PERFORMANCE EVALUATION OF COMMERCIALLY AVAILABLE DIFFERENT MEDIA ON VEGETABLE PRODUCTION IN POT CULTURE.

THESIS

Submitted in partial fulfilment of the requirements

For the Degree of

MASTER OF TECHNOLOGY

IN

AGRICULTURAL ENGINEERING

(IRRIGATION AND DRAINAGE ENGINEERING)

By

Miss Karande Sonal Popat
(ENDPM/2021/199)

DEPARTMENT OF IRRIGATION AND DRAINAGE ENGINEERING,
COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY,
DAPOLI

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DECEMBER, 2023

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Under the Guidance of

(Prof. Dr. U. S. Kadam)
Director (Education), MCAER, Pune and
Ex. Professor & Head

DEPARTMENT OF IRRIGATION AND DRAINAGE ENGINEERING,

COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY,

DAPOLI

DR. BALASAHEB SAWANT KONKAN KRISHI

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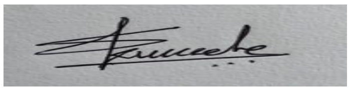
DECEMBER, 2023

DECLARATION OF STUDENT

I hereby declare that the experimental work and its interpretation of the Thesis entitled **"PERFORMANCE EVALUATION OF COMMERCIALLY AVAILABLE DIFFERENT MEDIA ON VEGETABLE PRODUCTION IN POT CULTURE."** or part thereof has neither been submitted for any other degree or diploma of any University nor the data have been derived from any thesis/publication of any University or scientific organization. The source of materials used and all assistance received during the course of investigation have been duly acknowledged and that no part of the thesis has been submitted for any other degree or diploma.



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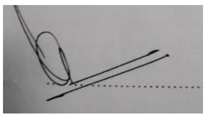
CERTIFICATE

This is to certify that the thesis/dissertation entitled, **"PERFORMANCE EVALUATION OF COMMERCIALLY AVAILABLE DIFFERENT MEDIA ON VEGETABLE PRODUCTION IN POT CULTURE"** submitted for the degree of M. Tech. (Irrigation and Drainage Engineering) of the College of Agricultural Engineering and Technology, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, is a bonafide research work carried out by Miss Sonal Popat Karande (ENDPM/2021/0199) under my supervision and that no part of this thesis has been submitted for any other degree. The student had completed all the Course and Research requirement as per the norms in regular mode and has published one research paper from her M. Tech. research work.

The assistance and help received during the course of investigation have been fully acknowledged.



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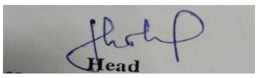

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   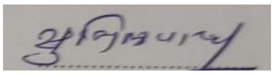
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   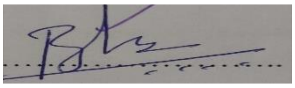
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   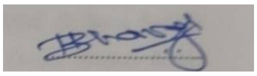
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   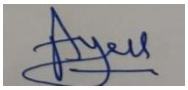
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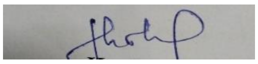

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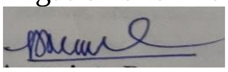

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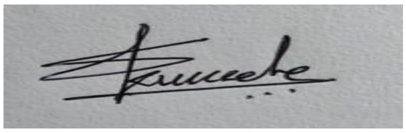

Place: Dapoli

Date: 11 / 12 / 2023

(Karande Sonal Popat)

Table of Contents

List of Tables

List of Figures

List of Plates

List of Symbols

Symbols	Meanings
<	Less than
>	Greater than
%	Per cent
°C	Degree Celsius
@	At Rate
ρ	Rho
=	Equal to
+	Plus
-	Minus
/	Division
×	Multiplication
±	Plus or Minus

List of Abbreviations

Abbreviations	Meanings
ANOVA	Analysis of Variance
BC	Benefit Cost
CD	Critical Difference
DAS	Days After Sowing
DBSKKV	Dr. Balasaheb Konkan Krishi Vidyapeeth
EC	Electrical Conductivity
et al.	And others
fig.	Figure
FYM	Farm yard manure
i.e.	That is
LLDPE	Linear low density polyethylene
m.	Meter
m^2	Square meter
ml	Milliliter
mm	Millimeter
dS/m	Decisimeons per meter
kPa	Kilopascal
pH	Hydrogen potential
AFP	Air filled porosity
viz.	Namely
WHC	Water holding capacity
CO_2	Carbon dioxide
C/N	Carbon nitrogen ratio
OMC	Organic matter concentration
Vol.	Volume
g.	Gram
cm^3	Cubic centimeter
etc.	Etcetera
sr. no.	Serial number
kg	Kilogram
kg/m3	Kilogram per meter cube

CHAPTER I
INTRODUCTION

Healthy soil is essential for healthy plant growth, human nutrition. Healthy soil supports a landscape that is more resilient to the impacts of drought, flood, or fire. Soil helps to balance the Earth's climate and stores more carbon. Soil carries out a range of functions and services without which human life would be impossible. It provides an environment for plants to grow in, by anchoring roots and storage of nutrients. It filters our water and helps to prevent natural hazards such as flooding. Day by day our country is facing the issues related to the soil erosion, compaction, nutrient imbalance, pollution, acidification, water logging, loss of soil biodiversity and increasing the salinity have been affecting soil, reducing its ability to support plant life period.

