CHARACTERIZATION OF SOIL MEDIA OF POLYHOUSE CULTIVATION

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DECLARATION

We hereby declare that this project entitled **“Characterization Of Soil Media of Polyhouse Cultivation**” is a bonafide record of project work done by us during the course of study and that the report has not previously formed the basis for the award to us of any degree, diploma, associate ship, fellowship or other similar title of any other university or society.

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CERTIFICATE

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TABLE OF CONTENTS

Chapter	Title	Page No.
	LIST OF TABLES	i
	LIST OF FIGURES	ii
	LIST OF PLATES	iii
	SYMBOLS AND ABBREVIATIONS	iv
I	INTRODUCTION	1
II	REVIEW OF LITERATURE	6
III	MATERIALS AND METHODS	26
IV	RESULTS AND DISCUSSION	45
V	SUMMARY AND CONCLUSION	60
VI	REFERENCES	64
	APPENDICES	69
	ABSTRACT	73

LIST OF TABLES

Table no.	Title	Page No.
1	Fertilizer Application	30
2	Reference value of Nitrogen	36
3	Observation on Soil pH	46
4	Observation on Soil EC	48
5	Observation on Soil texture	50
6	Observation on Nitrogen	52
7	Observation on Phosphorus	55
8	Observation on Potassium	56
9	Observation on Soil moisture	57
10	Observation of micronutrients in soil	58
11	Irrigation water quality report	59

LIST OF FIGURES

Fig. No	Title	Page No.
4.1	pH Vs time	47
4.2	EC Vs Time	48
4.3	Relationship between EC and pH	49
4.4	Particle size distribution curve	53
4.5	Variation of N	53
4.6	Relationship between EC and N	54
4.7	Variation of phosphorus	55
4.8	Variation of potassium	57

LIST OF PLATES

Plate no	Title	Page No.
3.1	Naturally ventilated polyhouse	27
3.2	Details of polyhouse	28
3.3	Okra cultivation	29
3.4	Drip Irrigation system	30
3.5	Soil sample collector	32
3.6	pH meter	33
3.7	EC meter	34
3.8	Sieve Analysis	35
3.9	Titration for Nitrogen estimation	37
3.10	Spectrophotometer	39
3.11	Flame photometer	41
3.12	Oven drying of soil sample	42
3.13	Core cutter	43
3.14	Working with core cutter	44

SYMBOLS AND ABBREVIATIONS

@	At
°	Degree
°C	Degree Celsius
=	Equal
/	Per
X	Multiply
%	Percentage
±	Plus or Minus
$\mu S \cdot cm^{-1}$	Micro siemens per centimeter
ASTER	Advanced spaceborneThermal Emission and Radiation Radometer
C	Carbon
Ca	Calcium
Cd	Cadmium
Cm	Centimeter
Cr	Chromium
CRD	Completely Randomised Design
Cu	Copper
Cwsi	Crop Water Stress Index
Ds	Deci Siemens
EC	Electrical Conductivity
et al.	And Others
etc.	Et cetera
Fe	Iron
Fig.	Figure
g	Gram
GS	Geospatial Sector
GY	Grain Yield

H	Hydrogen
ha	Hectare
h	Hour
ie.	That is
IoT	Internet of Things
IPM	Integrated Pest Management
K	Potassium
KAU	Kerala Agricultural University
KCAET	Kelappaji College of Agricultural Engineering and Technology
Kcal	Kilo Calories
Kg	Kilogram
KJ	Kilojoules
l	Liter
lpm	Liter per minute
m^2	Square Meter
m^3	Cubic Meter
M	Meter
MARS	Multivariate Adaptive Regression Splines
Mg	Magnesium
Min	Minute
ml	Millilitre
mm	Millimeter
Mn	Manganese
Mo	Molybdenum
mol	mole
$ms \cdot cm^{-1}$	Millisiemens per centimeter
N	Nitrogen
Ni	Nickel
O	Oxygen
OM	Organic Matter

P	Phosphorus
Pb	Lead
pH	Potential of Hydrogen
PLSR	Partial Least Squares Regression
PPM or ppm	Parts Per Million
PVC	Poly Vinyl Chloride
S	Second
S	Sulfur
T	Tonnes
TDS	Total dissolved solvent
TSS	Total Soluble solvent
Wqmp	Water quality management program
Wqp	Water quality program
WUE	Water Use Effeciency
Zn	Zinc

INTRODUCTION...

CHAPTER 1

INTRODUCTION

Agriculture has always been a vital element of human existence. The growth of plants and crops, depends on numerous factors, and soil media is among the most critical ones. In recent years, the polyhouse farming system has emerged as a popular choice for farmers, especially in areas with harsh weather conditions. Polyhouse farming involves growing crops in a controlled environment, which allows farmers to regulate temperature, humidity, and other essential climatic factors. However, to ensure optimal plant growth, it is crucial to characterize the soil media used in polyhouses. Conventional vegetable cultivation in the state is constrained by limitations of land holdings, market price fluctuations, perishability of the produce, constraints in marketing, erratic climatic conditions etc. In this context, protected cultivation offers a new dimension to produce more from a limited area. Protected cultivation or controlled environmental agriculture involves cultivation of horticultural crops in a controlled environment wherein factors like temperature, humidity, light, soil, water, and nutrients are regulated to attain maximum produce and regular supply of them even during off-season. Polyhouse is one of such protected cultivation technologies aimed at increasing productivity, protecting the plants from biotic and abiotic pests and to break the seasonal barriers of production. Polyhouse cultivation is an intensive production system requiring relatively high investment in production and marketing. The cost of the polyhouse structure was reported as the decisive factor for adoption and sustainability of vegetable production in polyhouses elsewhere. (Lakshmi *et al*., 2017).

Greenhouses are framed or inflated structure covered with transparent or translucent material large enough to grow crops under partial or fully controlled environmental conditions to get optimum growth and productivity. Greenhouses have many advantages and some limitations also. Due to this farmers are abandoning this cultivation method citing crop failures after the initial phase. A survey was conducted by Deepthi, 2021to explore the reasons of failures of greenhouse farmers in Kerala covering all fourteen districts. The study reported that major problem faced by farmers was crop failure due to ageing of cladding material, fungal growth and dust deposit over the cladding material which reduce the light transmission to the greenhouse affecting its microclimate and growth and yield parameters.

Other major problems faced by farmers were a decrease in soil fertility, fungal/insect attack inside the greenhouse, high maintenance cost and structural problems of greenhouse, lack of demand and marketing facility of greenhouse products.

Soil media characterization involves the assessment and analysis of various parameters that affect plant growth, such as pH, electrical conductivity, organic matter content, nutrient availability, and physical properties. These parameters are essential for selecting the appropriate soil media and determining the optimal nutrient requirements for plants. Understanding soil media properties is particularly important in polyhouse farming, where the controlled environment can affect soil properties, leading to changes in plant growth and yield.

One of the critical factors in soil media characterization is the pH level. The pH level of soil determines the acidity or alkalinity of the medium and affects plant growth and nutrient availability. Most crops grow best in a slightly acidic to neutral pH range of 5.5 to 7.0. However, polyhouse farming systems may have pH levels that differ from traditional soil systems due to variations in irrigation water quality, fertilizers, and other factors. Therefore, it is essential to measure the pH level regularly and adjust the soil media accordingly.

Another important factor in soil media characterization is the electrical conductivity (EC) level. EC measures the concentration of soluble salts in the soil media and indicates the potential for crop damage due to salt accumulation. High EC levels can affect the availability of nutrients to plants, causing stunted growth and reduced yield. In polyhouse farming, the controlled environment can cause salt buildup, making it essential to monitor EC levels and ensure appropriate measures are taken to mitigate salt accumulation.

The organic matter content of the soil media is another crucial factor in plant growth and development. Organic matter provides nutrients to plants, improves soil structure, and enhances water holding capacity. However, polyhouse farming systems may have lower organic matter content than traditional soil systems due to the use of inorganic fertilizers and lack of organic matter incorporation. Therefore, it is essential to supplement the soil media with organic matter to maintain optimal plant growth.

In addition to chemical properties, physical properties such as texture, structure, and porosity of soil media are essential in soil media characterization. Soil texture determines the size and distribution of soil particles, affecting water retention, aeration, and nutrient availability. Soil structure refers to the arrangement of soil particles into aggregates, affecting water infiltration, root penetration, and soil stability. Soil porosity refers to the amount and distribution of pores within the soil media, affecting water holding capacity, aeration, and nutrient availability. Understanding these physical properties is essential in the selection and management of appropriate soil media for optimal plant growth.

In conclusion, soil media characterization is a critical aspect of polyhouse farming systems. Characterizing soil media involves the assessment and analysis of various parameters, such as pH, electrical conductivity, organic matter content, and physical properties, which affect plant growth and yield. Understanding and monitoring these parameters is crucial in selecting appropriate soil media, adjusting nutrient requirements, and maintaining optimal plant growth in a controlled environment.

In this contest, this study has been taken up with the following objectives:

- To identify the various soil parameters governing the growth and yield of plants.
- To determine the correlation between important soil parameters.
- To study the variation of important soil parameters and nutrient status.

REVIEW OF LITERATURE…

CHAPTER 2

REVIEW OF LITERATURE

This chapter illustrates a comprehensive review of the research works published through peer review journals related to protected cultivation, its prospects and challenges. The chapter also discusses the reports referring the determination and significance of different soil parameters. The significance of the crop has also been elaborated referring to the available literatures.

2.1 PROTECTED CULTIVATION

Protected cultivation or greenhouse cultivation is the most contemporary approach to produce mainly horticultural crops qualitatively and quantitatively and has spread extensively the world over in the last few decades. Protected cultivation also known as controlled environment agriculture (CEA) is highly productive, conservative of land and water and also environment friendly. By adopting protected cultivation technology, the farmers can look forward to a better and additional remuneration for high quality produce (Naved and Balraj, 2012).

Kumar *et al.* (2018) studied the Status and Constraints in Vegetable Cultivation under Polyhouse in Haryana. Karnal district was selected purposively based on predominance of vegetable cultivation under polyhouse. The result of this study revealed that short life of polyethylene sheet (92.5%), problem of nematode and whitefly (90%), high cost of fertilizer (82.5%) and high cost of seed (77.5%) were found to be the main constraints. Simple statistical tools like averages and percentages were used to compare, contrast and interpret the above factors.

Santosh *et al.* (2023) embarked a study on optimizing microclimate control in polyhouses for enhanced crop growth and productivity in distinct climatic zones of Chennai. From the study it was found that improving the microclimate in polyhouses is crucial for enhancing crop growth and yield. It is feasible to establish ideal growing conditions for a variety of crops by employing automatic climate control systems and other methods to adjust the temperature, humidity, and other environmental factors.

Naved and Balraj. (2012) carried out a study elaborating the global aspects of protected cultivation. The world scenario shows the area under protected cultivation to be nearly 6,23,302 hectares while total estimated world greenhouse vegetable production area is 4,02,981.Of the total world greenhouse vegetable area, soilless/hydroponic culture systems account for 95, 000 ha. Faced with constraints of land holdings, rapid urbanization, declining crop production, declining biodiversity and ever-increasing population, demand for food, especially vegetables have increased manifold and protected cultivation has offered a new dimension to produce more in a limited area.

2.2 OKRA CULTIVATION

These studies have explored the effects of different fertilizers and cultivation methods on okra growth and yield. It also emphasizes the importance of careful fertilizer application, including the use of bio-fertilizers and organic manures, for enhancing okra crop quality and productivity.

