंद्र में मिट्टी कम मीडिया के तहत विभिन्न फसलों के लिए हाइड्रोपोनिक प्रणालियों के प्रदर्शन के विकास के लिए वर्तमान अध्ययन किया गया था। इस प्रयोग को चार उपचारों T1 (A- फ्रेम स्ट्रक्चर मिट्टी.छर्रों मीडिया), T2 (A- फ्रेम स्ट्रक्चर कोको. पीट मीडिया), T3 (U- आकार की संरचना मिट्टी.छर्रों मीडिया, एवं T4 (U- आकार की संरचना कोको.पीट मीडिया) के साथ निर्धारित किया गया था।

हाइड्रोपोनिक प्रणाली के प्रदर्शन का मूल्यांकन दो अलग-अलग मीडिया यानी कोको.पीट और मिट्टी.छर्रों में दो सब्जी फसलों पाक.चोई और पत्तेदार लहसुन और दो फूलों की फसलों ;गुलदाउदी और पेटुनीया के प्रत्यारोपण द्वारा किया गया था। इस प्रणाली में ईब और प्रवाह प्रणाली द्वारा फसल में सिंचाई लागू की गई थी। पोषक तत्व घोल बनाने के लिए नाइट्रोजन, फॉस्फोरस और पोटेशियम को सही संतुलन में पानी में मिलाया गया था। पोषक तत्व घोल के अनुकूलन के लिए विभिन्न पौधों के विकास के चरणों के लिए पोषक तत्व घोल की अलग.अलग सांद्रता बनाई गई थी।

इस अध्ययन के परिणामों से पता चला कि कोको.पीट मीडिया में पाक.चोई की उपज मिट्टी.छर्रों मीडिया की तुलना में अधिक थी। दूसरी ओर, कोको.पीट मीडिया की तुलना में गुलदाउदी की फसल मिट्टी.छर्रों के मीडिया में अधिक दर्ज की गई। इसके अलावा, मिट्टी.छर्रों के माध्यम से पेटुनीया की फसल की पैदावार अधिक होती है, हालांकि कोका.पीट मीडिया में पत्तेदार.लहसुन की उपज भी अधिक थी। वर्तमान जांच में हमने पाया कि कोको.पीट मीडिया में रेशेदार जड़ों की फसल की वृद्धि दर अधिक है, लेकिन मिट्टी.छर्रों की मीडिया में छोटी जड़ों की फसल की वृद्धि दर अधिक है।

हाइड्रोपोनिक खेती में उच्च्व जल उपयोग दक्षता तुलनात्मक रूप से कम क्षेत्र के साथ प्राप्त की जा सकती है। कम खेती वाले क्षेत्र में संरक्षित खेती के तहत, अधिक संख्या में पौधे उगाए जा सकते हैं, जो कि छोटे या सीमांत किसान के लिए अधिक

लाभदायक होते हैं, तथा वें इसको अपनाकर अधिक लाभ कमा सकते हैं। शोध से यह पता चला है कि यदि संरक्षित स्थिति में खेती की हाइड्रोपोनिक प्रणाली की जाए तो 1.5 गुना अधिक पौधे लगाए जा सकते हैं, क्योंकि भूमि की तुलना में हाइड्रोपोनिक प्रणाली में ऊर्ध्वाधर खेती संभव है। इस प्रणाली के लिए प्रति पौधे या रोपण के लिए कम इकाई क्षेत्र की आवश्यकता होती है। इस अध्ययन के आधार पर यह निष्कर्ष निकाला जा सकता है कि हाइड्रोपोनिक प्रणाली किसान की आय बढ़ाने के लिए संरक्षित स्थिति में सब्जी और फूल जैसी उच्च मूल्यवान फसल की खेती में बहुत सहायक है। वर्तमान अध्ययन के उपरांत कह सकते है कि भविष्य में कृषि को लाभदायक बनाने के लिए हाइड्रोपोनिक प्रणालि व्यावसायिक रूप से अपनाई जा सकती हैं।

CHAPTER I

INTRODUCTION

Method of cultivation of crop in a soil less media and application of nutrient rich solution for their growth is known as hydroponics system. In a hydroponic system the root system is supported by the inert medium like perlite, rock-wool, clay-pellets, coco-peat and vermiculite. The basic concept in hydroponics is to allow roots of growing plant to come in direct contact with the nutrient solution for use and also create conducive environment for utilizing necessary oxygen for proper growth. The root system also having access to oxygen which is essential for proper growth.

With the advent of civilization, Open field / soil based cultivation of agriculture crops are facing considerable challenges, including per capita availability of land which is decreasing day by day. In 1960 with 3 billion people over the entire world, the per capita land availability was 0.5 ha but in the year 2013 with 6 billion people it decreases up to 0.25 ha only. The soil fertility status has also attained it's saturation level there by productivity is not increasing further even by providing increased amount of fertilizer. Beside, poor fertility of soil there are problems of less chance of natural soil fertility which is generally build up by microbes due to continuous cultivation, occurrence of frequent drought and uncertainty of climate and weather conditions, rise in temperature and change in humidity. Under such circumstances, it will become impossible in near future to feed the entire population with the production receive only by using land based agriculture farming. These challenges can be minimized by adopting soilless cultivation techniques more relevant and useful for land surface also. Growing plants in soilless media with nutrient solution is easier than soil culture because there is no need of soil, no soil born disease or pest attack to the crop. Irrigation is less frequent in solution culture than in soil culture. Roots in case of soilless media are visible and monitoring of root zone environment is easy for management.

Water is considered as most limiting natural resource over the world which is affecting the economic development of most of the countries, including India. India is having abundant water resources, but due to various constraints, the utilizable water for irrigation is decreasing. Further, in near future the increasing demand of water for expansion of urbanization and industrialization will create more critical situation because of allocation of water will increase for various activities. Therefore, creation of an efficient and effective irrigation management system in order to irrigate more area with the available water. Inadequate irrigation management not only decrease crop yield but also waste valuable water resources. Improvement of irrigation systems, including irrigation schedules and methods of water application are very much essential to increase the water productivity in a sustainable manner.

Without soil crop growing means that hydroponics system should have some concrete way out of supporting the plant root system for maximum exposure to the nutrient solution. Media like coco-peat has got distinct quality for holding the water for the longer as compared to soil. Coco peat is cent percent organic material and has anti-fungal properties. Coco-peat is sterile having natural rooting an inert material which is used to support the plant roots. Nutrients are added to this media through external source which is retained for longer duration.

Clay pellets are an inert material which is used to support plants root, whereas coco-peat clay pellets do not hold water but support the plant roots. Nutrients solution is passed through the clay pellets and the plant roots directly absorb the nutrients from the solution. Because of size and shape of clay pellets root can spread more freely in it as compared to coco-peat. Clay-pellets pH is natural and they are reusable as well. Keeping these advantages of coco-peat and clay pellets in mind these two medium of growing plants have been used in the present study. These are very common media in the hydroponics system cultivation but study on their advantages and disadvantages need to be carried out. In this present study vegetables and flowers crop grown in the hydroponically, the main aim during this research is to optimizing the nutrient solution, and to calibrate different supporting media.

Various hydroponic systems are available in the market but they are expensive and poor urban peoples/farmer could not afford that much cost. Looking to this different type of hydroponic systems like A-frame and U-shaped have been developed using locally available materials at Indira Gandhi Krishi Vishwavidhyalaya, Raipur, but not tested properly for various soil less media, nutrient solutions and for crops. The low cost hydroponic system developed by previous research works need to be tested for growing different crop under different soil less media and nutrient solutions.

In this view the present study has been undertaken with following specific objectives:

1. To evaluate performance of coco-peat and clay pellets as supporting media for different crops grown under hydroponic systems.
2. To know the optimum concentration of nutrient solution for different crop grown the different media.
3. To workout the utility of hydroponic system in terms of space utilization under protected condition.

CHAPETER-II

REVIEW OF LITERATURE

The chapter deals with the review of literature related to the present study. A brief review pertaining to research work conducted on different supporting media for growing crop, concentration of nutrient solution, nutrient film technique, crops grown hydroponically in greenhouse, quality of flowers and fruits in greenhouse are presented in this chapter.