Land degradation has become a serious issue in both non-irrigated as well as irrigated areas of India. Degraded lands also cause economic loses for country. One of the solutions to this problem can be shift to soil less farming. It guarantees flexibility and escalation of crop production system in areas with adverse growing conditions. Precise control over the supply of water and nutrients is possible through it. Soilless farming also helps in elimination of soil-borne diseases, reduction in labour requirement, and more crops per year resulting to economic benefits to farmers.

Now a day people prefer for the organic, naturally grown, chemical free vegetables in their meal. With the help of soil-less farming we can get control on these issues. That is because the entire system uses clean water and high-quality nutrients in a controlled environment. Hence, the greens you grow in a hydroponic system taste better and are also more nutritious. There are some differences between soil-based and soil-less farming. Generally the differences are between the use of fertilizer and use of water, the ability to use non-arable land, and overall productivity. In addition, soil-less agriculture is typically less labour-intensive. Finally, soil-less techniques support monocultures better than soil-based agriculture. Water use in soil less farming is lower than with soil production. Water is lost from soil-based agriculture through evaporation from the surface, transpiration through the leaves and percolation into the subsoil, runoff and weed growth. However, in soil-less culture, the only water use is through crop growth and transpiration through the leaves. The water used is the absolute minimum needed to grow the plants, and only a minor amount of water is lost for evaporation from the soil-less media. Owing to the fact that soil is not needed, soil-less culture methods can be used in areas with non-arable land. Soil-less culture does not require operation like ploughing, tilling, mulching or weeding.

Pot experiments have the advantage of allowing direct measurements under controlled conditions without the influence of distracting biotic and abiotic factors (Passioura, 2006). In a pot experiment, it is not realistic to study adult trees over a long time period. Thus, in most studies, young trees were used (Mousseau and Saugier, 1992). We can grow different type of vegetables in soil less farming.

India's diverse climate ensures availability of all varieties of fresh fruits and vegetables. India ranks second in fruits and vegetables production in the world, after China. We can use different kind of media such as vermicompost, vermiculite, cocopeat, hydrotons and perlite, etc. Vermicompost is considered as a high nutrient bio-fertilizer with diverse microbial communities, it plays a major role in improving growth and yield of different field crops, vegetables, flowers and fruit crops. Earthworms consume various organic wastes and reduce the volume by 40–60%. Each earthworm weighs about 0.5 to 0.6 g, eats waste equivalent to its body weight and produces cast equivalent to about 50% of the waste it consumes in a day. The moisture content of castings ranges between 32 to 66% and the pH is around 7.0. (Reddy *et al*. 1998). The worm castings contain higher percentage (nearly two-fold) of both macro and micronutrients than the garden compost. From earlier studies also, it is evident that vermicompost provides all nutrients in readily available form and also enhances uptake of nutrients by plants (Sreenivas *et al*. 2000).

Cocopeat and vermicompost can be useful in soilless cultivation especially in areas facing different growing constraints such as water shortage, low fertility and poor soil drainage, unsuitable soil reaction, soil salinity, pest and other ecological problems. Besides the use of cocopeat in agricultural fields or as a water conservator in the dry land, coco peat has gained prominence as a potting medium. Furthermore, its distinct features like water resistance and enhanced aeration enable its usage for various agricultural purposes.

Cocopeat is an excellent soil conditioner and is being extensively used as a soilless medium for agro-horticultural purposes such as planting lawns, parks and gardens, golf courses and planting vegetable gardens. The application of coco peat in the soil helps in improving the structure and other physical and chemical properties of the soil. Because of its sponge-like structure, coco peat helps to improve aeration and retain water in the root zone. Soilless culture is based on environmentally friendly technology resulting in higher yields and that too without quality deterioration (Gruda, 2009).

Soilless culture is a method of artificially supporting plants and serving as a reservoir for nutrients and water. It is now commonly utilized in research institutes as a method for researching plant nutrition. Tomatoes, capsicum, cucumber, peas, and cauliflower are among the crops produced in soil. Substrates used in soilless culture must be low-cost, disease-free, and conveniently accessible, as well as capable of providing sufficient nutrients to agricultural plants growing in them (Hussain *et al*. 2014). Vegetables production by using soilless farming techniques have given outstanding quality, high yield, quicker harvest, and great nutritive values. However, in the case of less developed nations, there is a lack of awareness and a poor transmission of existing technology. It’s indeed critical to supply scientifically proven technology to gardeners and generate wider understanding in prospective regions at the global level in order to popularize soilless gardening (Jaripiti *et al*. 2023).

Vermicomposting techniques has a great potential for recycling the urban organic wastes that resulted in the mitigation of CO2 emission from different organic wastes instead of burying or incineration and save essential nutrients and organic matters from being lost via producing the Vermicompost can enhances the physical and chemical properties of mineral substrates beside the ability of using vermicompost-tea as nutrient solution. Vermicomposting alters multi-products could be offered such as Vermicompost, Vermicompost-tea, Vermi-liquid (liquid collected during vermicomposting process) and earthworm biomass. Vermicomposting (Worm composting) is defined as a process in which earthworms play a major role with microbes in the conversion of organic solid waste into more stabilized dark, earth-smelling soil conditioner and nutrient-rich compost that is rich in major and micronutrients. During vermicomposting, organic matter is stabilized by the enhanced decomposition (humification) in the presence of earthworms, but by a non-thermophilic process . Different organic wastes can be used in vermicompost production by different species of earthworms which include horse waste, urban solid waste city leaf litter and food wastes paper waste and residues of plant decomposition. Several studies assessed the effects of vermicompost amendments in potting substrates on seedling emergence and growth of a wide range of marketable fruits cultivated in greenhouses.(Emam *et al*. 2015).