Mishra *et al*. (2012) conducted an experiment during in a semi cylindrical greenhouse of 4 m × 25 m each for cultivation of okra at Bhubaneswar in coastal Orissa, India. The yield of okra per sq m inside the greenhouse was 2.42 times more than open field conditions. The green house was evaluated in terms of its techno-economic analysis, which was carried out by using different economic indicators such as Net Present Value, Benefit-Cost Ratio, Internal Rate of Return and Pay Back Period. The fruit yield per sq m inside the greenhouse was 2.42 times more than the open field conditions. The okra sown during off-season under greenhouse produced 42 percent higher fruit yield than the normal sowing date in the open field (0.49 kg/m 2).

Choudhary *et al*. (2015) initiated a field experiment at Regional Horticultural Research Station, Navsari Agri-cultural University, Navsari (Gujarat) during rabi season to assess the effect of chemical fertilizers along with bio-fertilizers on okra in terms of growth and yield. Among the different combinations of bio and chemical fertilizers maximum plant height (96.03cm), pod weight (11.53 g), girth of pod (4.88cm), yield plant-1 (139.39 g) and yield ha-1(10324.94 kg) were observed in the treatment were observed in treatment re-ceiving azospirillum 5 kg ha-1 + RD NPK. The plants under the treatment of PSB 5 kg ha-1 + RD NPK through chemical fertilizers had the highest length of pod (12.03 cm). Whereas the treatment of VAM 15 kg ha-1 + 75% P +100% NK through chemical fertilizers had the highest number of pods per plan. The study led to a conclusion, that the maximum growth parameters, highest yield and yield attributing characters of okra could be achieved by judicious application of bio-fertilizers and chemical fertilizers.

A field experiment was conducted by Kumar *et al*. (2017) at the Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat during March to July 2016 to study the effect of "integrated nutrient management in okra organic manures", inorganic fertilizers were applied in combinations with bio-fertilizers. Treatment consisted of recommended dose of fertilizers (RDF). Among the treatments highest plant height (118.52 cm), least numbers of days taken to first flowering (46.20 days) and fruiting (47.33 days), number of fruits per plant (16.00) and yield (12.70 t/ha) were recorded. The perusal of result revealed that most of the growth and yield attributes were found highest in treatment receiving RDF. However, INM treatments exhibited superior value regarding quality and soil parameters as compare to the treatment receiving RDF.

Ray *et al*. (2022) carried out an experiment in Birchandramanu district of Tripura on early seasonal okra cultivation. The study is conducted in the mid of January rather than the usual sowing season of June -July. The objective of the study was to determine the performance of okra with integrated nutrient management (INM) practices. The results reveal that cultivation of okra with INM practices during early season increases yield (5.30 to 6.95 t/ha) of okra by 28 to 67 per cent compared to farmer's practice (4.15 t/ha), while production (6.92 to 7.66 t/ha) were also increased significantly with INM by 48 to 64 per cent compared to farmer's practice (4.67 t/ha) during the normal season. The production during the normal growing season (0.28 to 1.62 t/ha) was substantially higher than the early seasonal growth.

2.3 IDENTIFICATION OF RELEVANT SOIL PARAMETERS IN POLY HOUSE

A study on intensive cultivation in poly-house conditions found that the majority of poly-house soils exhibited higher soil health levels compared to open conditions. Various soil indicators, including pH, N, K, Ca, Mg, micronutrients, and bicarbonates, had less influence on soil health, while EC, phosphate, organic carbon, porosity, chloride, sulfur, and microbial biomass significantly influenced soil health. Soil EC and pH were identified as important factors shaping bacterial community composition.

The study conducted by Kim *et al*. (2016) analyzed 187 samples of greenhouse soil across Korea and adopted pyrosequencing to analyze the bacterial community structure and composition, and to investigate the relationships between the bacterial community and environmental factors such as pH, EC, exchangeable cations (Ca^{2+}, Mg^{2+}, Na^{+}, and K^{+}), available P_2O_5, organic matter, and NO3-N. In addition, the main environmental factors shaping the bacterial communities in greenhouse soils were also determined. The soil EC was also found to be one of the main factors influencing the soil bacterial community compositions in our study. EC is apparently associated with soil salinity. The results show more prominent relationship between the community composition and soil pH and suggest that pH has a dominant effect on the bacterial communities of greenhouse soils.

Chandel *et al*. (2017) carried out a study to find out the impact of intensive cultivation on soil health under polyhouse condition of mid hill zone of Himachal

Pradesh. The soil samples were collected from polyhouses and adjacent open fields from three districts of Himachal Pradesh and were analyzed for physical (bulk density, particle density and porosity), chemical (pH, EC, organic carbon, cation exchange capacity, bicarbonate, chloride, available N, P, K, extractable calcium, magnesium, DTPA extractable Zn, Fe, Mn and Cu) and biological (microbial biomass) properties. All the soil indicators were combined to calculate soil health index. The contribution of most indicators to soil health had no significant difference in polyhouse and open condition. The pH, N, K, Ca, Mg, micronutrients and bicarbonates had less influence on soil health, while EC, phosphate, organic carbon, porosity, chloride, Sulphur and microbial biomass greatly influenced the soil health. The results suggested that relatively more healthy and productive soil was observed in the polyhouse conditions as compared to open conditions. The majority of polyhouse soils had high soil health level which accounted for 57 % of the surveyed samples, followed by very high (40%) and medium soil health (3%).

2.4 EFFECT OF GROWING MEDIA AND MICRONUTRIENTS IN POLY HOUSE

The main focus is to investigate the impact of growing media and micronutrients on the growth, yield, and quality under polyhouse conditions. It explores different combinations of growing media and foliar spray of micronutrients to determine their effects on various growth parameters, yield attributes, and overall fruit yield. The study emphasizes the need for cultivar selection, media preparation, crop management, and post-harvest care, with a particular emphasis on precision crop management technologies.

Yadav *et al*. (2020) embodied an experiment entitled “Effect of growing media and micronutrients on growth, yield and quality of cucumber (Cucumis sativus L.) under polyhouse condition” during kharif season 2017 at S.K.N. College of Agriculture, Jobner. The experiment consisted treatment with three growing media (garden soil, garden soil + FYM, garden soil + vermicompost) and three foliar sprays (combination of boron, calcium, boron + calcium of micronutrients in completely randomized design with three replications. Growing of cucumber with garden soil 18 kg/bag + vermicompost 2 kg/bag and foliar spray of boron 0.5 % + calcium 0.5% significantly improved all the growth parameters (plant height, number of green leaves per plant, number of nodes per plant, stem diameter, total number of pickings), yield attributes (number of fruits per plant, avg. fruit weight, fruit yield per plant, fruit yield) per 1000 m^2 area.

Maitra *et al*. (2022) overtook a scientific study in Paralakhemundi district of Odisha for the proper identification of package of practices for gerbera cultivation in greenhouse inclusive of choice of suitable cultivars, media preparation and planting, crop management, harvest and post-harvest care. The significant difference among the varieties were found in almost all the characteristics of the cultivars inclusive of growth, quality parameters and yield. Moreover, precision crop management technologies under protected cultivation are also observed in different parts of the country which needs further research to make this user friendly and cost-effective.

Bijeta et al. (2019) carried out a study in Nauni district of Himachal Pradesh. The growing media Soil + Cocopeat + Vermicompost + FYM (2:1:0.5:0.5) with plant spacings 45×60 cm resulted the maximum total carotenoids (2.10%), ascorbic acid (122.23%) and total soluble solid (7.08 °B) while minimum was recorded under Soil + Sand + FYM (2:1:1) with plant spacing 45×30 cm (1.86%, 117.03%, 6.28 °B). The result revealed that among various treatment combinations growing media Soil + Cocopeat + Vermicompost + FYM (2:1:0.5:0.5) with plant spacing 45×60 cm recorded maximum leaf area index (3.23), net assimilation rate (0.083 mg/leaf area/day) and plant biomass (150.36 g/plant). Therefore, it can be inferred that incorporation of Soil, Cocopeat, Vermicompost, and FYM with appropriate crop spacing led to the better quality and growth of capsicum.

2.5 LONG TERM CULTIVATION EFFECT ON SOIL HEALTH INSIDE POLY HOUSE

The study tells that open field soils had lower levels of available nitrogen, phosphorus, and potassium due to high rainfall. Soil pH ranged from 4.30 to 5.18 inside the poly houses and in the open field regardless of the season. Long-term research in this area is crucial because effects such as organic matter enrichment and potential accumulation of soil toxic elements evolve slowly and are challenging to predict. Their analysis revealed that microbial properties, such as microbial biomass carbon, were stimulated, particularly with high rates of composted organic amendments.

Diacono et al. (2012) embarked a study in Bary, Italy to address long-term research on organic amendment on cropland. It is particularly relevant because many effects like organic matter enrichment and possible soil toxic element accumulation, evolve slowly and are difficult to predict. Enzyme activity and microbial biomass analysis indicated that microbial properties were stimulated, e.g., microbial biomass C increased to about 100%, more by high rates and composted than by low rates and fresh paper mill residuals (78 t ha^{-1} and 22 t ha^{-1}, respectively). crop yield was enhanced by about 250%, with high rates of municipal solid waste compost repeated applications. Long-term organic amendment application can play a positive role in climate change mitigation by soil carbon sequestration, which in turn can reverse the process of soil degradation.

Mahanta *et al*. (2020) carried out an experiment to evaluate the long-term cultivation effect on soil health under poly houses of varying age groups in Jorhat, district of Assam. It was observed that after 3-5 years of cultivation, the soils under the poly houses were deteriorated due to formation of soil acidity, nutrient imbalance and reduction in microbial diversity and enzyme activity. The available N, P2O5, K2O in soils showed an increasing trend up to 3-5 years of poly house age, thereafter decreased significantly. Irrespective of seasons and soil depth, the bacterial and fungal population showed a decreasing trend with advancement of poly house age. Study indicated that the soils under poly houses required rejuvenation particularly after 6-8 years for improvement of physical, chemical and biological properties so as sustain soil health as well as crop productivity.

Roy *et al*. (2012) studied the effect of organic growing media and plant spacing on growth and yield of capsicum variety California Wonder in the mid hills of north western Himalayas. It can be inferred that incorporation of vermicomposting and FYM led to the better soil properties and nutrient supply to plants, whereas appropriate crop geometry created suitable micro environment for proper plant competition. Better performance of the plants in lesser depth of media in turn made the cultivation economical for the growers.

2.6 INTEGRATED PEST MANAGEMENT IN PROTECTED CULTIVATION

The study emphasized the importance of regular visual inspection and surveillance in implementing an effective IPM program for flowers and ornamental foliage production. Integrated pest management (IPM) strategies should be implemented by greenhouse producers in India to manage insect pests effectively.

Kaur *et al*. (2018) initiated a scientific study on efficacy of some insecticides and botanicals against sucking pests on capsicum under net house in Ludhiana district of Punjab. The results shows a significantly low aphid counts/plant (0.76-1.05) in treatments asataf (acephate) 75 SP @ 0.10% and neem soap (*Azadirachta indica*) @ 1.0%. Significantly low chilli thrips counts /top canopy/plant (0.03-0.06) were recorded in treatments confidor 17.8 SL (imidacloprid) @ 0.05% followed by asataf (acephate) 75 SP @ 0.10% and significantly lower mean yellow mite rating (2.42-2.45) was recorded in treatment decis 2.8 EC @ 0.05 %. Successful management of greenhouse pests can be done by using integrated approach. It is important for greenhouse producers in India to implement as many IPM exclusion strategies as possible to manage insect-pests.

Sreeja *et al*. (2018) conducted a study in 82 polyhouses comprising 13 agro-ecological zones covering 12 districts of Kerala, with a view to document the pests and natural enemies associated with salad cucumber, yard long bean, tomato, chilli, amaranthus, bitter gourd and cabbage. Twenty-eight species of pests were recorded in the study comprising of nineteen insect pests, five plant parasitic nematodes, two each of mite and mammalian pests. The incidence of mammalian pests in polyhouse is reported for the first time. American serpentine leaf miner, Liriomyza trifolii, cowpea aphid, Aphis craccivora, leaf caterpillar, Spodoptera litura, spider mite, Tetranychus truncates and root knot nematode, were found to be the predominant ones.