2.1 Growing Media

Clematis et al. (2008) investigated to the use of Radicisly coperisici on recycled perlite and perlite-peat mix media. This media use for cultivation in closed and open soilless systems. In Northern and Southern Italy region they have taken nine trial in different places. They found considerable drop in disease attack of plant. It below the average value. In perlite media 44% to 60% below the average value and perlite peat mix the decreased disease average ranging from 36% - 75% below the average value.

Ghamande et al. (2016) repoted an experiment on Growing Plants based on Nutrient solution (Hydroponics) in Pune India. Plants grown hydroponically are generally more healthy as compare to grown in soil, because they receive flawless balanced nutriment and no chance of any soil transmitted pathogens or fungus. Hydroponic systems water and nutrient solutions continuously flow in plant root area. If plant meet every nutrient in right time their growth rate will be increasing and not undernourished to each other. Hydroponic systems also help to save water and stop the evaporation and runoff losses.

Joseph and Muthuchamy (2014) observed that carried out in three replications in form of factorial randomized brick design. To use three different type hydroponic arrangements. First coco-peat + gravel + silex stone, second cocopeat + pebble + silex stone and third is cocopeat + perlite + silex stone. The maximal yield was noticed for the treatment T1 in the mixture of cocopeat + gravel

+ silex stone is 4.9kg/plant and second position cocopeat + perlite + silex stone is 4.2 kg/plant and trough with cocopeat + pebble + silex stone 4 kg/ plant . The treatment T_2 use tray with cocopeat + pebble + silex stone production was 2.8kg/plant. Total one hectare production was 138.44 tonnes.

Tsakaldimi (2006) reported that aeration property varies between 11 to 53% and water holding capacity varies between 50 to 81%. Added some of rubbles & gravels a materials into coco-peat, the result shows that increase exposing to air in coco-peat media.. Many courser materials such as Farmyard manure, milling husk of rice, and Cascading style sheets can also be used to increase air and water holding capacity of coco-peat media. Vermiculite types courser material was increase air and water flow rate through the supporting media.

2.2 Nutrient Solution

Avalhaes *et al.* (2009) investigate the outcomes of release of small nutrients in the growing of Napier-grass crop in American country. This arrangements was randomized blocks and use Hoagland and Arnon solutions. This research having total seven treatments. The height of the plants, number of leaves, diameter of apex and tillers number were evaluated. The deletion all chemicals like nitrogen, phosphorous, potassium, calcium, magnesium are finite. This research compare the produce of with and without treatment Napier grass.

Hoagland & Arnon (1950) reported the issue of water dpended cultivation technique. This technique does not use soil. The objective was to obtain a good knowledge about its basic constituent and to deal about soil and plant interrelations presents in the field. They make nutrient solution and give the name was Hoagland solution. This solution complete every nutrients require of plant in different growth stages.

Gallegly *et al.* (1949) investigated about equal discharge rate drip system use in tomato plants. The plants growth were measure after approximately 25 days. During summer months more disease develop in nutrient solution and diseases are reduced with an increase in salt concentration. If the intensity of light is increasing or decreasing that causes more effect of disease in plant. The intensity of light had effect on disease expansion on low concentration of Potassium solution.

Hochmuth and Hochmuth (2008) evaluated the hydroponic solution for tomato plant. Through air, water and fertilizers plant meet every nutrient as its needed. All nutrients present in air and water at desired quantity. Different levels of minerals and fertilisers are need to various growth stages of tomatoes plant. The excessive quantity of Nitrogen effect the growth rate and destroy the leaves and stems. The higher amount of potassium are restrict for absorbing calcium and magnesium to plant. Firstly we have measure the pH value of water which was having 6.5 and calcium or magnesium are available in small amount in the solutions.

Karimaei *et al.* (2004) evaluated that applied two concentration of Massantini solution. First is full 100% and second is half 50% strength. We know the quantity and ratio of nitrogen, phosphorus, and potassium fertilizers. Hoagland solution gave robust consequence. It followed by 50% Massantini solutions. The relation between growth rate, plant attributing characters and N, P and K concentrations were pessimistic. The pH value or electrical conductivity showed negative inter-relations with some plant attributing characters such as number of leaves, weight of dry leaves and concentration of Potassium.

Kaur, *et al.* (2016) investigated a study on the reaction of Hoagland solution for tomato plants cultivating hydroponically. This inquiry was done in ventilated cooled protected structures. The ratio of media is (3:1:1) in mixer of cocopeat, perlite and vermiculite. In Nutrient film technique hydroponically grown tomatoes plants transplanted in hole type pots in plastic pipes. The inquiry having 3 version and 3 treatments. Hoagland solution make three type solutions. First at 100% congregation, second is 75% and third is 50% congregation. In Hoagland 100% concentration solution the value of plant height, number of fruits, total soluble solids and acid ware higher than others solutions.

Maia *et al.* (2001) conducted work about the cultivation of Menthaarvensis L. Essential oil. Plants are transplanted into net pots. In this study use 11 type nutrient solution. The main aim about these work is determine the main element require for nutrient solution for commercially cultivation. That causes increases the plant yield and oil present high menthol composition. The plants were grown in solutions containing three concentrations of each nutrient. This plant mainly cultivated because of its essential oil. In the presence of Nitrogen will increase the leaves weight, but decrease the oil with low menthol content. Magnesium will increase in oil percentage in the plants. The effect of nitrogen and magnesium is more in oil present in this plant.

Matsuda *et al.* (2012) suggested that cultivate tomato in protected structures. In this model the growth of plant and other characters like leaves area, stem elongation rate or leaves development are same. For both electrical conductivity treatments, immature frit accumulated DW in similar way, but dynamics observed in fruit total soluble protein and F1-v are different during fruit growth. They discover that increasing in electrical conductivity of nutrient solution, decreasing in total soluble protein. They have suggesting that adjusting nutrient solution electric conductivity at desired level is important to ignore the salinity stress in tomato crop.

Natarajan *et al.* (2008) studied that the outcome of plant density and nutrision level of Pterisvittata L. This study having four replication, four type plat densities, two nitrogen concentrations and two phosphorous concentrations. The results is low plat density is more effective , reducing as in water. They evaluate that P.vittata was great as contamination present in ground water.

Niu *et al.* (2015) conducted a study to evaluate the availability to cultivate eucalyptus seedlings in hydroponic systems. Phosphorus is one of the most important chemical of growing plat. Its direct affect on leaves area, plant height, and stem diameter. The phosphorus use efficiency (PUE) was highest at lower P concentration in nutrient solution. That was good for optimum production and good quality crops. This work make confirm to produce comfortably in high vigor woody plants cultivations.

Park *et al.* (1995) investigate the most appropriate nutrient rich solutions among Cooper's, Hoagland and Arnon and Yamazakis solutions. In Yamazaki solutions gave best results in terms of root weight, and crop yield. Second investigation was conducted with Yamazaki solution. It has treated with electric conductivity of 0.5, 1.5, and 2.0 mS/cm with different ionic strength and noticed change in mineral content or vitamin C content.

Orsini and Pascale (2007) conducted the experiment of effects of cultivar, nutrient solution and intensity of light on daily up-down nitrate content in basil leaves. In this studied two nutrient solution ware compared. First is single strength Hoagland (H) and second is double strength Hoagland (2H). Two nutrient solutions were compared: single strength Hoagland (H) and double strength Hoagland (2H). The results was 2H solutions more number of leaves in plants. Nitrate content in leaves was depended on response of light intensities. 2H solution ware divided various shading treatments after 30 days of transplanting. In a whole day total 9 times measured how much nitrate content present in plant leaves.

Paiva *et al.* (1998a) studied about cultivation in hydroponic under greenhouses. This studied use advance type Hoagland solution accommodate various calcium concentration (0.2, 2.5, 5.0, 10, 15, 20 mm/lit). These are represents in randomized design with three treatments. This work results is if fruit keep less relative humidity, the concentration of calcium will be more. That causes more water is loss from plant tissues lead blossom-end rot when low concentration of calcium are goes to the crop.