Perlite is typically combined with other soilless media in order to attain promising results in crop germination. This gleaming-like volcanic rock will expand itself under rapid controlled heating in which it would retain its lightweight aggregation, low bulk density, chemically inert in many environments, exceptional as filter aids and fillers for numerous as well as expansive in its used mainly in plant cultivation. In terms of input costs, perlite is also cheaper than the Rockwool and has been incorporated around the world for agricultural productions. Vermiculite is preferable due to its low moisture retention yet it could still uphold greater amount of water than perlite which can lead to the optimization of plant germination.

Vermiculite is typically neutral in pH, possess decent water holding capacity as well As containing little amounts of magnesium and potassium. This soilless media was also known to be porous due to its foam-like cellular structure, with decent characteristics such as Upright thermal stability, low moisture retention, low density and relatively cheap in cost.(Mat *et al*. 2018).

The hydroton planting media that is marketed has the characteristics of low water holding capacity. The addition of organic material in the form of husk charcoal, cocopeat, and compost clay can increase the water holding capacity of the hydroton so that plant productivity increases. (Suryadi *et al*. 2019).

Keeping these needs in view, the present study entitled "Performance evaluation of commercially available different media on vegetable production in pot culture" will be undertaking with the following objectives:

Objectives:

1. To study different Physio-chemical properties of media under consideration.

2. Performance evaluation of different media used for vegetable production.

3. Cost analysis of vegetable production of media under consideration.

CHAPTER II
REVIEW OF LITERATURE

This chapter deals with review of literature related to the title and objective of present study. This chapter describes reviews related to physio-chemical properties of different growing media, performance evaluation to fulfil the title of the present study and its objectives. Therefore, the reviews are distinguished in three sections as given below:

I. Physio-chemical properties of commercially available different growing media.

II. Performance evaluation of different media on vegetable production.

III. Cost analysis of vegetable production of media under consideration.

2.1 Physio-chemical properties of commercially available different growing media.

Heiskanen (1995) studied that the physical properties, in the water retention characteristics, of two-component growth media based on low- humified *Sphagnum* peat. The high-water retention of pure peat, which is further increased by compression of the medium at desorption, yielded low air-filled porosity at high matric potentials (≥ -1 kPa). The inclusion of coarse perlite to peat decreased the compression noticeably and also tended to increase the low saturated hydraulic conductivity of peat, which has initially been rather low. In peat that contained half impermeable rockwool or hydrogel, water retention was, noticeably lower. Between −10 and −50 kPa matric potential, water retention was preferably low in all media (< 10%). Within the lowest matric potential range studied (−50 to −1500 kPa), water retention was considerably elevated in peat which contained half hydrogel. The allusion of the physical properties of the media for plant-available water and aeration in the media are discussed.

Allaire *et al.*(1996) performed 2-year experiment with Prunus ×cistena sp. were carried out in pots using seven substrates composed of various proportions of primarily peat, compost and bark. The pH, electrical conductivity, C/N ratio as well as NO_3^--N and NH_4^+-N in solution were also measured. Limitations of plant growth due to the lack of aeration which suggested by evaluation of physical properties. Plant growth was remarkably correlated with both the gas relative diffusivity and the pore tortuosity factor. Among the chemical factors, pH and soil nitrate level were also correlated with plant growth. No remarkable co-relation was found between plant growth and air-filled porosity or any other measured chemical properties. This study specifies that an index of gas-exchange dynamics could be a useful complementary diagnostic tool to guide substrate manufacturing.

Wall and Heiskanen (2003) studied that the effects of air-filled porosity (AFP) and organic matter concentration (OMC) of soil on the growth of Norway spruce [Piceaabies (L.) Karst] seedlings were studied in a greenhouse experiment. The media were mixed to attain five levels of OMC (1, 25, 50, 75 and 97% by mass). Five AFP levels (5, 10, 20, 30 and 40%) were applied to the mixtures of growth media during irrigation. The shoot height and mass growth as well as root mass were remarkably higher in 20, 30 and 40% AFP than in 5 and 10% AFP ($p<0.05$). The longest shoots were produced in growth media with 25, 50 and 75% OMC ($p<0.05$). The effect of OMC on root mass, while significant ($p =0.03$), was less articulate than the effect on height growth and mass of the shoots ($p <0.001$). The results of study showed that, in greenhouse conditions for good seedling growth in pots, AFP should be 20-40% and OMC, 25-75% in the growth medium.