Chakravarthy *et al.* (2020) elaborated a study on effective IPM program for flowers and ornamental foliage production demand regular visual inspection and surveillance at New Delhi. In polyhouses and greenhouses, sucking pests pose a problem. In fields, lepidopterans, and beetles generally may attack flower plants. Spot treatments, use of yellow sticky cards, pheromone traps, prophylactic cultural and mechanical tools, insecticidal soaps, botanicals, and microbial application are important for IPM in flower crops. Valid sampling and scouting plans should be adopted for healthy and quality flowers, cut-flowers, and ornamental foliage production. Impetus, funding, and attention are being now given to IPM in flowers and ornamental foliage production globally.

2.7 EFFECT OF IRRIGATION ON PLANTS GROWN UNDER POLYHOUSE

The study emphasized the importance of appropriate irrigation techniques in protected cultivation. Micro irrigation allows precise application of water and nutrients, saving resources and controlling pollution. It also has the potential to increase crop yield.

Singh. (2012) emphasized a study in pantnagar district of uttarakhand pertaining the relevant irrigation techniques in protected cultivation. Irrigation techniques having the characteristics of frequent application of water in small quantity as per crop need at right location in right manner is essential for obtaining the maximum benefit of protected cultivation. Mulch can be used to further enhance the water and nutrient use efficiency along with improving the quality of produce and precise resource savings. Automation further reduces the manual intervention and increases the input use efficiency. In this way significant amount of two important agricultural inputs (water and nutrients) could be saved significantly besides controlling the environmental (non-point source/agricultural) pollution. Further, it has the potential to increases crop yield.

Sethi *et al.* (2018) embarked a study on the significance of drip and micro irrigation in the Barak valley located in north east. The daily water requirement of lady's finger crop is 2.4 l/day/4 plants during early growth stage and during the peak growth stage irrigation requirement is 7.6 l/day/4 plants recommended by National Committee on Plasticulture Applications in Horticulture. The drip irrigation system should be operated daily for 10 minutes during initial growth stage and for 30 minutes during peak growth of the crop with an emitter capacity of 4 lph. And the micro-sprinkler system should be operated daily for 5 minutes during initial growth stage and 15 minutes during peak growth of the crop with an emitter capacity of 10 lph. Micro-sprinkler irrigation system gives comparatively better vegetative growth and yield of lady's finger than the drip irrigation system inside the green house may be due to the uniform distribution of water on plants and soil.

Santosh *et al*. (2017) elaborated a study in Kharagpur district of West Bengal on effect of drip irrigation levels on yield of lettuce under Polyhouse and Open Field Condition. The total water requirement of Lettuce crop was estimated to be 219 mm and 339 mm for polyhouse and open field condition respectively. There were total five treatments, four irrigation levels (120%,100%, 75% and 50% of crop water requirement) using drip irrigation system in polyhouse. lettuce production in winter for sub humid region is fatal due to fall of temperature below optimum level which results in deficient growth. Polyhouse offer a great solar energy saver and increased temperature inside structures from the above data we can conclude that, lettuce production in open field condition requires higher irrigation water comparing to polyhouse cultivation. It also shows that 35.2 % less irrigation water require for poly house cultivation comparing to irrigation water requirement for open field cultivation.

2.8 SIGNIFICANCE OF WATER QUALITY IN PROTECTED CULTIVATION

The study aims to identify essential use and approaches for planning and optimizing a water quality management program (WQMP). It evaluated the effect of different water pH levels on the growth of hops in a greenhouse. The study found that a pH range of 6.5 to 7 promoted better availability and absorption of potassium, increased photosynthetic capacity, and resulted in higher yield compared to other pH levels.

Behmel *et al.*, (2016) explored about the nuances of water quality monitoring strategies to identify additional essential use cases, delve into the use cases to show the underlying actions and interactions, and search the literature to identify approaches providing important leads to address the use cases. some of the proposed approaches to address use cases (e.g. optimize the number and distribution of sampling points; evaluate the representativeness of a sampling site network for the water quality of a watershed; evaluate the representativeness of the type and number of WQPs, explore relationships between WQPs, assess sampling frequency and recurrence) were selected and submitted to a more in-depth analysis in order to verify their transferability, case specificity and degree of difficulty of application water quality standards, geographical and geological differences, land use variations, etc., it is difficult, if not impossible, to suggest a one-in-all solution for the decision processes of planning and optimizing a WQMP. However, it is possible to suggest that an intelligent decision support system can guide a watershed manager through the process for his/her site-specific requirements, be they natural, regulatory or land use specific (or any other constraint). In addition, it is necessary to develop participative approaches based on geographical information systems which represent spatially the territory and adaptive questionnaire-based surveys to tap into local knowledge and the knowledge needs of the stake-holders.

Guimaraes *et al.,* (2021) evaluated the irrigation effect with different water pH ranges on the agronomic development of hops grown in a greenhouse, in Botucatu, state of São Paulo, Brazil. It was used a completely randomized design (CRD), with three treatments (pH levels) and ten replications. The treatments consisted of three water pH levels: T1 – 6 to 6.5, T2 – 6.5 to 7, and T3 – 7 to 7.5. To obtain the different pH ranges were used solutions of 0,1 mol L−1 of sodium hydroxide (NaOH), and phosphoric acid (H3PO4). Gas exchanges, nutritional content in plant leaf tissue, yield, and alpha and beta-acids concentration were evaluated. The results obtained allowed us to conclude that the pH range 6.5 to 7 promotes greater availability, absorption, and accumulation of K in plant leaf tissue, as well as greater photosynthetic capacity, in addition to greater yield between treatments

2.9 IMPACT OF WATER STRESS IN CROPS GROWN UNDER POLYHOUSE

Numerous studies have been conducted to explore the impact of water stress on crop growth and quality. It was found that stress during flowering resulted in better yields and quality than stress at other developmental stages.

Deepa *et al.* (2010) performed research to standardize the irrigation requirement of salad cucumber grown in polyhouse and to find the suitable packaging for extending the shelf life of salad cucumber at Tavanur, Kerala. The experiment had five irrigation treatments with six replications. Two types of irrigation: basin, and drip were practiced. The plot having basin irrigation with 2.5 l/plant/day was taken as the control plot. The crop inside the polyhouse with drip irrigation of 1.5 l/plant/day performed well during the experiment. The experiment reveals that the soil temperature inside the polyhouse has a direct relation with rainfall, since the temperatures show maximum value at minimum rainfall, and vice versa. Since soil temperature plays an important role at the critical growth stages of salad cucumber, the rainfall has a great significance.

Nuruddin *et al.* (2013) studied the relative impact of water stress on tomatoes grown under protected cultivation at Montreal, Quebec. Available soil water (ASW) deficit thresholds, 65% and 80%, at which plants were irrigated to field capacity were factorially combined with five irrigation timing patterns: no water stress, stress throughout the entire growing season, stress during first cluster flowering and fruit set, stress during first cluster fruit growth, and stress during first cluster fruit ripening. Crop yields, water use efficiency, as well as maximum and minimum equatorial fruit diameters and fruit height were measured. Non-stressed and flowering-stressed fruit showed lower soluble solids and a lighter color of red ripe fruit than the other stress treatments. No significant differences in yield or quality were found between the two stress levels (65% vs 80% ASW depletion before irrigation). Water stress only during flowering resulted in better yields and quality than stress at other specific developmental stages or at all times, but equal or poorer yields and water use efficiency than non-stressed plants.

Qin *et al.* (2021) studied the "Effects of CWSI (crop water stress index) thresholds on grain yield (GY) and water use efficiency (WUE) of winter wheat and summer maize in the NCP (North China Plain)" at China. CWSI thresholds for CPIS (center pivot irrigation systems) irrigated crops could be identified via the determinate relationships between CWSI and GY/WUE. The objectives of this study were to quantify the relationships among CWSI, Tc – Ta, and GY/WUE for winter wheat and summer maize in the NCP, and to identify reliable CWSI thresholds using a distinctly different methodology. CWSI thresholds were proposed as being 0.322

for winter wheat, and 0.299 for summer maize, corresponding to a Tc − Ta threshold value of 0.925 and 0.498 °C, respectively. Farmers can achieve the dual goals of high GY and high WUE using the optimal thresholds proposed for a winter wheat–summer maize cropping system in the NCP.

2.10 STATISTICAL ANALYSIS OF SOIL PROPERTIES IN POLYHOUSE

The analysis of soil properties in a polyhouse is an important aspect of plant growth and development. The study found that the MARS and PLSR models were successful in mapping soil properties, with MARS being more suitable and superior for estimating and mapping soil salinity, clay content, and OM.

Nawar *et al.* (2015) studied the "Digital mapping of soil properties using multivariate statistical analysis and ASTER data in an arid region". The descriptive statistical analysis of the soil samples collected from El-Tina Plain, Sinai, Egypt. It explored a digital soil mapping methodology based on the MARS and PLSR models. This study demonstrated how predictive models coupled with ASTER spectra could successfully map the soil properties over a large agricultural area. The models of soil clay content were found the best, with R2 = 0.94 and 0.90, RPD = 4.38 and 3.22, for MARS and PLSR, respectively. Soil salinity models had a good performance (R2 = 0.85 and 0.80, RPD = 2.60 and 2.16, for MARS and PLSR, respectively). Soil properties in the study area, MARS as a non-linear model, exhibited better estimation for all mapped soil properties than PLSR. Results indicated that MARS is a more suitable and superior modeling technique than PLSR for the estimation and mapping of soil salinity (EC), clay content, and OM.

Carmon *et al.* (2017) researched the advanced analytical approach for spectral-based modeling of soil properties at Israel. It developed a robust prediction model to analyze soil attributes from spectral information has significant importance for hyperspectral remote sensing applications. Using partial least squares for model development is a multi-step process with many optional alterations. The correlation matrix between all chemical attributes will be studied to explain the spectral feature paracuda II extract for the best model (out of many checked). It is apparent that paracuda II brings a highly elaborated and robust modeling technique to a basic user with powerful automated nature. All of the modeled soil properties showed remarkable results, with R^2 between 0.861 and 0.946 for applying the models on the validation set.

Martín *et al.* (2022) conducted a study on the "Spatial relations of heavy metals in arable and greenhouse soils of a Mediterranean environment region located in Spain". It characterizes and compares Cr, Ni, Pb, Cu, Zn and Cd contents and the main edaphic parameters in arable soil. The study explorers 192 soil samples from green house and 142 from the arable land. Despite anthropogenic HM input, the association patterns of these elements were similar on the two spatial variability scales. Cd, Pb and Zn contents, and partly those of Cu, were related to agricultural practices. The associations found with Cr and Ni suggest a lithogenic influence combined with a pedogenic effect on spatial maps. This natural origin input becomes more marked on the long spatial scale, where the main Cr and Ni contents were found in the vicinity of mountain areas not influenced by human activities.

2.11 INSTRUMENTS FOR MEASUREMENT OF IMPORTANT SOIL PARAMETERS

These studies highlight the importance of accurately measuring soil properties for agricultural purposes and suggest different techniques to do so.

Moebius *et al.* (2012) conducted a study on "Evaluation of laboratory measured soil properties as indicators of soil physical quality". Soils were sampled for three experiments from five related long-term controlled trials under maize production located on Cornell University research farm. Water-stable aggregates with sizes ranging from 0.25 to 2 mm were the most sensitive indicator of changes in soil management. The indicators PO 9, 30 and >b was less sensitive but nevertheless useful in assessing soil quality. We propose that routine physical soil quality assessment include >b, AWC and WSAsm, and possibly PO 9, 30 represents physical processes in the soil (such as physical root proliferation, water-stable aggregates (0.25–2 mm), available water capacity, bulk density, and PO 9, 30 appear most promising as indicators for routine evaluation and monitoring of soil physical quality, storage, aeration and water movement resp.) that are essential for agricultural functions.