Paiva *et al.* (1998b) conducted the experiment in a greenhouse hydroponically using a modified Hoagland solution containing different Ca concentrations (0.2, 2.5, 5.0, 10.0, 15.0, and 20.0 mmol L-1). The fruits of the second and third replications were picked after full ripening and analyzed for their

Ca, magnesium (Mg), potassium (K), lycopene, and total carotene levels. The total lycopene and carotene levels decreased with increasing Ca concentration in the nutrient solution, possibly due to the reduction in K absorption with minimum levels of at the Ca concentration of nutrient solution.

Roosta and Hamidpur (2011) conduct a study about the consequence of folier is apply to the nutrients in water based cultivation systems. Different 40 to 50 carp fish were stocked in the rearing tanks. This stocked water was source of nutrients for plants growing in aquaponic system. In case of iron deficiency we have added iron iron in solutions. In water loses case to balance this situations use tap water. Tap water was used for compensating water loses. Fishes diet plan present 46.3% protein nutrition. This nutrition help to increase the growth rate of plant. Among all chemical only Iron and boron help to increase the growth of hydroponic plants, but in case of aquaponic system potassium, magnesium, iron, megnies, and boron all chemicals are help for growing crop. The effect of different chemicals was in order of B < Mg < Zn < Mn < Fe < K.

Teragishi *et al.* (2000) report that the studied of foiler applications. This foiler solutions used in this study on winter cropped Masui-Dauphine plants. This plat use Hoagland II solution and rock-wool media. The nursery plant transplanted into non circulating closed type water based culture. This cultivation process are kept under green house condition. The sprayed type fruit is heavier than control type. If decrease photosynthetic photon flux density the photosynthetic rates are also decrease.

2.3 Crops are grown in Hydroponics under Greenhouse

Bradley and Marulanda (2000) conducted experiment to the use of hydroponic technology in simple manner. That are more efficient in terms of land requirement and water use. This system 25% less land requirement for crops and water use efficiency is above 85%. No residual salts were released to environment and less chance to attack any pest-herb to plant.

Galvez *et al.* (2014) conducted the experiment about effect of reclaimed and surface water use on hydroponics structures. It is use on micro biological safety on hydroponic tomatoes. Coconut fiber and rock wool medias are use to growing crop in hydroponic structures. In this tomatoes apply reclaimed and surface water for irrigation purpose.

Sample of water ware collected from irrigation pipes before and after addition of fertilizers. Tomatoes samples gave negative results in attack of bacteria or pathogens, that is the generic E coil make below the observation limits. This studies create excellent results and more helpful for profitable agriculture work which in the microbial bacteria and pests attacks should be avoided.

Meric *et al.* (2011) investigate effects of fertigation systems and irrigation schedule on soilless cultivation of tomato plants. This study was carried out under protected condition. Whole structures covered in polyethylene sheets. Many parameters are calculated in this work like water use efficiency, rates of evapor-transpirations, fertilizers use efficiency, and total yield of crop. Results shows that in open atmosphere cultivation the yield value was 7-10% increases. We noticed the highest water use efficiency values in the closed system in both growing season because less evaporation and runoff losses. This study in closed protected condition the water use efficiency values are high, but yield values and nutrition consumption values are low.

Rosberg *et al.* (2014) evaluate the experiment on protected hydroponic cultivation. It has been commonly known as green house farming of vegetables. The different between inoculated and non-inoculated plants main reason was P. ultimum change the carbon source by root micro bacteria's. The relationship between microbial communities and plant development was examine with the help of CLPP. In case if presence of pathogens this method potential was less.

Steidle *et al.* (2009) studied about that type cultivation system. This system irrigation and nutrient applying process are fully automized. The automation system not affected on crop production and easy to control this. The main losses in this system is to apply extra irrigation in initial growing stages of crop and if atmosphere is cloudy conditions. This system increase amount of irrigation and nutrient requirement as compare to conventional control systems.

Varlagas *et al.* (2010) conducted experiment about simulation of uptake concentration of Na+ and Cl- in root zone area of crop. In hydroponic system three experiment ware conducted. One was carried out to check the model with NaCl concentrations. The range of NaCl concentration lies between 0 to 14.7 mol/m^3. Other treatments ware investigated to calibrate the model in either low or high ranges. The low range of concentration lies between 0.5 to 2 mol/m^3 and high range of concentration lies between 1.2 to 12 mol/m^3. The concentration of Na+ chemical forecast easily but concentration of Cl- chemical was difficult. Cl- value not less than 10 mol/m^3. The results shows that tomatoes genotypes high salt prohibition properties for maintain the sodium ion in root zones at optimum level in tomatoes hybrid.

2.4 Critiques of Review

Review literature summered for this study revealed that most of the available hydroponic systems all developed in other countries. However, some of the hydroponic system developed in India are of high cost and cannot be effort by the poor common peoples. Most of work done in hydroponic systems are concentrated for its fabrication. Very few studies have been repeated for evaluation of performance for vegetable and flowers crop under protected cultivation system. On the basis of reviews of literature it can be said that these is still gap for testing the performance of low cost hydroponic systems for small and marginal farmers of urban and semi-urban areas.

CHAPTER III

MATERIALS AND METHODS

This chapter deals with the methodology applied to the performance evolution of hydroponic systems for different vegetable and flower crop under protected structures. The experiment was conducted in the Department of soil and water Engineering at the Centre of Excellence on Protected Cultivation and Precision Farming (CoE-PCPF), Indira Gandhi Krishi Vishvavidhyalaya, Raipur (C.G.) during the year 2018-19.

3.1 Description of Study Area

The experiment was conducted in controlled condition of the naturally ventilated poly-house during the year 2018-19 at the Centre of Excellence on Protected Cultivation and Precision Farming (CoE-PCPF), IGKV, Raipur (C.G.). Raipur is situated in the central part of Chhattisgarh at latitude 21°14"9" N and longitude 81°42"10" E and at an Altitude of 302 meters above the mean sea level. The location of study site is shown in Fig. 3.1. A pictorial view of Centre of Excellence on Protected Cultivation and Precision Farming, IGKV, Raipur is shown in Plate 3.1.

3.2 Agro-climatic Condition

Raipur comes under dry, sub-humid agro climatic region. The source of rainfall is south west Monsoon. It receives an average annual rainfall of 1155 mm out of which 80-85 percent is received from third week of June to mid September and very little during October to February. May month is the hottest and December is the coolest month of the year. The pattern of rainfall particularly during June to September months has a great variation from year to year the maximum temperature goes as high as 48°C during summer and minimum as below as 6°C during winter months. The atmospheric humidity is high from June to October and wind velocity is high from May to August with its peak in June-July months.