Shen and Zinati (2006) attempted to physical and chemical properties of container media are important elements in controlling the supply and movement of water and nutrients for nursery plant growth. The purpose of this study was evaluated the physical and chemical properties and quality of media formulated with systematic substitution of composted pine bark (bark) for sphagnum peat (peat) in the presence of sand. Ten formulations were prepared that contained 40-90% bark, 0-50% peat, and 10 or 20% sand by volume. Increasing the percentage of bark in the media remarkably decreased water holding capacity, whereas bulk and particle densities and total porosity were affected by the interaction of bark x peat x sand. Increasing the percentage of bark increased electrical conductivity. Accessibility of nutrients was also increased by increasing percentages of bark. Substitution of bark for peat did not influence the pH of the formulated media. The results suggested that 10 to 20% peat and prepared media with 70 to 80% composted pine bark and exhibited physical and chemical properties considered most favourable for the growth of container nursery plant crops.

Michel (2009) studied part of clay affiliation on the physical properties and wettability of peat-growing media was assessed from water retention curves and from contact angle and water drop penetration time measurements, respectively. Two peat substrates presenting different degrees of decomposition (weakly and highly decomposed Sphagnum peat) had used and combine with clay in the form of powder with a peat: clay ratio of 90:10 (by vol.). Results specified relatively little change in water retention resulting from clay incorporation in the peat-growing media tested. Incorporating clay into peat-growing media should be considered for its capacity to improve the wettability of growing media with a hydrophobic character (i.e., to improve the ability of the growing media to be rewetted) rather than only its capacity to influence the water retention characteristics of the growing media.

Michel (2010) performed that specifies criteria for assessing the physical properties (water retention characteristics, wettability and physical stability) of growing media which influence the availability of air and water to plant roots. The analysis of physical properties indicates that weakly decomposed (H_1–H_5, generally referred to as white) Sphagnum peat is still indispensable for soilless horticulture. During a number of materials can be used as peat additives, especially to improve aeration, no other products with equivalent physical properties are available at present.

Naasz and Bussieres (2011) guided that components selection and growing media manufacturing for horticultural production, dependable indicators of substrate quality are still needed. They attempted to made correlation of mass of the different particle sizes and some of the physical properties of substrates (air-filled porosity, saturated hydraulic conductivity, tortuosity or gas relative diffusivity). The purpose of the study was to estimate possible correlations between the mass of the different particle sizes and initial physical properties of different peat blend along with peat- perlite and peat-sawdust substrates. The overall survey of substrates (n=28) indicated that intermediate (0.85 to 2 mm) and fine particles (less than 0.3 mm) fractions were remarkably correlated to air-filled porosity but also with saturated hydraulic conductivity, gas diffusivity and pore tortuosity of substrates. For the peat- perlite substrates, fine particles were solely negatively correlated to saturated hydraulic conductivity.

Awang *et al*. (2012) attempted to study chemical and physical characteristics of cocopeat-based media mixtures and their effects on the growth and development of celosia cristata. They concluded inceptive pH for 100% cocopeat and 70% cocopeat: 30% kenaf core fibre was higher than the other media but the values were in the end similar by the end of the study. The bulk density and EC of media containing burnt rice hull was markedly higher than the other media. Incorporation of burnt rice hull and perlite into cocopeat increased water taking up ability of the media which reached saturation earlier than the other media. The growth and flowering of Celosia cristata were the greatest when grown in a mixture of 70% cocopeat: 30% burnt rice hull and perhaps linked with a good control in the aeration and moisture relationship of the media. Results of this attempt indicated that certain chemical and physical properties of cocopeat can be improved through combination of burnt rice hull and its positive effect was plainly reflected in the growth and development of Celosia cristata.

Emam *et al*. (2015) studies during two successive winter seasons at the central laboratory for agricultural climate, Giza, Egypt. The first study was to check the effect of vermicompost as an alternative organic substrate mixed with different mineral substrate perlite, vermiculite and sand (20:80 %) compared to peat moss + perlite (50:50 %) combined with different sources of nutrient solutions (vermicompost-tea, compost-tea and chemical) on the growth and yield of strawberry. Improving the physical and chemical properties of substrates (Sand and perlite) by vermicompost look over in the second study by mixing vermicompost with sand and perlite as alternative of peat moss in different proportions of 15:85, 30:70 and 45:55 % respectively compared to sand 100 % and perlite 100%. The acquire data of the first study disclosed that chemical nutrient solution recorded the highest values of vegetative, yield (337 and 359 g/plant), while using vermicompost as a substrate mix combined with different substrates has a positive significant effect compared to control. Vermicompost + sand followed by vermicompost + vermiculite recorded the highest results of vegetative, yield (327 and 356 - 329 and 346 g/plant) respectively and quality characteristics of strawberry. The second experiment illustrated that increasing the vermicompost rate has a negative notable impact on growth and yield of strawberry.

Fazlil and Desa (2017) studied the physical and hydraulic characteristics of cocopeat, perlite mixture as a growing media in containerized plant production. This study concentrated on the physical and hydraulic characteristics of cocopeat and perlite mixture as a growing media in containerized plant production. Perlite was added to cocopeat at a ratio of 3 cocopeat: 1 perlite. Bulk density, particle density, porosity, particle size distribution, water holding capacity, wettability and hydraulic conductivity of the media were calculated. About 82.93 % of the total particles were in the range between 0.425 and 4 mm in diameter at a bulk density of 0.09 g/cm3. Total porosity (79%) and wettability improved with the combination of perlite to cocopeat. This study laid out that water holding capacity was very high at 912.54 % whereas the saturated hydraulic conductivity was low at 0.1 cm/s. The results exhibited that adding perlite to cocopeat has improved the physical and hydraulic characteristics of the media.