Radman *et al.* (2017) studied about an Arduino-based system for soil moisture measurement at Podgorica. In this study design of the microcontroller system for soil moisture measurement using Watermark 200SS soil moisture sensor is described. The initial soil moisture was at 50.9%. The soil is then briefly moistened and allowed to dry over a period of several minutes. Increase in soil moisture can be noticed until the soil has reached the maximum humidity saturation of 51%. The excess water is then removed and slight pressure is applied to the soil to remove a certain amount of water for the purposes of demonstration. The idea was to develop a modular, flexible system using affordable components. This greatly improves manageability of the system as it allows us to control the system from a central point wirelessly, without the need for field work.

Qingsong *et al.* (2023) conducted a study to develop a device for the measurement of soil physical or mechanical properties of rapeseed direct planting field at Wuhan, China. The device can measure soil moisture content, firmness, cohesion, and internal friction angle, and the measurement results can be displayed and stored in the mobile app. An STM32 single chip microcomputer was used as the core controller, an FDR sensor was used to obtain the soil moisture content, and the soil firmness and shear strength parameters, including cohesion and internal friction angle were measured through the cone penetration component. In addition, the measurement principles of the cone penetration component and the soil moisture content detection component of the device were analyzed, the hardware circuit and software of the device measurement control system were designed. The results showed that compared to the AYD-2 type soil firmness meter, oven drying method, and ZJ-D type direct shear instrument, the average relative errors of soil firmness, soil moisture content, cohesion, and internal friction angle measured by the measuring device of farmland soil physical and mechanical properties were 3.34%, 5.06%, 10.40% and 8.20%, respectively.

2.12 IMPACT OF FERTILIZERS

The use of fertilizers and pesticides in agriculture has a significant impact on the soil microflora and overall ecosystem. Excessive and prolonged use of chemical fertilizers and pesticides can have detrimental effects on soil microflora, affecting functions and properties such as nutrient content, soil organic carbon, pH, and moisture. Studies also revealed that the use of chemical fertilizers has adverse effects on human health and environment, and that adopting new agricultural practices such as organic farming can create a healthier natural environment for present and future generations.

Chandini *et al.* (2013) conducted a study on “The Impact of Chemical Fertilizers on our Environment and Ecosystem” at Bihar, India. Chemically produced plant will accumulate toxic chemicals in the human body which are very dangerous. The study concluded that the adverse effect of these synthetic chemicals on human health and environment can only be reduced or eliminated by adopting new agricultural technological practices such as shifting from chemical intensive agriculture to the use of organic inputs such as manure, biofertilizers, biopesticides, slow-release fertilizer and nano fertilizers, etc. which would improve the application efficiency as well as use efficiency of the fertilizers. Opting organic farming will create a healthy natural environment and ecosystem for the present as well as future generation.

Geisseler and Scow (2014) studied about the "Long-term effects of mineral fertilizers on soil microorganisms" in California. The objective of this paper was to analyze the responses of soil microorganisms to mineral fertilizer using data from long-term fertilization trials in cropping systems. The meta-analysis revealed that over the long term, fertilization of agricultural soil results in increased microbial biomass (Cmic) content, which is likely caused by associated increases in organic carbon (Corg) due to higher crop productivity. Urea and ammonium inputs can considerably lower soil pH over time, while nitrate fertilizers generally do not decrease pH. When the soil pH drops below approximately 5, there are negative effects not only on soil microorganisms but also on crop yields.

Prashar and Shah (2016) conducted a study on the "Impact of Fertilizers and Pesticides on Soil Microflora in Agriculture" in New Delhi. In the study they review the impact of long term usage of fertilizers and pesticides on the soil microflora of cultivated soils in relation to soil health and fertility, their persistence level in soil, factors affecting their toxicity and pesticide degradation The amendment of soil with fertilizers and pesticides strongly influences a range of soil functions and properties like rhizodeposition, nutrient content of bulk and rhizospheric soil, soil organic carbon, pH, moisture, activities of soil enzymes, and many others. The study concluded that excessive and prolonged usage of chemical fertilizers and pesticides has a range of detrimental effects on the soil microflora of the agricultural ecosystem.

2.13 NUTRIENT STATUS

The sustainability of agriculture is a pressing issue due to the increasing global demand for food. The efficient use of soil nutrients is crucial for maintaining agricultural productivity while minimizing environmental impacts. In this context, several studies have been conducted to understand the management of soil nutrients and their impact on crop production and soil health.

Ying *et al.* (2012) studied about “Nutrient Budget and Soil Nutrient Status in Greenhouse System”. By investigating the management of 18 representative greenhouses in Shouguang, Shandong Province, China, and analyzing both the greenhouse and open field soil samples, the soil nutrient budget and the trend of nutrient accumulation and translocation in soils were thus studied. The total inputs of N, P_2O_5 and K_2O provided by chemical fertilizers which are the main source of soil nutrient were 63, 61 and 66%, respectively. The utilization rates of N, P_2O_5 and K_2O were only 24, 8, 46%. The level of the organic matter, total nitrogen, nitrate nitrogen, available phosphorus, and available potassium was increased substantially, and their maximum level was observed in the topsoil (0–20 cm) with an average value being 1.4, 1.9, 21.2, 5.4, and 3.7 times higher than that of the open field soil.

Miransari (2013) studied about the “Soil microbes and the availability of soil nutrients” at Krakow, Poland. The study focuses on the mechanisms and processes regarding the effects of soil microbes on the availability and hence uptake of nutrients by plants. The study concluded that Soil microbes can significantly contribute to the availability of soil nutrients for plant use and different soil microbes can differently affect the properties of nutrients in the soil. This is particularly important for the production of biofertilizer as the most efficient strains must be selected for inoculum preparation.

Tan *et al.* (2014) conducted a study on “Global Soil Nutrient Depletion and Yield Reduction”. This paper described the causality among soil nutrient depletion, soil quality, crop production, socioeconomic variables, and environmental condition. Severe nutrient deficits of N, P, and K occurred widely in harvested areas in both developing and least developed countries, particularly in the rice and wheat production systems in Asia, Central and South America, and Africa. Continuous depletion of soil N, P, and K in most African countries and other least developed countries, coupled with low crop production levels, poses a real threat to agricultural sustainability and food security.

MATERIALS AND METHOD...

CHAPTER III

MATERIALS AND METHODS

This chapter elaborates about location, materials used for the research work and methodologies adopted for the Characterisation of Soil Media In Polyhouse.

3.1 DETAILS OF STUDY AREA

3.1.1 Experimental location

The experiment was carried out in a solar powered naturally ventilated polyhouse located near to the Ladies Hostel, Kelappaji College of Agricultural Engineering and Technology, Tavanur. The place is located at 10°51'18" N latitude, 75°59'11" E longitude and 28 m above mean sea level.

Plate 3.1 Naturally ventilated Polyhouse

3.1.2 Environmental factors

The average annual rainfall of study area is 295 cm. The annual maximum temperatures ranges from 28.9 to 36.2°C and the minimum temperatures range to 20 to 23.4°C.

3.1.3 Study Area set up

The study area comprises of a solar powered naturally ventilated polyhouse having dimensions (26 m x 8 m) of area 213 m^2 having polyethylene as cladding material.

Plate 3.2 Details of Poly-house

3.1.4 Crop Description

Okra [*Abelmoschus esculentus* (L.) Moench] is an economically important vegetable crop grown in tropical and sub-tropical regions of the world. Okra is also locally known as Lady's finger or bhindi and is one of the major kharif and summer season cultivated vegetable crop of India. It is a member of the hibiscus family, Malvaceae.

The cultivation of okra can be done as a garden crop as well as on large commercial farm crop and nowadays okra is also cultivated under polyhouse or green house with the use of microclimatic modification strategies in all seasons. It is grown commercially in different countries like India, Turkey, Nigeria, Sudan, Iraq, Pakistan and Egypt. Okra plays a significant role in human nutrition by providing carbohydrates, protein, fat, minerals and vitamins that are generally deficient in basic foods in the diet of developing countries. Okra requires a long, warm and humid growing climate for better yield. It is sensitive to frost and extremely low temperatures. The okra plant requires warm temperatures and is unable to withstand low temperatures for long.

Anjitha a popular variety of okra is cultivated in the polyhouse environment. It is a tall and vigorous plant that can grow up to 5-6 feet in height and with an average root zone depth of 30 – 45 cm. The plant has dark green leaves and produces large and uniform pods that are 5-7 inches long. Optimum temperature is in the range of 21 to 30^0C, with minimum temperature of 18^0C and maximum temperature of 35^0C. The suitable environment for seed production is low precipitation, low relative humidity and high light intensity with hot and dry conditions during seed ripening. Due to its susceptibility to yellow vein mosaic virus disease, area under this crop decreases during rainy season. The effect of microclimate on vegetables has not been much studied in India (Budania and Dahiya, 2018).

Plate 3.3 Okra cultivation

3.1.5 Irrigation and fertigation schedule

3.1.5.1 ***Irrigation scheduling***

For the irrigation process, a drip irrigation system consisting of 250 emitters was utilized. Each plant was supplied with a 4lph emitter, with watering sessions of 15 minutes each in both morning and evening.

Plate 3.4 Drip Irrigation system

3.1.5.2 Fertilizer Scheduling

Table 1 Fertilizer Application

Date	Fertilizer / Pesticide Application
10/1/2023	SAAF Fungicide (2g/l) Pseudomonas (20g/l)
20/1/2023	Trichoderma coir pith compost (2g/plant)
25/1/2023	Actara (2g/5l)
30/1/2023	Bone meal (1kg/cent) Fish amino acid (5ml/l)
6/2/2023	1 kg Urea + 3.5 kg Factomphose + 2.5 kg Potash
15/2/2023	Fish amino acid (5ml/l)

16/2/2023	NPK 19:19:19 (3g/l) Hume (10ml/l)
17/2/2023	Vinegar (20ml) + Sodium bicarbonate (5g) + Starch solution (3-4 drops) / 1 liter
20/2/2023	Urea (2.37kg)
21/2/2023	Fipronil (1g/5l)
23/2/2023	Sampoorna (5g/l)
28/2/2023	Actara (2g/5l)
1/3/2023	SOP (10g/l)
7/3/2023	Hume (10ml/l)
11/3/2023	Oberon (8ml/10l)
24/4/2023	Actara (2g/5l)
02/5/2023	Rogor 2ml/l

3.2 DETAILS OF MEASUREMENT OF SOIL PARAMETERS

3.2.1 Soil Sampling Procedure

Soil sampling from polyhouse was done by means of soil sample collector. A soil profile of 30 cm depth from the root zone is extracted using this instrument for further determination of soil parameters. The soil collected using the instrument is sieved as part of the subsequent sample preparation process.

Plate 3.5 Soil sample collector

3.2.2 Determination of pH of Soil

Materials: pH meter, glass rod, buffer tablets, beakers, weighing balance etc.

Reagents: Standard buffer solutions- buffer tablets of pH 4.0, 7.0 are used for pH meter calibration. Dissolve one tablet in specified volume (100 ml) of water and preserve in refrigerator.

Procedure:

1. Sample Preparation

- Take 10 g of 2 mm sieved shade dried soil in a beaker.
- Add 25 ml distilled water to the soil taken.
- Continuously stir for 5 minutes using a glass rod.
- Allow it to stand with a cover above the beaker for about half an hour.

2. Soil testing

- Calibrate the instrument using known values of buffer solution 4 and 7.
- Dip the probe in the sample prepared and record the reading.