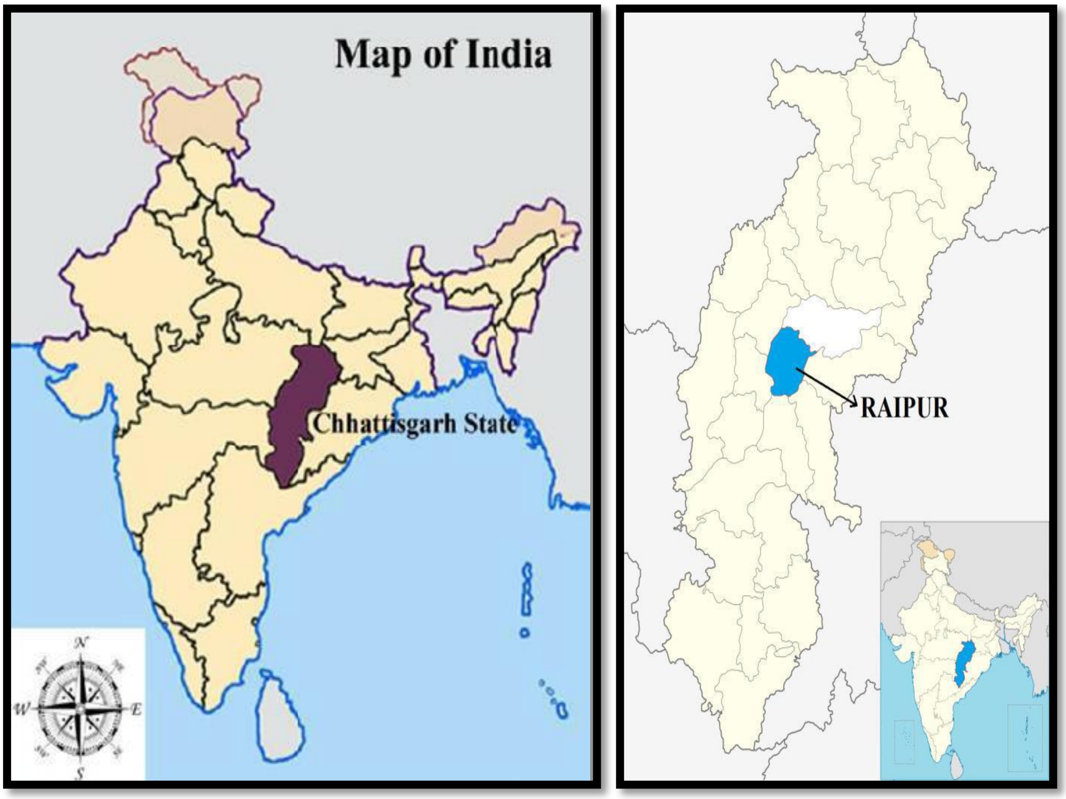

Fig 3.1: Location map of the study area

Plate 3.1: View of Centre of Excellence on Protected Cultivation and Precision Farming (CoE-PCPF), IGKV, Raipur

3.3 Experiment Details

The experiment was laid out with the treatments comprised of combination of four type of hydroponic structure, which are as given below. These treatments combinations ware tested for four crops namely Pak-choi, Chrysanthemum, Petunia, and Leafy-garlic.

Treatments	
T_1 =	A-frame structure + Clay Pellets Media + Standard Nutrients Solution
T_2 =	A-frame structure + Coco-peat Media + Standard Nutrients Solution
T_3 =	U-shaped structure + Clay Pellets Media + Standard Nutrients Solution
T_4 =	U-shaped structure + Coco-peat Media + Standard Nutrients Solution
Crops	
C_1 =	Pak-choi
C_2 =	Chrysanthemum
C_3 =	Petunia
C_4 =	Leafy garlic

The hydroponic system using ebb and flow was established under the poly house for the study of evaluate performance of coco-peat and clay pellets as supporting media for different vegetable and flower crops, know the optimum concentration of nutrient solution for different crop and yield of crop. The treatments comprised of two different type supporting media. The soil less media mixture of coco-peat and vermiculite (3:1) was used for the nursery establishment in the growing tray (pro-tray). We have cultivated two vegetable crop Pak-choi or leafy garlic and two flower crop chrysanthemum or Petunia in hydroponic systems. The seedlings of pak-choi, chrysanthemum, petunia and leafy garlic were transplanted in the net pots and there after placed in the hydroponic system. First crop i.e. pak-choi was transplanted during the last week of September 2018, second crop chrysanthemum was transplanted during last week of November 2018 , third crop petunia was transplanted during first week of February 2019 and fourth crop i.e. leafy garlic was transplanted during second week of March 2019. The hydroponic system was designed and developed with the help of locally available material and resources by the previous research work (Krishnan, Kavita 2018 M.tech Thesis). The hydroponic systems A-frame type structures and U-shaped type structures were considered to test their performance for all these four crops under two different media. Total four structures were used in this experiment. All four crops were cultivated in both clay pellets and coco-peat supporting media at different hydroponic systems, consecutively during the year 2018-19. Plate 3.2 and 3.3 shows the U-shaped hydroponic system with Chrysanthemum crop and A-frame hydroponic system with Petunia crop, respectively.

Plate 3.2: U-shaped Hydroponic System with Chrysanthemum crop

Plate 3.3: A-frame Hydroponic System with Petunia crop

3.4 Plant Supporting Media

3.4.1 Coco-peat : Coco-peat makes an excellent growing medium for hydroponics. Coco-peat also known as coir pith, coir fiber pith, coir dust or simply coir is made from coconut husk, which are byproduct of other industries that use coconuts. Coco-peat is used as a growing medium due to its unique characteristics. Coco peat is cent percent organic material and has anti-fungal properties. Coco-peat is sterile having natural rooting an inert material which is used to support the plant roots. Nutrients are added to this media through external source which is retained for a longer duration. It is sterile yet has natural rooting hormones, has anti-fungal properties and is 100% organic. Coco-peat holds 8-9 times its weight in water. Coco-peat has got distinct quality for holding the water for the longer as compared to soil. Plate 3.4 shows the view of coco-peat used in this study.

3.4.2 Clay pellets : Clay pebbles are a growing medium that is most often used in hydroponics gardening. Expanded clay pellets are made by heating the clay to over 2000 degree Fahrenheit. As the balls heat up, they fill with bubbles and form into small marble-sized units. In this type of gardening, soil is replaced by nutrient rich water, but the plant may still need a stabilizing medium for their root structure to grow. Because of natural pH, clay pebbles provide a growing medium that is ideal for a wide variety of plant, and they are reusable as well. The pores make throughout each ball, the pellets make it easy to support a steady distribution of nutrients, oxygen and water around the root of various plat. In this method plant are located in cup, pan, trey or bucket and a mixture of nutrients and water is pumped in until the roots of the plant are submerged. While the root of the plants are flooded with the nutrient-water mixtures, they absorb the nutrients and water that the plant need to grow. Nutrients solution is passed through the clay pellets and the plant roots directly absorb the nutrients from the solution. Clay pellets are an inert material which is used to support plants root, whereas coco-peat clay pellets do not hold water but support the plant roots. Because of size and shape of clay pellets root can spread more freely in it as compared to coco-peat. Clay pebbles provide a growing medium that is ideal for a wide variety of plants, they are reusable as well. Plate 3.5 shows the view of clay pellets material used in this experiment.

. Plate 3.4 : Coco-peat

Plate 3.5 : Clay pellets

3.5 Measuring Instruments

3.5.1 pH meter: The pH meter was used to measure the nutrient solution acidity and basicity range which should be maintained in hydroponic system. The pH meter shown in Plate 3.6.

Plate 3.6 : pH meter used in the study

3.5.2 EC and TDS meter: The EC meter was used to measure the nutrient solution salt concentration which should be in hydroponic system. The TDS meter was used to measure the total dissolved solid in the nutrient solution. The EC and TDS meter shown in Plate 3.7.

Plate 3.7: TDS and EC meter used in the study

3.6 Nursery Raising

The seeds of pak-choi were sown on 17th September 2018 in plastic plug trays by using soil-less media having coco peat and vermiculite in the proportion of 3:1. The seedlings were raised inside the naturally ventilated poly-house to get healthy and disease free seedlings of plants. Plate 3.8 (a) and 3.8 (b) shows the operation of nursery bed preparation and seed sowing in the tray, respectively.

Plate 3.8 (a): Nursery bed Preparation

Plate 3.8 (b): Seeds grown in the tray

3.7 Preparation of Bed and Media

Pipes were closed with end-caps on both ends having 152.40 cm length. Eight numbers of pipes were mounted on the A frame and two numbers of pipes ware mounted on the U-shaped. Each pipes bed contained 6 pot holding holes 64 mm diameter and spaced at 26.67 cm distance from each other. Net pots were made up of plastic material of 5.5 cm diameter and 4 cm depth. Net pot was perforated up to 4 cm height from its bottom.

Media such as coco-peat and clay pellets were considered for both A-frame & U-shaped structure. Total mass of coco-peat media used was 5 kg to fill up 60 net pots, each pot content 83 gm of media and total mass of clay pellets media used was 3 kg to fill up 60 net pots, each net pot content 50 gm of media.