Name	**Research**	**Design Aspect**
Heiskanen , 1995	The physical properties, in the water retention characteristics, of two-component growth media based on low-humified *Sphagnum* peat.	The allusion of the physical properties of the media for plant-available water and aeration in the media are discussed.
Allaire *et al.* 1996	Performed 2-year experiment with Prunus × cisterna sp. by using seven substrates composed of various proportions of primarily peat, compost and bark.	That an index of gas-exchange dynamics could be a useful complementary diagnostic tool to guide substrate manufacturing.
Wall and Heiskanen, 2003	The effects of air-filled porosity (AFP) and organic matter concentration (OMC) of soil.	Greenhouse conditions for good seedling growth in pots, AFP should be 20-40% and OMC 25-75% in the growth medium.
Shen and Zinati, 2006	Physical and chemical properties of container media are important elements in controlling the supply and movement of water and nutrients for nursery plant growth.	Exhibited physical and chemical properties considered most favourable for the growth of container nursery plant crops.
Michel, 2009	Part of clay affiliation on the physical properties and wettability of peat-growing media was assessed.	Results specified relatively little change in water retention resulting from clay incorporation in the peat-growing media tested.

Name	Research	Design Aspect
Michel, 2010	Criteria for assessing the physical propertiesof growing media which influence the availability of air and water to plant roots.	Weakly decomposed Sphagnum peat is still indispensable for soil-less horticulture.
Naaszand Bussieres, 2011	Guided that components selection and growing media manufacturing for horticultural production, dependable indicators of substrate quality are still needed.	For the peat-perlite substrates, fine particles were solely negatively correlated to saturated hydraulic conductivity.
Awang *et al*. 2012	To study chemical and physical characteristics of cocopeat-based media mixtures and their effects on the growth and development of celosia cristata.	Certain chemical and physical properties of cocopeat can be improved through combination of burnt rice hull.
Emam *et al*. 2015	To check the effect of vermicompost as an alternative organic substrate mixed with different mineral substrate perlite, vermiculite and sand.	Increasing the vermicompost rate has a negative notable impact on growth and yield of strawberry.
Fazlil and Desa, 2017	The Physical and Hydraulic Characteristics of Cocopeat Perlite Mixture.	Adding perlite to cocopeat has improved the physical and hydraulic characteristics of the media.

2.2 Performance evaluation of different media on vegetable production.

Neethi and Subramanian, (2006), revealed that coir pith is a by-product of the coir industry, producing more than 7.5 million tonnes annually in India. It can be used as fuel in loose form or briquettes. This study investigates different physical properties of coir pith concerning its moisture content (10.1 to 60.2%) and particle size (0.098 to 0.925 mm). Porosity and particle density varied from 0.623 to 0.862 and from 0.939 to 0.605 gm/cc respectively. Bulk density and static coefficient of friction against mild steel were in the range of 0.097 to 0.341 gm/cc and 0.5043 to 0.6332 gm/cc respectively. Models were developed for the above properties.

Rajarathnam and Shashirekha (2006), revealed that different physical properties of coir pith concerning its moisture content (10.1 to 60.2%) and particle size (0.098 to 0.925 mm)coir pith is a by-product of the coir industry, producing more than 7.5 million tonnes annually in India. It can be used as fuel in loose form or briquettes. This study investigates different physical properties of coir pith concerning its moisture content (10.1 to 60.2%) and particle size (0.098 to 0.925 mm). Porosity and particle density varied from 0.623 to 0.862 and from 0.939 to 0.605 gm/cc respectively. Bulk density and static coefficient of friction against mild steel were in the range of 0.097 to 0.341 gm/cc and 0.5043 to 0.6332 gm/cc respectively. Models were developed for the above properties.

Tzortzakis and Economakis (2008) studied that different substrates for the soilless culture of tomato plants over a 5-month period in a closed soilless culture system employing five different substrates (perlite, pumice or maize and their mixtures with 50 % crushed maize stems in a numbing glasshouse). Plants grown in a maize stem-containing medium produced earlier fruits, followed by pumice. Plants grown in pumice and perlite substrates obtained lower total yield; a higher yield was associated with the addition of maize crushed stems. Pumice + 50 % maize and 100 % maize bring about the higher total number of fruits per plant. The results proposed that the addition of maize in perlite and pumice could improve inorganic substrates properties for tomato soilless culture, leading to higher yields and superior fruit quality.

Kratky (2009) studied those three non-circulating hydroponic methods for growing lettuce impulsively watered lettuce plants because the whole growing medium in the net pot becomes moistened by capillary action. He observed that the plant growth reduced the nutrient solution level, creating an enlarging moist air space. Meanwhile, the root system expands and continues to absorb water and nutrients. Leaf and semi-head lettuce cultivars were usually harvested at about 6 to 7 weeks after seeding. The cover initially floats on the nutrient solution, and then, comes to rest on 2 parallel plastic pipes (10 cm dia.) be laid on the tank floor as the nutrient solution level recedes due to plant growth. The tank is filled with water instantly prior to harvesting and floating rafts may be easily moved to a harvesting station.