Plate 3.6 pH meter

3.2.3 Determination of EC of Soil

Principle: A simple Wheatstone bridge principle is used for the measurement of EC of the soil solution, as EC of any solution is directly proportional to the concentration of soluble salt. EC is expressed in milliohms/cm (mmhos/cm) or decisiemens/meter (dS/m).

Materials: Conductivity meter with conductance cell, mechanical shaker, Buchner funnel, 100 ml conical flask, Whatman No. 42 filter paper.

Reagents: Standard potassium chloride solution (0.01 N): Dissolve 0.7456 g of AR grade potassium chloride (KCI) and make up volume to 1 liter with distilled water. The EC of 0.01 N KCl solution is 1.413 dS/m.

Procedure:

1. Preparation of Soil-Water Extract

- Take 20g air dry soil in a 100 ml conical flask and add 50 ml (1:2.5) distilled water.
- Shake on a mechanical shaker for 30 minutes and allow settling down for another 30 minutes.
- Filter the supernatant liquid through Whatman No. 42 filter paper into a beaker.

2. Determination of Electrical Conductivity

- Switch on the conductivity meter and warm it up for 30 minutes
- Adjust temperature at 25°C.
- Thoroughly wash the cell with distilled water and then rinse with test solution. Measure the conductance of the solution directly from digital display and calculate specific conductance by multiplying electrical conductance with the cell constant value.

Plate 3.7 EC meter

3.2.4 Determination of Soil texture of Soil

Apparatus: Stack of test sieves, Balance (with accuracy to 0.01g), Rubber pestle and mortar (for crushing the test material if lumped or conglomerated), Sieve shaker, Oven.

Procedure:

- Take a representative oven dried sample that weighs approximately 500g.
- If particles are lumped or conglomerated, crush the lumps but not the particles using the pestle and mortar.
- Determine the mass of sample accurately – Weight (g).
- Prepare a stack of test sieves. The sieves are stacked in order, with the largest aperture size at the top, and the smallest at the bottom. A receiver is placed under all of the sieves to collect samples.

- Weigh all the sieves and the pan separately.
- Pour the samples into the top of the stack of sieves and put the lid on, place the stack in the sieve shaker and fix the clamps, adjust the timer to between 10 and 15 minutes, and switch on the shaker.
- Stop the sieve shaker and measure the mass of each sieve and retained soil/material.
- Once the whole procedure has been completed analyze the results. The starting sample weight should be recorded and compared with the finished total sample weight retained on the sieves after the experiment. If the weight of the finished sample deviates by more than 2% from the initial weight, the analysis and sample should be discarded.

Plate 3.8 Sieve analysis using sieve shaker

3.2.5 Determination of Nitrogen

Procedure:

- Take 1g of 0.5 mm sieved shade dried soil sample.

- Take two 500ml conical flask say test (T) and blank (B).
- Add the soil sample to the beaker T.
- Pipette out 10ml potassium dichromate to both T and B.
- Now carefully add 20ml conc. H_2SO_4 to both the beakers.
- Allow it to sit for 30 minutes.
- Fill the burette with ferrous ammonium sulphate.
- After 30 minutes add 200ml distilled water and 4 drops of ferroin indicator to both.
- Now titrate the sample B until a deep red colour appears.
- Repeat the same for T and note the value**.**

Calculation:

$$\left(10 - \frac{\text{Titrated value (T)} \times 10}{\text{Titrated value (B)}}\right) \times 0.39$$

Table 2 Reference value of nitrogen

Nitrogen	Low	Medium	High
Reference value:	< 0.76	0.76 to 1.5	> 1.5

Plate 3.9 Titration for Nitrogen estimation

3.2.6 Determination of Phosphorus

Determination of plant available phosphorus in soil has 2 distinct phases. First, the extraction of plant available pool of phosphorus present in soil, and second the quantitative determination of the P in the extract. The choice of colorimetric methods depends on the concentration P in the solution, the concentration of interfering substances in the solution to be analysed and the particular acid system involved in the analytical procedure. The molybdenum blue method is the most sensitive and widely used one for soil extracts containing small amounts of P.

Principle: In an acid molybdenate solution, the orthophosphate ion gets precipitated as phosphomolybdate complex forms that can be reduced by ascorbic acid, stannous chloride and other reducing agents. This reduced phosphomolybdate has blue colour The intensity of the blue colour varies with the P concentration but is affected also by other factors such as acidity, arsenates, silicates and substances that influence the oxidation-reduction conditions of the system. As the available pool of P varies depending on the pH if the soil, reagents used for extraction of this pool also are different.

3.2.6.1 *Available P in acidic soils*

Available P is commonly extracted using Bray No.1 which consists of 0.03 N NH_4F and 0.025 N HCL. The combination of HCL and NH_4F is designed to remove easily acid soluble P forms, largely calcium phosphates, and a portion of the aluminium and iron phosphates. The NH_4 F dissolves Aluminium and iron phosphates by its complex ion formation with these metal ions in acid solution

Reagents

- Ammonium fluoride (NH_4F), 1 N: Dissolve 37 g of NH_4F in distilled water and dilute the solution to 1 litre. Store the solution in bottle.
- Hydrochloric acid (HCI), 0.5: Dilute 20.2 ml concentrated HCl to a volume of 500 ml, with distilled water.
- Bray No 1: Add 15 ml. of 1 N ammonium Fluoride (NHF) and 25 ml of 0.5N Hydrochloric acid (HCI) to 400 mL of distilled water. This solution can be kept in glass for more than one year.
- Ammonium paramolybdate ($NH_4Mo\text{-}O_{24}$ $4H_2O$), Dissolve 12 g of ammonium paramolybdate in 250 ml of distilled water. Dissolve 0.2908 gram of potassium antimony tartarate in 100 mL of distilled water. Add these dissolved reagents to 1 litre of 5 N sulphuric acid, mix thoroughly with distilled water to 2 litre.
- Ascorbic Acid: Dissolve 1.056 gram of ascorbic acid in 200 ml of reagent A and mix it.
- Standard Phosphate solution: Dissolve 0.493 gram of oven dry AR grade Pottasium dihydrogen phosphate in distilled water and dilute it to 1 litre.1 millilitre of this solution contains 100 micro grams of P. From this solution

prepare 2 microgram per millilitre by pipetting out 2 ml and dilute it to 100 ml with distilled water

Procedure

- Weigh our 5 g of soil to a 100 ml conical flask and add 50 ml. of Bay No .1 and shake for exactly 5 minutes. Filter through Whatman No.42 filter paper. To avoid interference of fluoride. 7.5 ml of 0.8 M boric acid (50 g of H_3BO_3, per litre) can be added to 5 ml. of the extract if necessary. Estimate phosphorus in the extract by acid method.
- Pipette out 5 mL of the extract into 25 ml volumetric flask and dilute it to approximately 20 ml. Add 4 mL of Reagent B. Make up the volume with distilled water and shake the contents well. Read the intensity of colour after 10 minutes at 660 mm. The colour is stable for 24 hours and the maximum intensity develops within 10 minutes. The concentration of P in the sample is computed from the standard curve.
- Prepare different concentrations of P taking 1,2,3,4, 5 and 10 ml of 2 microgram per millilitre P solution in 25 ml volumetric flask. Add 5 ml of the extracting reagent (Bray No 1) and develop colour as described above by adding agent B. Plot the concentration vs absorbance curve on a graph paper.

Plate 3.10 Spectrophotometer

3.2.7 Determination of Potassium

A relatively small portion of the total K in soils is exchangeable (approx 1%). Exchangeable K generally ranges from<100 to 2000 microgram per mille litre or with total K values which is in the order of 1 to 2%. Water soluble K seldom exceeds a few part per million except in the case of certain saline soils.

Exchangeable plus water soluble K contributes to the plant available pool of potassium in the soil. Hence, most soil test procedures to estimate plant available K involve extractants that place a significant portion of the exchangeable K. In highly weathered soils, or soils where parent material contains little k - bearing minerals, the exchangeable k can be depleted by k removal and replenished only by fertrilizer application or return of K from plant residues.

Principle: By definition the exchangeable potassium in that, which is free to exchange with cations of salt solution added to soils. But the quantity exchanged from the soil depends on the nature of the replacing solution. Hence with reference to fertility evaluation, exchangeable K is defined more specifically as that which is extracted with neutral 1 N ammonium acetate minus the water soluble K. In neutral solution as water soluble K is so small, there is no appreciable error even if it is included the war soluble plus exchangeable K represent the available pool. The removal of water soluble K before extraction with ammonium acetate is not recommended because as the salt content of sol solution is decreased, the adsorption of divalent cations in solution increases.

Reagents

1. Neutral IV ammonium acetate solution (CH_3COONH_4). Dissolve 77.08 g of ammonium acetate in distilled water and made up to 1 L. Adjust the Ph if necessary to 7 with acetic acid or ammonium hydroxide.

2. Standard K solution: Dissolve 1.908 g of dried pottasium chloride (KCl) AR grade in distilled water and made up to 1l so as to get 1000mocrogram per mL K solution.

Procedure

1. Extraction

Shake 5 g of soil with 25 ml of neural ammonium acetate for 5 minutes and filter immediately through a dry Whatman No 42 filter paper. First few mL of the filtrate may be discarded. Potassium concentration in the extract is determined using flame photometer after necessary setting and calibration of the instrument.

2. Standard curve for potassium

Dilute measured aliquiot from the standard solution using ammonium acetate solution to give concentrations of 5 to 20 microgram per mL K. After attaching the appropriate fillet and adjusting gas and air pressure, set reading in flame photometer as zero for the blank. And at 100 for 20 microgram per mL k. The curve is obtained by placing the reading against the different concentrations (5, 10, 15, and 20 microgram per mL) of k. Fluctuation in gas and air pressure doesn't allow steady reading in the meter and must be taken care of.

Plate 3.11 Flame photometer

3.2.8 Determination of Soil moisture

The gravimetric method was employed to determine the soil moisture. Soil samples were collected from the root zone of the crop using a soil sample collector, and standard procedures were subsequently applied to determine the moisture content.

Plate 3.12 Oven drying of soil sample

3.2.9 Determination of Bulk Density of Soil

Materials: Cylindrical core cutter of steel (127.4 mm long and 100 mm internal diameter with wall thickness of 3 mm and bevelled at one end), steel dolly (25 mm high and 100 mm internal diameter with a wall thickness 7.5 mm fitted with a lip to enable it to fit on top of the core cutter), steel rammer, plate knife, steel rule, spade or pickaxe, straight edge, balance accurate to 1g, container for water content determination.

Plate 3.13 Core cutter

Procedure:

- Measure the inside dimensions of the core cutter accurate to 0.25 mm and calculate its volume. Weigh the core cutter accurate to 1 g.
- Expose the small area, about 30 cm^2 to be tested and level it. Put the dolly on top of the core cutter and drive the assembly into the soil with the help of rammer until the top of the dolly protrudes about 15 mm above the surface.
- Dig the container from the surrounding soil, and allow some soil to project from the lower end of the cutter. With the help of the straight edge, trim flat the bottom end of the cutter. Take out the dolly and also trim flat the top end of the cutter,
- Weigh the cutter full of soil.

- Keep some representative specimen of soil (from the middle of the cylindrical soil sample) for water content determination.
- Repeat the test at two or three locations nearby and get the average dry density.

  Bulk density = weight of soil/volume of soil

  Particle density = dry weight/volume of soil solid.

Plate 3.14 Working with core cutter

RESULTS AND DISCUSSION...

Chapter IV

RESULTS AND DISCUSSION

4.1 SOIL pH ANALYSIS

The pH analysis of the soil samples was conducted to determine the acidity or alkalinity of the soil. The pH values ranged from 5.27 to 5.92, indicating a slightly acidic to neutral soil pH. The average pH value was found to be 5.74.