3.8 Transplanting Operation

Near about one month old seedling were transplanted on prepared pots and placed fabricated structures including A frame shaped and U shaped hydroponic structure for the study. Nursery its placement in the pots and transplants in the structure is shown in plate 3.9, 3.10, and 3.11.

Plate 3.9 : Nursery raised for transplanting in the Net-Pots

Plate 3.10 : Nursery plant hold in the Net Pot

Plate 3.11 : Crop Transplant in the structure

3.9 Nutrient Solution Parameter

3.9.1 pH value: After the transplanting of the plants in the structure the pH value of the hydroponic solution ware maintain in the range of 5.5 to 6.5. This range maximum number of elements are reported to be at their highest availability for plants. When the pH value rise more than 6.5 some of nutrient and micro nutrients begin precipitate out of the solution and can stick the wall of reservoir and growing chamber. But if it increased then nutrient solution i.e. Hydroponic solution should be changed essentially. The hydroponic nutrients solution have been changed twice in week.

3.9.2 TDS value: After the transplanting of the plant in the structure TDS value of the solution made in the tank was measured with the help of TDS meter. Then solution was changed and its TDS value was measured again. This process was repeated for the entire period of the experiment.

3.9.3 EC value: After the transplanting of the plant in the structure EC value of solution ware maintain in the range of 1.5 to 2.5dS/m. The EC of nutrient solution should not decrease but if decreases then nutrient solution have to be changed. The EC of nutrient solution decreases due to consumption of nutrients from the nutrient solution. In general, EC > 2.5 dS/m may lead to salinity problems while EC < 1.5 dS/m may lead to nutrient deficiencies. Higher EC reduces the nutrient uptake by increasing osmotic pressure, whereas the lower EC may affect the plant health and yield. This variation is due to the precipitation of nutrients and micro-nutrients in the tank.

3.10 Crop Parameters

3.10.1 Plant leaf height: Four plants were selected at random from each treatment to measure their height after 5 days of transplanting, then it was measured every three days. It was measured from the base of plant to the tip of the plant with the help of measuring scale (Plate 3.12).

3.10.2 Plant leaf width: Four plants were selected at random from each treatment to measure width of the leaf after 5 days of transplanting, then it was measured every three days. It was measured from the horizontal distance of the plant leaf with the help of measuring scale.

3.10.3 Plant height: Four plants were selected at random from each treatment to measure height of the plant after 5 days of transplanting, then it was measured every three days. It was measured from the base of plant to the tip of the plant vertical distance with the help of measuring scale (plate 3.13 and 3.14).

3.10.4 Total number of leaves : Four plants were selected at random from each treatment to count how many numbers of leaves in each plant after 5 days of transplanting, then it was measured every three days.

3.10.5 Total number of flowers : Four plants were selected at random from each treatment to count how many numbers of flowers in each plant after flowering started, then it was measured every three days.

3.10.6 Perimeter of flowers : Four plants were selected at random from each treatment to measure diameter of flowers in each plant then calculating perimeter of each flower after flowering started, then it was measured every three days (Plate 3.13)

3.10.7 Length of plant roots : Four plants were selected at random from each treatment to measure length of roots on each plant. In hydroponic system plant roots are visible. It was measured visible root length outside of net pot.

Plate 3.12: Measuring root length and leaves height of pak-choi and leafy garlic crop

Plate 3.13 : Measuring plant height and flower diameter of petunia crop

Plate No.3.14:Measuring plant height and flower perimeter of chrysanthemum crop

3.11 Yield of crops : Pak-choi, Chrysanthemum, Petunia and leafy garlic was harvested as per the standard harvest indices and the yield was recorded on the treatment basis. Full mature crops of chrysanthemum, pak-choi, petunia and leafy garlic is shown in Plate 3.15

Plate No.: 3.15 Full grown crops of petunia, pak-choi, chrysanthemum, and leafy-garlic.

3.12 Concentration of Nutrients Solution

Nutrient solution is the most important chemical of the hydroponic system. In the present study the nutrient solution were prepared by following the guideline of poly-house drip system. The solution were prepared by mixing major fertilizers like Nitrogen, Potassium and Phosphorus and calcium nitrate, with bore well water. The pH of the water was 6.5 and 6.3 before and after mixing the chemical. The compositions of the chemicals in nutrients solution were shown in Table 3.1

Table 3.1 Quantity of different nutrient solution used in the study

Chemical	Quantity (gm) for 100 L	Quantity (gm) for 30 L
1) Planting Stage		
(N:P:K) (19:19;19)	30g	25g
+ Calcium Nitrate	30g	25g
2) After planting Stage		
(N:P:K) (12:61:00) +	30g	25g
(N:P:K) (17:44:00)	30g	25g
3) Flowering Stage		
(N:P:K) (13:00:45) +	100g	80g
(N:P:K) (12:61:00)	50g	40g
4) Fruiting Stage		
(N:P:K) (13:00:45) +	100g	80g
(N:P:K) (00:00:50)	50g	40g

CHAPTER -IV

RESULTS AND DISCUSSION

A field examination enabled "Performance Evaluation of Hydroponics Systems for Different Crops Under Soil Less Media" was carried out in the poly-house at the Centre of Excellence on Protected Cultivation and Precision Farming (CoE-PCPF), IGKV, Raipur (C.G.) during the year 2018-19. Elaborate of standard nutrients solution for hydroponic systems are given in this section. Outcome showing of hydroponic system for different flower and vegetable crops are mention in this section. Observations are collected throughout the experiment on various aspects including crop growth, yield attributing characters and root grown are shown in this division. The results and discussion of the study are described in this section including tables and graphs. Explanation of result are included in this chapter.

4.1 Effect of Media on Yield Attributing Characters and Yield of Vegetables

4.1.1 Yield of pak-choi crop in A-frame and U-shaped structures

The result revealed that there were variations in yield of pak-choi plants according to the treatments (Table 4.1 and Fig.4.1). These values of length and width of leaves, number of leaves and root length were observe after 7 days of transplanting (7 DAT) with the help of measuring scale. In case of treatment (T_1) average width of leaves, average length of leaves, average number of leaves and root length is 8.9cm, 10.6cm, 9 and 11.5cm, respectively. In case of treatment (T_2) average width of leaves, average length of leaves, average number of leaves and root length is 9.6cm, 14cm, 11 and 10.8cm, respectively. In case of treatment (T_3) average width of leaves, average length of leaves, average number of leaves and root length is 8.5cm, 11.3cm, 9 and 11cm, respectively. In case of treatment (T_4) average width of leaves, average length of leaves, average number of leaves and root length is 10.2cm, 15.4cm, 10 and 10.2cm, respectively. Yield of pak-choi crop per hectare in T_1 treatment 29,641 kg, T_2 treatment 34,581 kg, T_3 treatment 25,863g and T_4 treatment 32,070 kg harvested. We have notice that in coco-peat growing media the yield of pak-choi crop is higher than clay-pellets media, because coco-peat media excellent water holding properties. Plant roots are submerged with nutrient rich solution and continuously absorbed nutrient directly. But in clay-pellets media don't have water holding properties that's why plant no meet nutrient continuously. Clay-pellets media provide good aeration in plant root, so root growth is better in clay pellets media as compare to coco-peat growing media. The view of pak-choi crop and its produce as sample is shown in Plate 4.1.