Wahome *et al.* (2011) concluded that the hydroponics growing systems developed to get higher yield and quality, to conserve water and land, to save labour and to protect the environment. They found yields with hydroponics averaged around 20 to 25 percent higher than in ordinary cultivation. Hydroponics and green house yields were commonly five times the field yield for a two crop per year field harvest and 10 times the field yield for a one crop per year field harvest. In addition, since hydroponics plants have eruption to unlimited nutrition and water, they can grow up to 10 times faster and healthier than soil grown ones. Growth rate of tomatoes in hydroponics culture was 30 to 50 percent faster than a soil grown plant, under the same conditions and the yield was also higher.

Majdi *et al.* (2012) studied an effectiveness of substrate on growth indices and yield of green peppers and select acceptable cultivar in hydroponic cultivate system for growing green peppers with three substrates include vermiculite + sand, peat, perlite and rock wool. They concluded that there was remarkable difference between interaction effect of green pepper and substrate in their leaf weight, root weight and dry stem and leaf weight in level of 5 percent and dry root weight in level of 1 percent. According to these results, Substrate of peat + perlite had most effect on growing traits and yield of green pepper.

Olle *et al*. (2012) studied the Vegetable quality and productivity as controlled by growing medium. The purpose of their research was to present an overview of the effects of mineral soil, inorganic and organic growing media on the growth, development, yield and quality of vegetables grown under greenhouse conditions. Growth and evaluation of vegetables were enhanced, when plants are grown in inorganic media compared to organic ones. They concluded some Vegetables grown by inorganic media and they had grown very well, as perceived with organic media, it was difficult to draw general conclusions on the impact of inorganic media on the chemical composition of vegetables. Results differ with the crop and the chemical composition and availability of elements of the inorganic substrate.

Marinou *et al*. (2013) studied that, the use of sawdust, coco soil and pumice in hydroponically grown Strawberry. Three substrates, pumice, sawdust, coco soil and mixtures of these, were used to create six treatments. The physic-chemical properties of pumice, coco soil and Sawdust mixtures were looked into in three replicants. The amount of pore space of media is critical physical characteristic which influences water and nutrient absorption and gas exchange by the root system. They concluded that the reputative use of organic medium i.e., sawdust on top of the widely used coco soil as substrate medium in strawberry culture.

Abafita *et al*. (2014) attempted to the effects of different rates of vermicompost as potting media on growth and yield of tomato (Solanum Lycopersicon L.) and soil fertility improvement. The study was conducted through effect of increasing concentration of Vermicompost (p_0=control, p_1=10%, p_2=20%, p_3=30% and p_4=40%w/w) in plant growth. The acquired results from the present research showed that applied vermicompost especially; at 20% level had remarkably improving effects on better growth and development of vermicompost treated tomatoes as they had higher leaf area, leaf dry mass, fresh stem and dry weight, number of fruits and yields. Low doses of vermicompost (10%) and high doses (40%) produced lower yields of the tomato plants. They could be suggested that treated plants, with this vermicompost increased the growth, yield and the above chemical compositions and pH of the soil.

Ferguson *et al*. (2014) studied the effects of hydroponic media on quality of greenhouse grown leafy greens. They found that the continuous flow system allows refreshing of the nutrient solution at the root rapidly, allowing rapid uptake on nutrients without a large investment in root biomass continuous flow systems allow lower levels of nutrients to be used which decreases costs and waste.

Joseph and Muthuchamy (2014) studied the productivity, quality and economics of tomato. The different growing systems designed for this particular study were tray, trough and pot systems.

They use three different media combinations, i.e., cocopeat + gravel+ silex stone, cocopeat + pebble + silexstone and cocopeat + perlite +silex stone, constituted the factors of the treatment's nutrient solution was loaded in 200-liter capacity tank sand irrigation has given by 5mm micro tube drip emitters connected to 16mm diameter LLDPE lateral pipes. They observed the maximum yield for the treatment of trough with cocopeat + gravel + silex stone.

Gupta *et al*. (2014) concluded that the effect of vermicompost application in potting media on growth and flowering of marigold crop. They have used media as mixture of household solid waste containing mostly kitchen waste, Vegetables peel of paper products, plant leaves and also non-biodegradable material such as glass, gravel, plastics, metals etc. Then they sorted that all organic waste and then they were crushed, shredded and used as vermicomposting material for their studies. Then the result showed that the potting media has remarkably positive effects on growth and that media has symbiotic effects on growth and yield of marigold.

Nejatianand Mazahrih (2015) studied that the effect of different growing medias on cucumber production and water productivity in soilless culture under UAE conditions. The purpose of their studies is to identify the best and more suitable growing media for producing healthy, strong, homogeneous cucumber crop in greenhouse in UAE condition. They have used coco-peat grow bag and perlite. They have got the result with using both media are totally different. In terms of water productivity, the results also showed that produced cucumber yields had good conditions in perlite with the highest net profit and water productivity values. In addition, the results indicated that by mixing coco-peat with perlite in 1:1 ratio, the yield remarkable increased by 82 % compare to coco peat grow bags.