The pH of the soil plays a crucial role in nutrient availability of the plants and microbial activity of soil. pH of growing substrate affects the availability of nutrient, especially magnesium, zinc, nitrogen, potassium, iron and boron. Iron deficiency is a common problem that occurs when pH is very higher than optimal. At low pH manganese, zinc and boron are highly soluble. If pH is too low, micronutrient becomes very soluble and iron toxicity symptoms such as leaf bronzing appears. Therefore, the slightly acidic to neutral pH observed in the soil samples suggests favorable conditions for nutrient availability (Bhosale and Sonavane, 2016).

4.1.1 Observation on soil PH

Table 3 Observation on soil pH

Time period	**PH value**
38^{th} day after flowering	5.83
43^{rd} day after flowering	5.85
44^{th} day after flowering	4.82
45^{th} day after flowering	5.69
50^{th} day after flowering	5.89

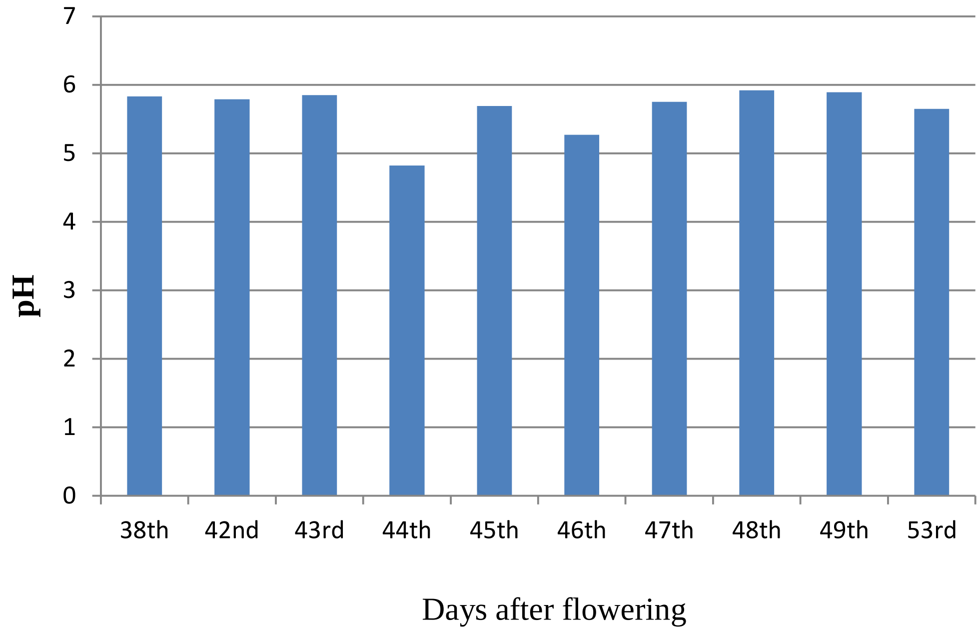


Fig 4.1 pH Vs time

4.2 SOIL EC ANALYSIS

The soil EC analysis was performed to assess the salinity or salt content in the soil. EC values were measured and ranged from 0.246 to 0.88. These values indicated low to moderate levels of electrical conductivity in the soil.

Soil EC is an important parameter that reflects the presence of soluble salts in the soil, which can affect plant growth and soil fertility. High levels of soil salinity can hinder water uptake by plants, leading to water stress and reduced crop productivity. The low to moderate EC values obtained in the soil samples suggest that salinity is not a significant concern in the analyzed soil.

The soil EC analysis indicated low to moderate salt content, suggesting that salinity is not a major issue in the analyzed soil. When conductivity of soil is higher than desired, it can be reduced by decreasing the frequency of fertilization and leaching method . (Bhosale and Sonavane, 2016).

4.2.1 Observation on soil EC

Table 4 Observation on soil EC

Time period	EC value (ds/cm)
38th day after flowering	0.342
43rd day of flowering	0.306
44th day of flowering	0.342
45th day of flowering	0.339
50th day of flowering	0.88

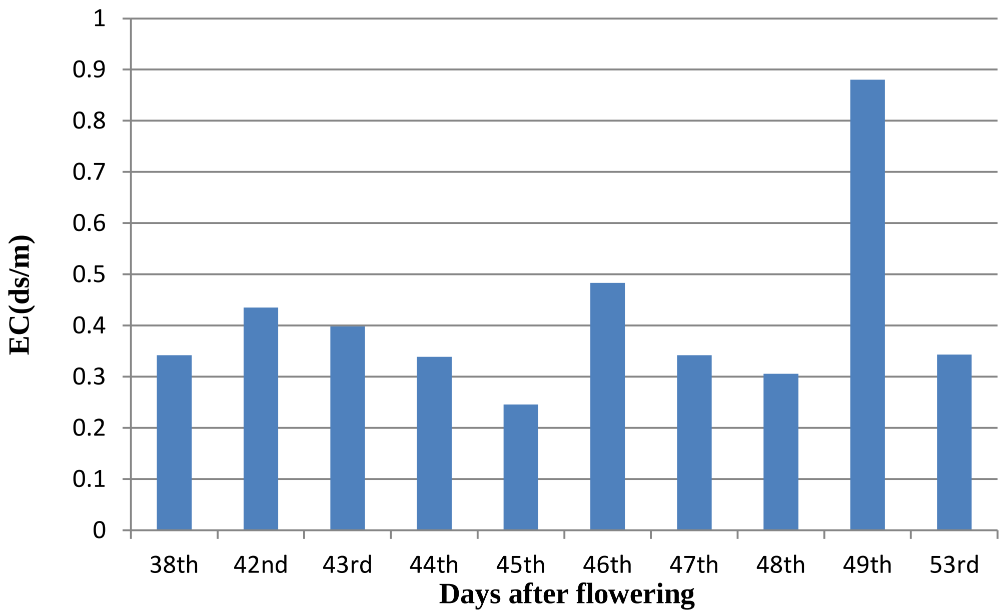
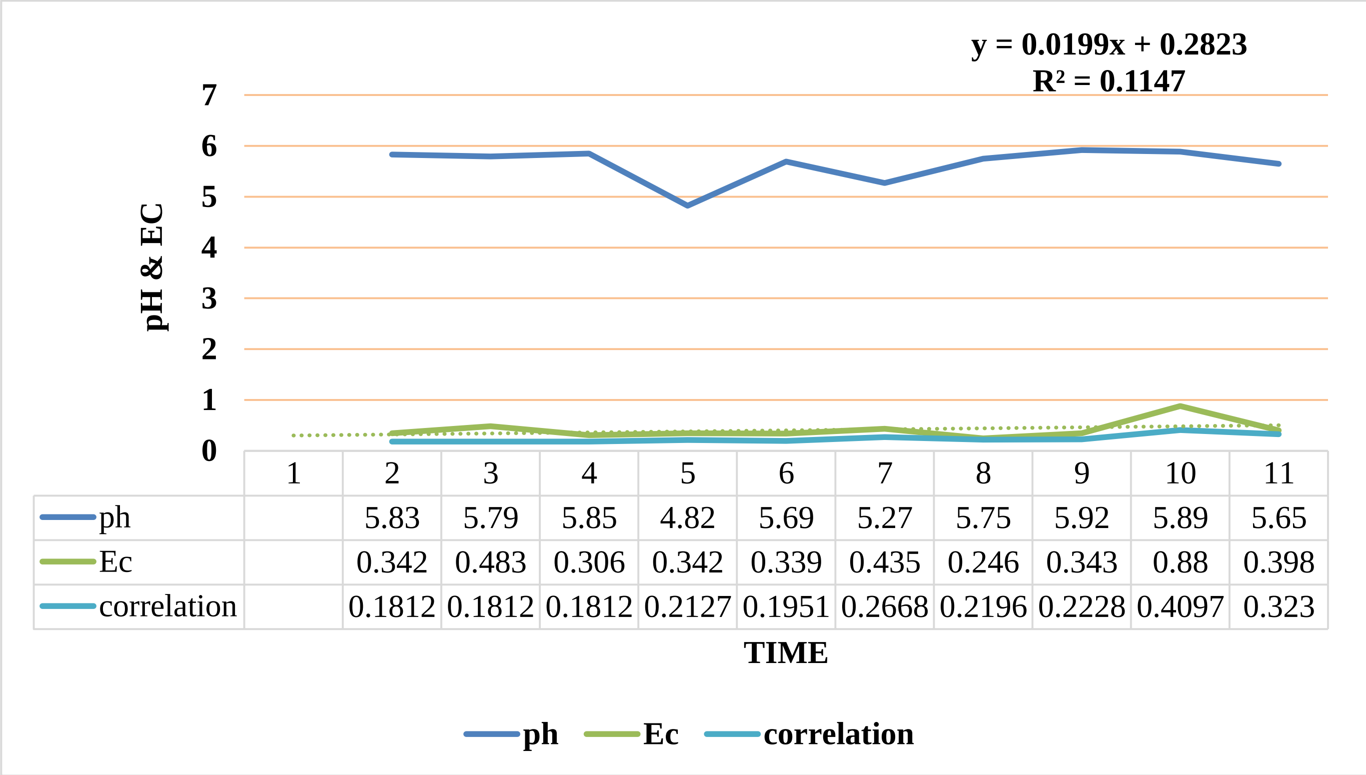


Fig 4.2 EC Vs Time

4.2.2 Relationship between EC and pH



	1	2	3	4	5	6	7	8	9	10	11
ph		5.83	5.79	5.85	4.82	5.69	5.27	5.75	5.92	5.89	5.65
Ec		0.342	0.483	0.306	0.342	0.339	0.435	0.246	0.343	0.88	0.398
correlation		0.1812	0.1812	0.1812	0.2127	0.1951	0.2668	0.2196	0.2228	0.4097	0.323

Fig 4.3 Relationship between EC and Ph

- The correlation coefficients between pH and EC values ranged from 0.181165917 to 0.40971255.
- The positive correlation coefficients indicate a positive relationship between pH and EC values.
- However, it's important to note that the correlation coefficients are relatively low, suggesting a weak positive relationship.
- The data suggests that as the EC values increase, the pH values also tend to increase.

4.3 SOIL TEXTURE ANALYSIS

4.3.1 Observation on soil texture

Table 5 Observation on soil texture

Sieve size	**Weight (gram)**	**% Retained on sieve**	**CPR**	**% Finer**
2mm	186.5	46.05	46.05	53.95
1mm	68	16.79	62.84	37.16
600	57	14.07	76.91	23.09
425	31.5	7.78	84.69	15.31
300	36.5	9.01	93.7	6.3
150	19.5	4.81	98.52	1.48
75	1	0.25	98.77	1.23
Pan	0.5	0.12	98.89	1.11

Based on the provided data, we can conclude that

- 53.95% of the particles in the sample are smaller than or equal to 2 mm. This indicates that a significant portion of the particles have size larger than 2 mm. It suggests the presence of coarse particles in the sample.
- 37.16% of the particles in the sample are smaller than or equal to 1 mm. This value is lower than the percentage for the 2 mm sieve, indicating that a considerable portion of the particles falls between 1mm and 2mm in size.
- 23.09% of the particles in the sample are smaller than or equal to 600 µm. This value is significantly lower than the previous percentages, indicating that a large number of particles have sizes between 600 µm and 1 mm.

- 15.31% of the particles in the sample are smaller than or equal to 425 µm. This suggests that a considerable portion of the particles falls within the 425µm to 600 µm size range.
- 6.3% of the particles in the sample are smaller than or equal to 300 µm. This indicates a further decrease in the percentage finer, suggesting that the sample contains a significant number of particles between 300 µm and 425 µm.
- 1.48% of the particles in the sample are smaller than or equal to 150 µm. This value is relatively low, suggesting that the majority of particles are larger than 150µm.
- 1.23% of the particles in the sample are smaller than or equal to 75µm. This value is slightly lower than the previous percentage, indicating a decrease in the number of particles within the 75µm to 150µm size range.