Table 4.1: Yield of Pak-choi in A-frame and U-shaped structures

Crop Parameters	**Treatments**			
	A-Frame Structures		**U-Shaped Structures**	
	T_1	**T_2**	**T_3**	**T_4**
Leaf width (cm)	8.9	9.8	8.5	10.2
Leaf length (cm)	10.6	14	11.3	15.4
No. of leaves	9	11	7	10
Root length (cm)	11.5	10.8	11	10.2
Yield of crop (kg/ha)	29,641	34,581	25,863	32,070

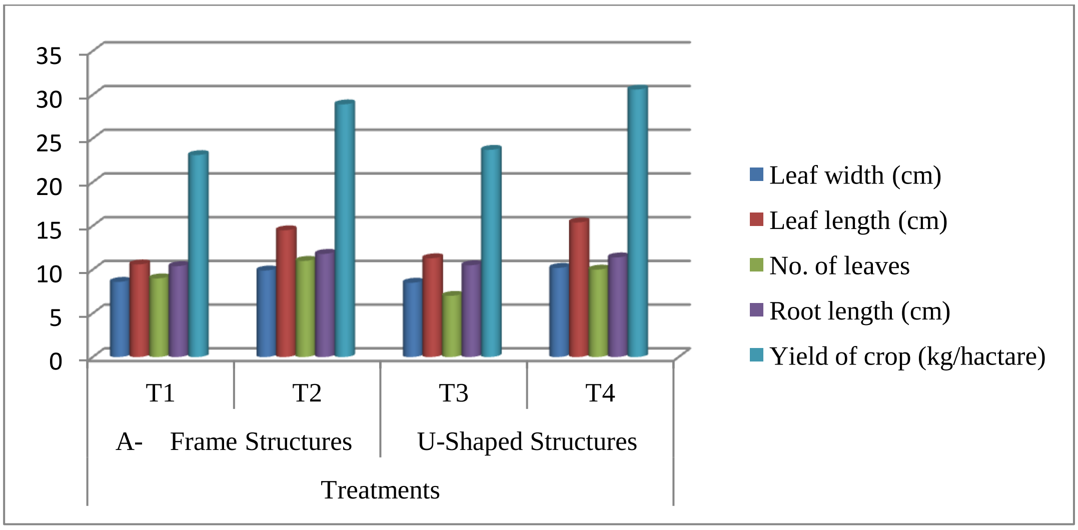

Fig. 4.1: Bar diagram shows yield and yield attributing characters of Pak-choi

Plate 4.1 : A view of Pak-choi crop and its produce

4.1.2 Yield of Leafy garlic in A-frame and U-shaped structures

The result as given in Table 4.2 and shown in Fig 4.2 revealed that there were variations in yield of leafy garlic plants according to the treatments. These values of maximum plant height, total number of leaves and root length were observed. In case of A-frame structure in clay pellets media (T_1) average length of leaf of the leafy garlic plant was recorded to be 17.5cm, and in coco-peat media (T_2) average length of leaf of the leafy garlic plant was recorded to be 22 cm. In case of U-shaped structure in clay pellets media (T_3) average length of the leafy garlic plant was recorded to be 18.7 cm and coco-peat media (T_4) average length of leaf of the leafy garlic plant was recorded to be 22.2 cm. Yield of leafy-garlic crop per hectare in T_1 treatment 494 kg, T_2 treatment 741 kg, T_3 treatment 413 kg and T_4 treatment 621 kg harvested. The view of leafy-garlic crop and its produce as sample is shown in Plate 4.2.

Table 4.2: Yield of leafy garlic in A-frame and U-shaped structures

Crop Parameters	**Treatments**			
	A-Frame Structures		**U-Shaped Structures**	
	T_1	**T_2**	**T_3**	**T_4**
Leaf width (cm)	17.5	22	18.7	22.2
Total no. of leaves	7	11	7	10
Root length (cm)	1	2	1.2	2.3
Yield of crop (kg/ha)	494	741	413	621

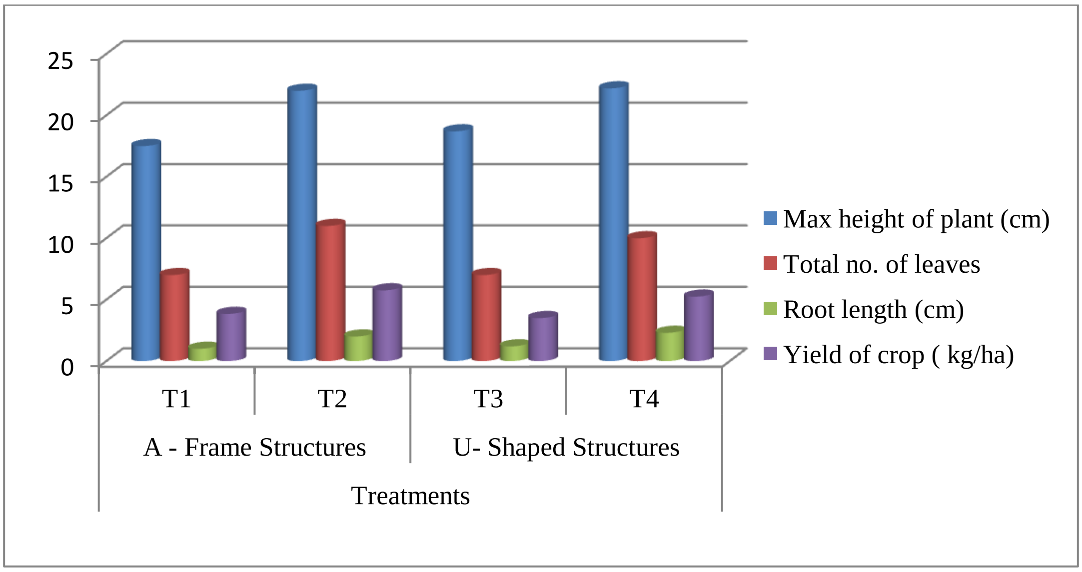

Fig.4.2 : Bar diagram shows yield and yield attributing character of leafy-garlic.

Plate 4.2 : A view of Leafy-garlic crop and its produce

4.2 Effect of Media on Yield Attributing Characters and Yield of Flowers

4.2.1 Yield of chrysanthemum in A-frame and U-shaped structures

There were variations in yield of chrysanthemum plants according to the treatments for both the hydroponic systems as depicted in Fig.4.3 and given in Table 4.3. These values of plant height, number of leaves, number of flowers, diameter of flowers and root length were observe with the help of measuring scale. In case of treatment (T_1) average length of leaf, number of leaves and diameter of flowers is 42cm, 20, 10.5, respectively. In case of treatment (T_2) average length of leaf, number of leaves and diameter of flowers is 36cm, 16, 6.4cm, respectively In case of treatment (T_3) average length of leaf, number of leaves and diameter of flowers is 40cm, 18, 8.8cm, respectively and in case of treatment (T_4) average length of leaf, number of leaves and diameter of flowers is 32cm, 15, 5.5, respectively in chrysanthemum plant. Total number of flowers per hectare in T_1 treatment 3,70,512, in T_2 treatment 2,47,008, in T_3 treatment 3,10,356, and in T_4 treatment 2,06,904 flowers ware harvested. The view of chrysanthemum crop and its produce as sample is shown in Plate 4.3.

Table 4.3: Yield attributing characters and crop yield of chrysanthemum in hydroponic structures

Crop Parameters	Treatments			
	A-Frame Structures		U-Shaped Structures	
	T_1	T_2	T_3	T_4
Leaf width (cm)	42	33	40	32
Total no. of leaves	20	16	18	15
Diameter of flowers (cm)	10.5	6.4	8.8	5.5
Yield of crop (kg/ha)	3,70,512	2,47,008	3,10,356	2,06,904

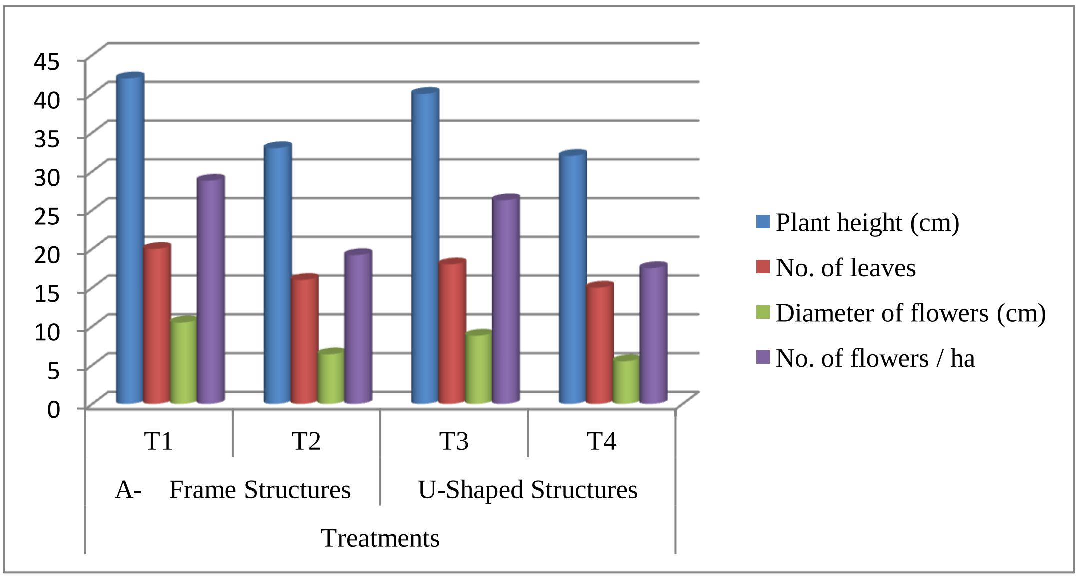

Fig.4.3: Bar diagram shows yield and yield attributing character of chrysanthemum