Hossain *et al*. (2016) experimented on the growth and quality of hydroponically grown lettuce (*Lactuca sativa* L.) using nutrient solution from coconut-coir dust and hydroton substrate. The purpose of the research was to study the effect of used nutrient solution (UNS) on growth and quality of lettuce. They concluded the mean pH values in used nutrient solution (UNS) and Enshi nutrient solution (ENS) were continued a 6.0 during the lettuce cultivation in deep flow technique. pH value started to increase in all treatments from 7 days after transplanting. The pH of the UNS and ENS was increased from 6.2 to 7.0 as the growth of lettuce increased. The final results they have got an indication that 25 % UNS + 75 % FNS showed the better performance irrespective of substrate in case of growth and quality traits compared with other treatments.

Ahmadpour and Hosseinzadeh (2017) performed that the effect of vermicompost fertilizer on morphological traits of lentil under water stress. The purpose of their research was to improve plant performance under moisture deficit stress in a greenhouse environment. The result they have got that under moister deficit stress (25 and 50 % field capacity) remarkably decreased the morphological features. Results showed that under non-stress and severe stress conditions, vermicompost treatments at 15 and 25 % led to a significant increase in the plant height compared to the control.

Mat *et al*. (2018) revealed that soilless media culture-A propitious auxiliary for crop production. Soil-based cultivation is currently confronting dire challenges to the deficiency of land availability, massive increasing rate of industrialization and urbanization. Land-related agriculture is at spike due to irrepressible climate vicissitudes, relentless soil degradation, unbefitting management practices and other adversative effects. Therefore, they concluded that soilless media culture would make ways as an auspicious auxiliary in current pressing scenario. Proper management practices and technological advancements can utterly exploit the soilless substrates effectively and efficiently. Optimization of yield pertaining to incorporation of soilless media can also result in superior quality and growth performance in relevance to less agricultural inputs being consumed.

Kala *et al*. (2020) studied that the response of potting media composition for pot mum chrysanthemum production (*Dendranthema grandiflora* L.). The purpose of their research was to search out suitable potting media combination for growth, floral and media analysis parameter. The experiment was place out in Completely Randomized Design with 20 replications and 10 potting media as treatment. On the basis of result acquired, it was concluded that potting media treatment combination consisting from Soil: Sand: FYM: Vermicompost (2:1:0.5:0.5) were found best for pot mum chrysanthemum production over treatments.

Spehia *et al*. (2020) studied about the effect of soilless media on nutrient uptake and yield of tomato (*Solanum lycopersicum*). They included media in soil less farming, like cocopeat, vermiculite, perlite etc. or hydroponics system. The treatments consisted of different growing media viz. coco peat alone (control) coco peat + vermin compost 70:30) and vermiculite + vermicompost (70:30). They found that growing media consisting of cocopeat, vermicompost (70:30) increased the quality and yield of tomato over the generally preferred growing media i.e. coco peat, alone. The study they have found will be helpful for the growers for increasing the quality and yield of tomato under protected conditions to escape the problems faced in soil-based production system.

Krishnapillai *et al*. (2020) studied that the locally produced cocopeat growing media for container plant production. They have described the purpose of their research was process of creating the medium, along with a description of its properties and uses. From this work they got best medium for the crop production is as coco peat. In their activity of finding a local alternative to soil, they concluded that coconut husk, locally processed into cocopeat, was an ideal medium for growing plants in various container types.

Rowland *et al*. (2021) studied that the estimation of potato varieties grown in hydroponics for phosphorus use efficiency. They have evaluated the performance of potato varieties grown in hydroponics. They got results of this study show that the TCP solution was successful for screening P-efficient potato varieties.

Chhetri *et al*. (2022) concluded that the effect of different growing media on growth and yield of leafy vegetables in nutrient film technique hydroponic system. The experimental design used in this study was a factorial randomized block design with two factors. The results of this study showed that growing media coco peat followed by sponge performed better as compared to perlite. For the hydroponics cultivation of lettuce and pakchoi, coco peat followed by sponges should be used as a growing medium for better growth and yield.

Name	**Research**	**Design Aspect**
Tzortzakis and Economakis, (2008)	Different substrates for the soilless culture of tomato plants.	The addition of maize in perlite and pumice could improve inorganic substrates properties for tomato soilless culture, leading to higher yields and superior fruit quality.
Rajarathnam and Shashirekha (2006)	Different physical properties of coir pith concerning its moisture content	Porosity and particle density varied from 0.623 to 0.862 and from 0.939 to 0.605 gm/cc respectively. Bulk density and static coefficient of friction against mild steel were in the range of 0.097 to 0.341 gm/cc and 0.5043 to 0.6332 gm/cc respectively
Neethi and Subramanian, (2006)	Different physical properties of coir pith concerning its moisture content (10.1 to 60.2%)	Bulk density and static coefficient of friction against mild steel were in the range of 0.097 to 0.341 gm/cc and 0.5043 to 0.6332 gm/cc respectively
Kratky (2009)	Three non-circulating hydroponic methods for growing lettuce.	The tank is filled with water instantly prior to harvesting and floating rafts may be easily moved to a harvesting s
Wahome *et al.* (2011)	The hydroponics growing systems developed to get higher yield and quality.	Growth rate of tomatoes in hydroponics culture faster than a soil grown plant and the yield was also higher.
Majdi *et al.* (2012)	Effectiveness of substrate on growth indices and yield of green peppers and select acceptable cultivar in hydroponic cultivate system.	Substrate of peat + perlite had most effect on growing traits and yield of green pepper.
Olle *et al*. (2012)	The Vegetable quality and productivity as controlled by growing medium.	Differ with the crop and the chemical composition and availability of elements of the inorganic substrate.
Marinou *et al.*	The use of sawdust Coco soil	The reputative use of organic medium