The data reveals a gradual decrease in the percentage finer as the sieve size decreases. This indicates a distribution skewed towards coarser particles. The sample likely contains a significant amount of particles larger than 2 mm, followed by a decreasing proportion of particles in the 1 mm to 2 mm, 600 µm to 1 mm, 425 µm to 600 µm, and 300 µm to 425 µm size ranges. The percentages for the finer sieves (150 µm and 75 µm) have a smaller proportion of fine particles in the sample.

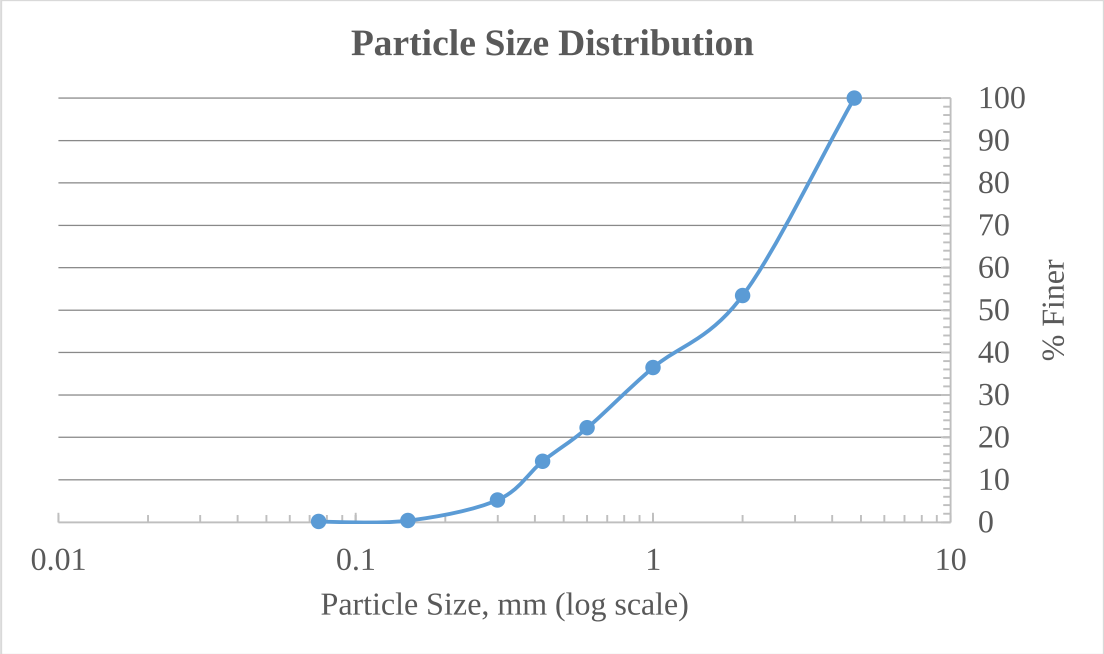


Fig 4.4 Particle size distribution curve

4.4 NITROGEN ANALYSIS

4.4.1 Observation on nitrogen

Table 6 Observation on nitrogen

Time period	**N value (mg/l)**
38^{th} day after flowering	0.813
43^{rd} day after flowering	1.28
44^{th} day after flowering	1.043
45^{th} day after flowering	1.406
50^{th} day after flowering	0.784

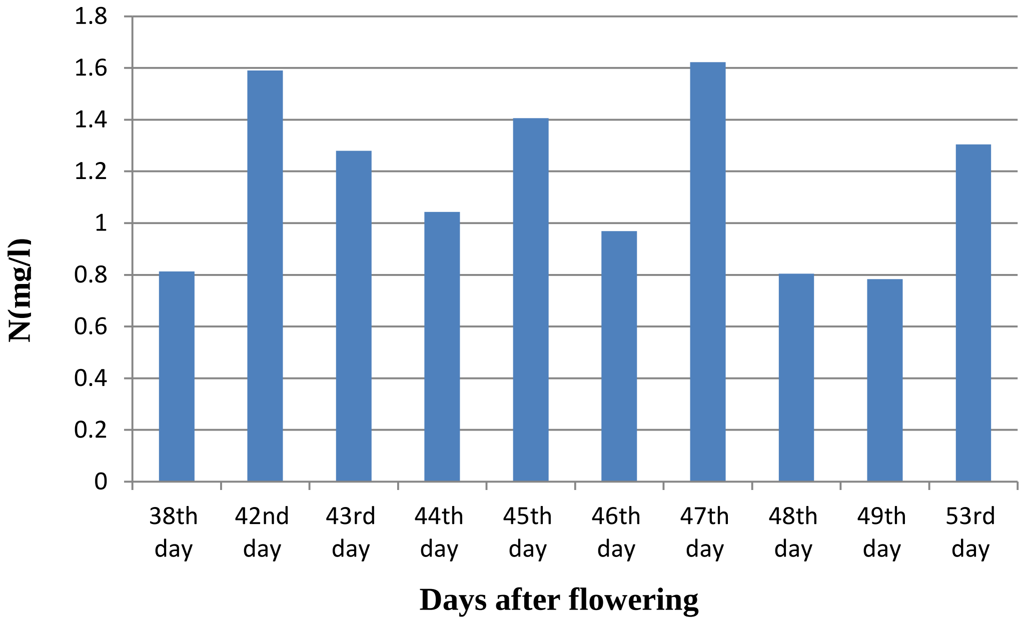


Fig 4.5 Variation of N

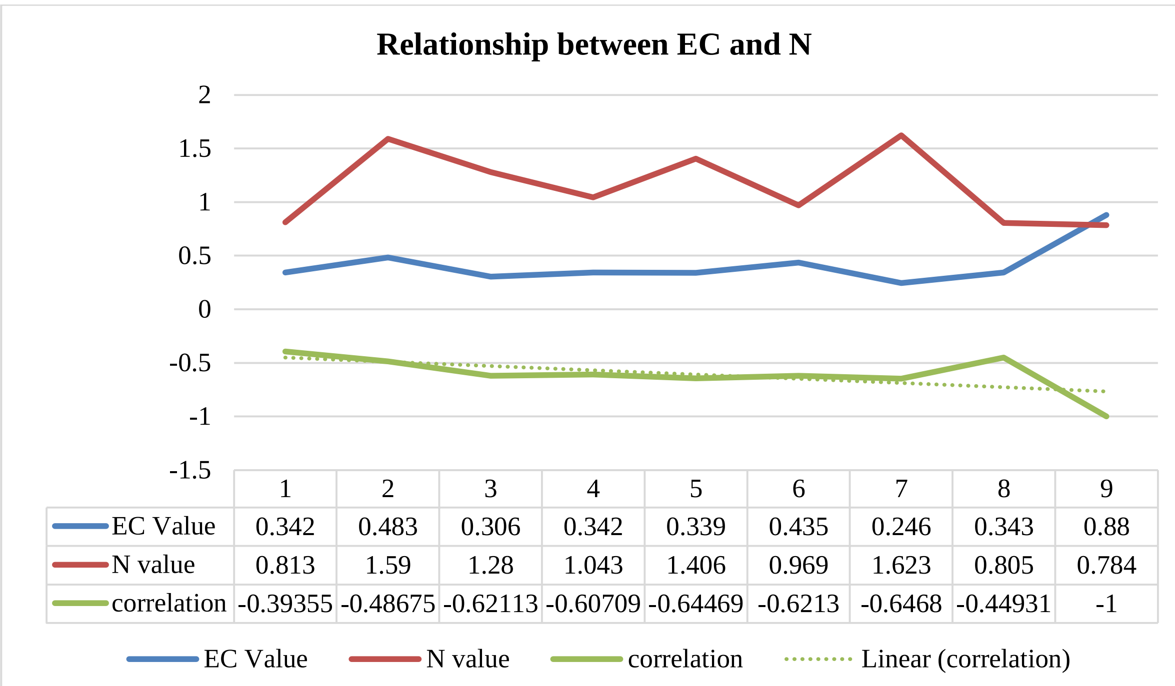
4.4.2 Relationship between EC and Nitrogen

Correlation Analysis:

- The correlation coefficients between EC values and N values range from -0.393554348 to -1.
- The negative correlation coefficients indicate an inverse relationship between EC and N values.
- However, the correlation coefficients suggest a relatively weak relationship between the variables, as they are not close to -1 or 1.
- This indicates that the EC values and N values do not exhibit a strong linear relationship.
- The data suggests that as the EC values increase, the N values tend to decrease.
- However, it is important to note that this relationship is not very strong, as indicated by the weak correlation coefficients.

- Other factors beyond the provided dataset may also influence the relationship between EC and N values, such as soil composition, environmental conditions, or other nutrient levels.

The provided data suggests a weak inverse relationship between EC values and N values, indicating that as EC values increase, N values tend to decrease.



	1	2	3	4	5	6	7	8	9
EC Value	0.342	0.483	0.306	0.342	0.339	0.435	0.246	0.343	0.88
N value	0.813	1.59	1.28	1.043	1.406	0.969	1.623	0.805	0.784
correlation	-0.39355	-0.48675	-0.62113	-0.60709	-0.64469	-0.6213	-0.6468	-0.44931	-1

Fig 4.7 Relationship between EC and N

4.5 PHOSPHORUS ANALYSIS

4.5.1 Observation on phosphorus

As the plants progress further into the growth cycle, they undergo a transition phase where their phosphorous requirements may temporarily decrease. This can be observed from the decrease in P values on the 42nd (1.281 mg/l) and 43rd (1.072

mg/l) days after flowering. The decreased P values suggest a reduced demand for phosphorous during this phase

Table 7 Observation on phosphorus

Time period	P value(mg/l)
38th day after flowering	1.905
43rd day after flowering	1.072
44th day after flowering	1.774
45th day after flowering	2.156
50th day after flowering	2.583

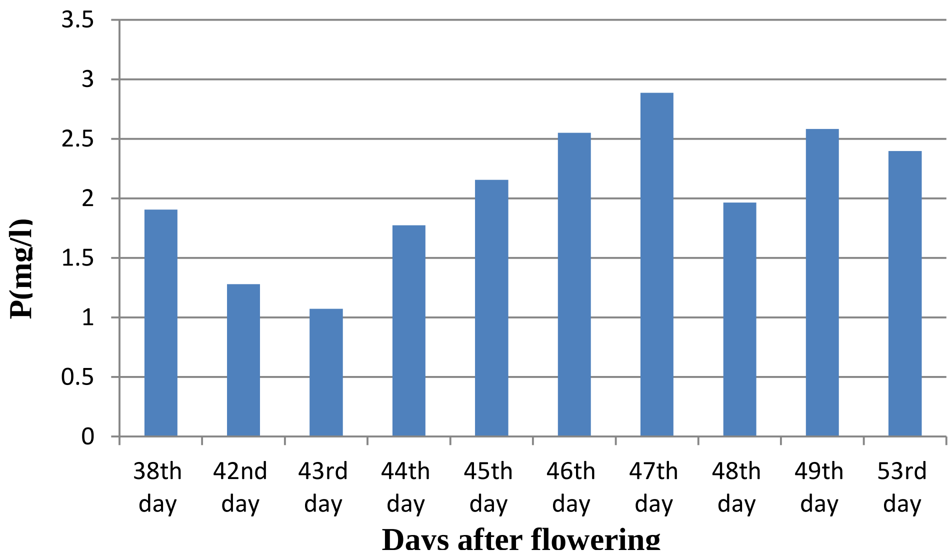


Fig 4.7 Variation of phosphorus

4.6 POTTASIUM ANALYSIS

4.6.1 Observation on potassium

Table 8 Observation on potassium

Time period	**K value(ppm)**
38th day after flowering	332
43rd day after flowering	276.64
44th day after flowering	439.04
45th day after flowering	318.78
50th day after flowering	394.24

From the above data it is understood that there is a general pattern of decrease and subsequent increase in K values observed between adjacent time periods. For example, the K value decreases from the 38th to the 42nd day, then increases from the 42nd to the 43rd day, followed by a decrease from the 43rd to the 44th day, and so on. The variations in K values reflect changes in nutrient availability or utilization by the plants. Potassium (K) is an essential nutrient for plant growth. Fluctuations in K values may indicate temporal shifts in the uptake or utilization of potassium, which can impact plant growth and overall productivity.