Plate 4.3 : A view of chrysanthemum crop and its produce

4.2.2 Yield of Petunia in A-frame and U-shaped structures

The result as tabulated in Table 4.4 and shown in Fig.4.4 clearly showed that there were variations in yield of petunia plants according to the treatments. These values of plant height, number of leaves, number of branches, and number of flowers were observe with the help of measuring scale.. In case of treatment (T_1) average height of plants, number of leaves and diameter of flowers is 22cm, 53, and 6.7 respectively. In case of treatment (T_2) average height of plants, number of leaves and diameter of flowers is 16cm, 46, and 6.6cm respectively. In case of treatment (T_3) average height of plants, number of leaves and diameter of flowers is 20cm, 55, 7.1cm respectively and in case of treatment (T_4) average height of plants, number of leaves and diameter of flowers is 13cm, 48, 6.8 respectively in chrysanthemum plant. Total number of flowers per hectare in T_1 treatment 8,64,528, in T_2 treatment 6,17,520, in T_3 treatment 7,24,164, and in T_4 treatment 6,20,712 flowers ware harvested. In clay pellets media more number of flower had harvested, because Petunia is water sensitive crop. Coco-peat media hold water in long duration and its slow drainage properties but clay pellets is highly porous material and not hold water in long duration. The view of petunia crop and its produce as sample is shown in Plate 4.4.

Table 4.4: Yield attributing characters and yield of petunia in hydroponics structures

Crop Parameters	Treatments			
	A-Frame Structures		U-Shaped Structures	
	T_1	T_2	T_3	T_4
Plant height (cm)	22	16	20	13
No. of leaves	53	46	55	48
No. of branches	5	4	5	5
Diameter of flowers (cm)	6.7	6.6	7.1	6.8
No. of flowers/ha	8,64,528	6,17,520	7,24,164	6,20,712

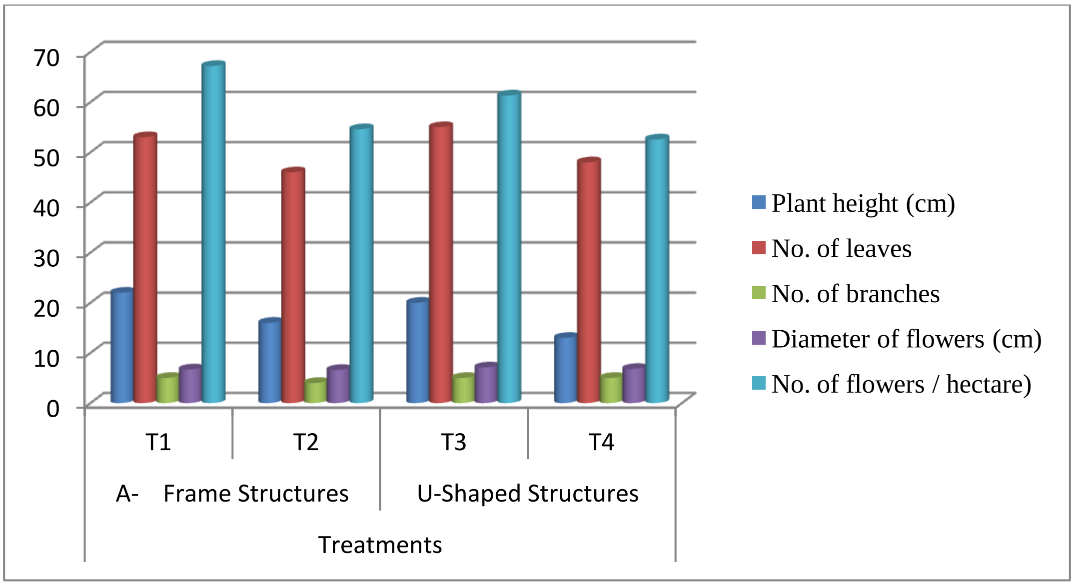

Fig.4.4: Bar diagram shows yield and yield attributing character of Petunia

Plate 4.4 : A view of petunia crop and its produce

4.3 Concentration of Nutrient Solution

Nutrient solution is very important parameter of every hydroponic system, because plant meet every nutrient through solution. Plant roots are fully submerged in nutrient rich solution. If plant not meet proper nutrient or fertilizer, it does not growth properly. Hydroponic system does not use soil i,e. every nutrient is mix in solution. If solution is more concentration of nutrient the plant will start reverse osmosis process and does not get nutrient from solution. So that optimum concentration of nutrient solution is most important in hydroponic system. Every plant require different nutrient in its planting stage, flowering stage and fruiting stages. To fulfil every stage nutrient requirement we have mix the nutrient or basic fertilisers in tank. Nitrogen, Phosphorus and Potassium are the basic fertilizer of any crops. In hydroponic systems only water soluble type fertilizer was used because in this system roots are directly submerged with nutrient solution. Concentration of nutrient solution for each stages of crop considered in this experiment are as follows.

1. **Planting Stage -** Plant nursery grown in plastic tray. In this stage the plants were picked up from tray and directly transplanted into hydroponic

structures. This stage required fertilizer N:P:K (19:19:19) was 30 g per 100 lit tank and Calcium Nitrate were also takes 30g per 100 lit tank.

2. **After Planting Stage** – This stage plant height increasing 5cm to 8cm and roots lengths is increasing 1cm to 2cm. This stage required N:P:K (12:61:00) i.e. 30 g per 100 lit tank and also N:P:K (17:44:00) i,e. 30g per 100 lit tank.
3. **Flowering Stage** – This stage plant start flowering and require more nutrient. This stage required fertilizer N:P:K (13:00:45) i,e. 100 g per 100 lit tank and also N:P:K (12:61:00) i,e. 50g per 100 lit tank.
4. **Fruiting Stage** – This stage plant start fruiting. This stage required fertilizer N:P:K (13:00:45) i,e. 100 g per 100 lit tank and also N:P:K (00:00:50) i,e. 50g per 100 lit tank.

4.4 Space Utilization of Hydroponic Systems

Under protected cultivation optimum utilization of land was noticed which is important, therefore equivalent plant population and open area required is estimated for the sake of knowledge for cultivation of high value crop. If an area is cultivated with optimum number of plants in a protected cultivation system can be profitable as compared with the open field. One A-frame Hydroponic structures contains 48 plant and one U-shaped structure contains 12 plant in the protected cultivation systems. The area required for the same number of plants in the open field is calculated as follows:

A-frame structures -

Length = 152.40cm

Tank length = 60cm

Total length of structure = 212.4cm

Width = 182.83cm

Total area covered by one A-frame structure = 3.88 m^2

Total number of A-frame structures require for 1 ha land cultivation = 2573

Total number of plant cultivate in 1 ha land = 1,23,504 plants

U-shaped structures -

Length = 152.40cm

Tank length = 80cm

Total length of structure = 232.4cm

Width = 50 cm

Total area covered by one U-shaped structure = 1.16 m^2

Total number of U-shaped structures require for 1 ha land cultivation = 8621

Total number of plant cultivate in 1 ha land = 1,03,452 plants

Plant spacing - In hydroponic structures distance between two plants is 26.67 cm and row to row is 45 cm.

4.5 Comparison between hydroponic structures and over land cultivation

In land cultivation spacing between plant to plant and row to row is

- Pak-choi crop = 27×40 cm^2
- Chrysanthemum crop = 27×45 cm^2
- Petunia crop = 27×45 cm^2
- Leafy-garlic crop = 27×45 cm^2

The results of comparison between number of plants which can be grown in hydroponic and open land system is given in Table 4.5 and shown in Fig. 4.5. Table 4.5 and Fig. 4.5 clearly revealed that more plants can be grown in hydroponic system under protected cultivation system as compared to open field cultivation system. Therefore, it can be concluded that hydroponic system of cultivation for high value crop is better than that of open field system in terms of area required for the crop to be grown.

Table 4.5 : Total number of plant per ha in hydroponic cultivation and over land cultivation

Crop	Cultivation System	Total number of plant per ha
Pak-choi	Hydroponic structures	123504
	Land cultivation	92593
Chrysanthemum	Hydroponic structures	123504
	Land cultivation	82305
Petunia	Hydroponic structures	123504
	Land cultivation	82305
Leafy garlic	Hydroponic structures	123504
	Land cultivation	82305

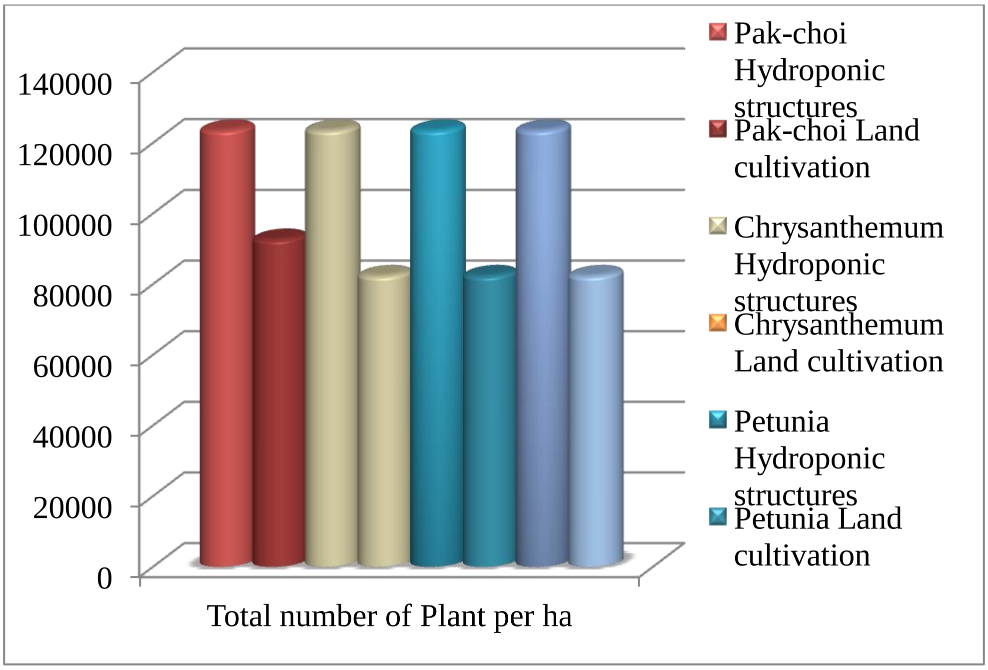

Fig 4.5: Bar diagram shows comparison of total number of plant between Hydroponic and open land cultivation system

CHAPTER V

SUMMARY AND CONCLUSIONS

The development of controlled environment agriculture techniques such as hydroponics (soilless culture) offers a viable alternative to obtain high efficiency in water use and higher productivity in an environmentally sustainable way. Hydroponics is the raising of plants in nutrient solutions without soil. This can be easily tried in urban and semi urban areas and kitchen gardens without much use of land. Hydroponics is the fastest growing sector of agriculture and could very well dominate food production in the future. The use of soil alone as growing medium has started to face serious limitations like soil-borne pests and diseases.

Without soil crop growing means that hydroponics system which uses many different substrate for supporting the plant root system. The supporting media are coco-peat, vermiculite, perlite, rock-wool, clay-pellets etc. The coconuts fiber is called coco-peat. It is purely organic material and has good anti-fungal properties. Coco-peat is sterile having natural rooting an inert material which is used to support the plant roots and has excellent water holding capacity.

Clay pellets are also an inert material which is used to support plants root, clay pellets do not hold water but support the plant roots. Nutrients solution is passed through clay pellets and the plant roots directly absorb the nutrients from the solution. Because of size and shape of clay pellets root can spread more freely in it as compared to coco-peat. These are very common media in the hydroponics system cultivation for growing vegetables and flowers.

A study on performance evaluation of different type of hydroponic systems for greenhouse vegetables and flowers has been carried out at the Centre of Excellence on Protected Cultivation and Precision Farming (CoE-PCPF), IGKV Raipur (C.G.) during the year 2018-19. The aim of this study was to evaluate the performance of both A-frame and U-shape hydroponic structures. Two vegetable crops and two flower crops were grown and performance of hydroponic structure was evaluated.

Performance evolution of hydroponic systems (A-frame and U-shape) for cultivation of Pak-choi, Chrysanthemum, Petunia and Leafy garlic have been carried out. Lengths and width of leaf of plants have been measured to determine crop growth performance in all treatments. It was noticed that every fibrous root crop yield was more on coco-peat media but every tap-root crop yield was more in clay-pellets media.

In this study four treatments with two media and two type of structures were considered to compare various aspect. The nutrient requirement of crops in hydroponic system can be fulfilled only through the right balance nutrient solution as per plant requirement to achieve optimum plant growth. Observations were taken time to time throughout the experimentation.

The results of study revealed that the yield of Pak-choi crop in A-frame structure was 29,641 kg/ha (Clay-pellets media) and 34,581 kg/ha (coco-peat media) and for U-frame structure was 25,863 kg/ha (Clay-pellets media) and 32,070 kg/ha (coco-peat media). Total number of Chrysanthemum flowers in A-frame structure was 3,70,512 per ha (Clay-pellets media) and 2,47,008 per ha(coco-peat media) and for U-frame structure was 3,10,356 per ha (Clay-pellets media) and 2,06,904 per ha (coco-peat media). Total number of Petunia flowers in A-frame structure was 8,64,528 per ha (Clay-pellets media) and 6,17,520 per ha (coco-peat media) or U-frame structure is 7,24,164 per ha (Clay-pellets media) and 6,20,712 per ha (coco-peat media). Yield of Leafy Garlic crop in A-frame structure was 494 kg/ha (Clay-pellets media) and 741 kg/ha (coco-peat media) and for U-frame structure was 413 kg/ha (Clay-pellets media) and 621 kg/ha (coco-peat media).

Further, in one hectare land total 1,23,504 plants can be grown in hydroponic structure, but in case of over land cultivation only 86,305 plants can be grown. In Hydroponic structures 1.5 times more crop can be incorporated as compare to over land cultivation.

Conclusions:

On the basis of the results of the study following conclusions can be drawn:

1. Coco-peat as a supporting media is suitable for fibrous root crop like Pak-choi, Leafy garlic.
2. Clay-pellets as a supporting media is suitable for tap-root and water sensitive crops like Chrysanthemum, and Petunia etc.
3. Vegetable crops like Pak-choi and Leafy-garlic and flower crops like Chrysanthemum and Petunia can be successfully cultivated under protected environment in the Hydroponic structures specially A-frame and U-shape.
4. As compared to overland cultivation 1.5 times more crop can be cultivated in the hydroponic systems.

Suggestions for Future Research Work

1. The hydroponic systems developed at IGKV, Raipur may be also tested in open environment.

2. Portable type hydroponic systems may be designed and tested for urban and semi-urban areas for terrace gardening.

3. The hydroponic system may also be used to cultivate crops on commercial basis.

4. The hydroponic system may be tested for different high value horticulture crops, since crop can be grown without any contact with soil but with nutrient solution only.

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