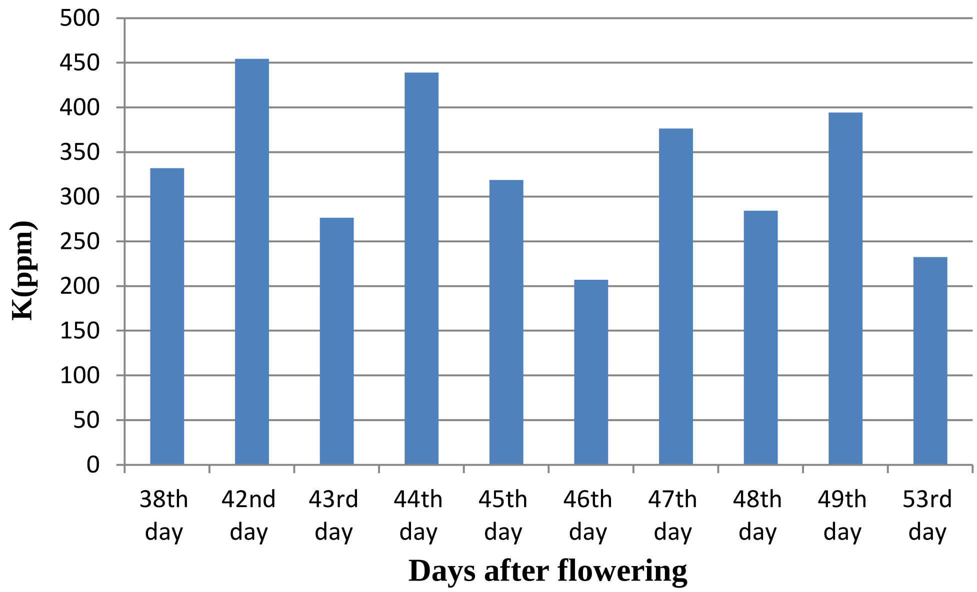


Fig 4.8 Variation of potassium

4.7 BULK DENSITY ANALYSIS

4.7.1 Observation on bulk density

Bulk density = (511/981.7)/1000= 520.5 kg/m^3

Bulk density of 520.5 kg/m^3 indicates a low density value and the soil is less compacted and has more pore space. This can be an indication of soil with higher proportion of organic matter, coarse particle size distribution.

Low bulk density values are often associated with good drainage and aeration properties. The above findings are in par with the results obtained from the study "Influence of soil organic matter on bulk density" by Athira *et al.* (2019).

4.8 ANALYSIS OF SOIL MOISTURE

4.8.1 Observation on soil moisture

Table 9 Observation on soil moisture

Time period	Moisture content (%)
38th day after flowering	18.95
43rd day after flowering	19.14
44th day after flowering	21.56
45th day after flowering	19.29
50th day after flowering	17.18

The inference from the above result is that the soil moisture is below the field capacity. The field capacity value of the soil was found to be 25.483% . It indicates that most plants will undergo substantial water stress, and vegetables will likely sustain substantial yield reductions long before the permanent wilting point is reached. The recommended method for scheduling irrigation for vegetable crops is to combine the crop water requirement, measurement of soil water status and guidelines for splitting irrigation (Zotarelli *et al.* 2010).

4.9 ANALYSIS OF MICRONUTRIENTS OF SOIL

4.9.1 Observation on micronutrients

Table 10 Observation of micronutrients in soil

Micronutrients	Value
Mn	18.9 (mg/kg)
S	23.5 (mg/kg)
B	1.29 (mg/kg)
Zn	4.31 (mg/kg)
Cu	3.11 (mg/kg)

According to the test report obtained from the District Soil Testing Laboratory in Pattambi, the micronutrient levels are found to be within the acceptable limits.

4.10 ANALYSIS OF IRRIGATION WATER QUALITY

4.10.1 Observation on Irrigation water quality

Table 11 Irrigation water quality report

WATER QUALITY REPORT			
Parameter	Unit	Value	Standard limit
pH		6.22	5.5-7
EC	µS/cm	154.2	0-800
TDS	mg/L	78.1	500
Fe	mg/L	High	0.3

The water quality test indicates that the pH, EC, and TDS values are within the acceptable range, while the iron content exceeds the allowable limit. The elevated iron concentration in the water can hinder the plants ability to absorb essential nutrients.

SUMMARY AND CONCLUSION...

CHAPTER V

SUMMARY AND CONCLUSION

In the face of a rapidly changing climate and an ever-increasing global population, the need for sustainable and efficient agricultural practices has become paramount. In this context, protected cultivation has emerged as a game-changing approach to meet the growing demand for high-quality produce while mitigating the challenges posed by un-favourable environmental conditions. With its ability to create controlled environments that shield crops from external factors, protected cultivation has gained immense significance in the present context of agriculture. The key to unlock the true potential of polyhouse farming lies beneath the surface, in the often-underestimated soil media. The significance of soil characterization in polyhouses cannot be overstated, as it holds the key to optimizing crop growth, resource management, and sustainability within these enclosed agricultural ecosystems. One of the primary reasons soil characterization is significant in polyhouses is its ability to optimize crop growth. By understanding the soil's texture, composition, and water-holding capacity, farmers can create an environment that fosters healthy root development, nutrient absorption, and moisture retention. Tailoring the soil media to the specific needs of the crops results in enhanced yields, improved quality, and increased profitability.

Furthermore, soil characterization aids in efficient resource management within polyhouses. By analysing the soil's nutrient content, pH levels, and organic matter composition, farmers can tailor their fertilizer application strategies to match the precise requirements of the crops. This ensures optimal nutrient uptake, minimizes waste, and reduces the environmental impact associated with excessive fertilizer use.

Hence the study “ Characterization of soil media in Polyhouse cultivation” was conducted in a naturally ventilated polyhouse located near the football ground of Kelappaji college of agricultural engineering and technology from January 2023 to May 2023. The study was undertaken with the objective to identify the various soil parameters governing the growth and yield of plants , determination of correlation between important soil parameters and variation of important soil parameters and nutrient status.

A comprehensive sampling for the collection of relevant parameters like Ph, EC, soil texture, soil moisture, nutrient status was done. These parameters were studied with respect to spatial and temporal variability. A statistical analysis for soil EC, Ph , Nitrogen values were conducted to determine the correlation between these parameters and also helps to recognize the hidden pattern underlying in it. EC and Nitrogen values shows an inverse relationship. Hence it is more critical to maintain consistent EC values throughout the media for better productivity and controls. Soil nitrogen pH, EC values determined so far shows a non-linear spatial and temporal variations. The soil media characterization in polyhouse cultivation is a fundamental component for optimizing crop growth, resource management, and sustainability. By analysing the composition, texture, and nutrient content of the soil, farmers gain valuable insights to customize cultivation practices, promote healthy plant development, and maximize nutrient uptake. Precise understanding of soil properties enables efficient resource utilization, including water and fertilizers, leading to improved water-use efficiency and reduced environmental impact. Additionally, soil media characterization aids in disease management and pest control, ensuring a healthier growing environment.

Overall, by harnessing the power of soil characterization, polyhouse farmers can achieve higher yields, enhanced crop quality, and sustainable agricultural practices, contributing to the advancement of modern farming and food security. It indicates the need of a detailed study regarding their mutual dependency and relative variability during the crop growth cycle under protected cultivation and reflects the need of precise automated soil control and monitoring mechanisms in parallel with microclimatic controllers. Monitoring and control of soil parameters holds a very significant role in the overall success of protected cultivation along with the microclimatic control. Hence it demands more detailed and precise studies in this domain to shed light in to the hidden underlying patterns and relations.

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CHAPTER VI

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APPENDICES...

APPENDIX I

Details of soil parameters

Daily pH data during the flowering period

Time point index	Time period	pH Value
1	38th day after flowering	5.83
2	42nd day after flowering	5.79
3	43rd day after flowering	5.85
4	44th day after flowering	4.82
5	45th day after flowering	5.69
6	46th day after flowering	5.27
7	47th day after flowering	5.75
8	48th day after flowering	5.92
9	49th day after flowering	5.89
10	53rd day after flowering	5.65

Daily EC data during the flowering period

Time period	EC Value
38th day after flowering	0.342
42nd day after flowering	0.483
43rd day after flowering	0.306
44th day after flowering	0.342
45th day after flowering	0.339
46th day after flowering	0.435
47th day after flowering	0.246
48th day after flowering	0.343
49th day after flowering	0.88
53rd day after flowering	0.398

Daily soil moisture data during the flowering period

Time period	Moisture content (%)
38th day after flowering	18.95
42nd day after flowering	22.67
43rd day after flowering	19.14
44th day after flowering	21.56
45th day after flowering	19.29
46th day after flowering	14.75
47th day after flowering	20.5
48th day after flowering	19.45
49th day after flowering	17.18
53rd day after flowering	19.29

APPENDIX II

Details of soil nutrient indicators

Daily Nitrogen data during the flowering period

Time period	N Value (mg/l)
38th day after flowering	0.813
42nd day after flowering	1.59
43rd day after flowering	1.28
44th day after flowering	1.043
45th day after flowering	1.406
46th day after flowering	0.969
47th day after flowering	1.623
48th day after flowering	0.805
49th day after flowering	0.784
53rd day after flowering	1.305

Daily phosphorus data during the flowering period

Time period	P Value (mg/l)
38th day after flowering	1.905
42nd day after flowering	1.281
43rd day after flowering	1.072
44th day after flowering	1.774
45th day after flowering	2.156
46th day after flowering	2.551
47th day after flowering	2.887
48th day after flowering	1.966
49th day after flowering	2.583
53rd day after flowering	2.396

Daily potassium data during the flowering period

Time period	K Value (ppm)
38th day after flowering	332
42nd day after flowering	454.5
43rd day after flowering	276.64
44th day after flowering	439.04
45th day after flowering	318.78
46th day after flowering	207.2
47th day after flowering	376.32
48th day after flowering	284.48
49th day after flowering	394.24
53rd day after flowering	232.56

ABSTRACT

A study on characterization of soil media in a Polyhouse cultivation was carried out in a naturally ventilated polyhouse located near football ground of KCAET, Tavanur. The objectives of the study includes identification of significant soil parameters governing growth and yield of crop, determination of the correlation between important soil parameters and study the variation of important soil parameters and nutrient status of soil media in polyhouse cultivation. sampling were conducted at multiple random points to determine various parameters like ph,EC,N,P,K status , micro nutrient status ,moisture content, and bulk density values of soil. Statistical analysis tools such as correlation and regression were used to determine the relationship between parameters and their variability among themselves.

The results showed a combination of gradual and sudden variations of the measured parameters with respect to both spatial and temporal variability .The mutual dependency of these parameters makes its management more complex. Proper monitoring and scientific management of this dynamic media is equally important along with the microclimatic control measurements. The key to utilize the true potential of polyhouse farming lies beneath the surface, in the often-underestimated soil media. It holds the key to optimizing crop growth, resource management, and sustainability within these enclosed agricultural ecosystems.

The study reveals the need of a detailed investigation regarding its mutual dependency and relative variability during the crop growth cycle under protected cultivation and reflects the need of precise automated soil control and monitoring mechanisms in tandem with microclimatic controls.