Name	Research	Design Aspect
(2013)	and pumice in hydroponically grown Strawberry.	i.e., sawdust on top of the widely used coco soil as substrate medium in strawberry culture.
Abafita*et al*. (2014)	The Effects of different rates of vermicompost as potting media on growth and yield of tomato (*Solanum lycopersicum* L.) and soil fertility improvement.	Applied vermicompost especially, at 20% level had remarkably improving effects on better growth and development.
Ferguson *et al*. (2014)	The effects of hydroponic media on quality of greenhouse grown leafy greens.	Continuous flow systems allow lower levels of nutrients to be used which decreases costs and waste.
Joseph and Muthuchamy(2014)	The productivity, quality and economics of tomato. The different growing systems designed for this particular study were tray, trough and pot systems.	The maximum yield for the treatment of trough with cocopeat + gravel + silex stone.
Gupta *et al*. (2014)	The effect of vermicompost application in potting media on growth and flowering of marigold crop.	The potting media has remarkably positive effects on growth and that media has symbiotic effects on growth and yield of marigold.
Nejatian and Mazahrih (2015)	The Effect of different growing Medias on Cucumber Production and Water Productivity in Soilless Culture under UAE Conditions.	That by mixing coco-peat with perlite in 1:1 ratio, the yield remarkable increased by 82% compare to coco peat grow bags.
Hossain *et al*.(2016)	The Growth and Quality of Hydroponically Grown Lettuce using nutrient Solution from Coconut-Coir Dust and Hydroton Substrate.	25% UNS + 75% FNS showed the better performance irrespective of substrate in case of growth and quality traits compared with other treatments.
Ahmadpour and Hosseinzadeh (2017)	The Effect of vermicompost fertilizer on morphological traits of lentil under water stress.	Under non-stress and severe stress conditions, vermicompost treatments at 15 and 25 % led to a significant increase in the plant height compared to the control.
Mat *et al*. (2018)	Soilless media culture-A propitious auxiliary for crop production.	Soilless media culture would make ways as an auspicious auxiliary in current pressing scenario.
Kala *et al*. (2020)	The Response of potting media composition for pot mum chrysanthemum production.	Potting media treatment combination consisting were found best for pot mum chrysanthemum production over treatments.
Spehia*et al*. (2020)	The Effect of soilless media on nutrient uptake and yield of	Growing media consisting of cocopeat, vermicompost (70:30) increased the

Name	Research	Design Aspect
	tomato.	quality and yield of tomato.
Krishnapillai *et al*. (2020)	The locally produced cocopeat growing media for container plant production.	Coconut husk, locally processed into cocopeat, was an ideal medium for growing plants in various container types.
Rowland *et al*. (2021)	The estimation of Potato Varieties Grown in Hydroponics for Phosphorus Use Efficiency.	The TCP solution was successful for screening P-efficient potato varieties.
Chhetri *et al*. (2022)	The effect of different growing media on growth and yield of leafy vegetables in nutrient film technique hydroponic system.	That growing media coco peat followed by sponge performed better as compared to perlite.

2.3 Cost analysis of vegetable production of media under consideration.

Sace and Estigoy (2015) studied recirculating hydroponic system was constructed in an urban vertical garden to determine the growth and yield of lettuce. The system used a 35-watt submersible pump to lift the nutrient solution from the reservoir to the uppermost growing tubes which were vertically configured to move the solution in circles. Results showed that lettuce variety Carlo Rossa tolerated an environment beyond the optimal and remained productive throughout the six growing seasons even at temperature of 25 to 35 °C and relative humidity of 50 to 88 %. The taste and tenderness of the harvest were highly acceptable to local consumers when harvested 30 days after transplanting even when sold at P150.00 per kilogram. The system costs P50,000.00 and can accommodate 560 plants resulting to a plant density of 48.6 hills per square meter per cropping. When adjusted to annual basis, a gross income of P47,900.00 is obtained. The system has a total cost of P23,994.00 per year when fixed cost of P5,550.00 and operating cost of P18,444.00 were added. An annual net income of P23,906.00 was computed when total cost is subtracted from the gross income while the annual gross margin was P29,456.00 when the total variable cost is deducted from the gross income. Payback period, the length of time it will take for the investment to return to its original cost, was 2.1 years when the initial cost was divided by the net income. Unit price is only P57.80 per kg when the total variable cost is divided by the total weight of lettuce.

Duyar and Kilic (2016) attempted research on production of baby leaf vegetables in floating system. In this research, the possibility of dill, parsley and leaf lettuce growth in a floating system was studied by them with the purpose of less nutrient (fertilizer) use. The effect of full and half strength nutrient solutions on yield, quality and leaf nutrient status was studied. Standard nutrient solution 12 $N\text{-}NO_3$, 3.8 $N\text{-}NH_4$, 2.8 P, 8.4 K, 3.5 Ca, 1.4 Mg, 9.5 Na, 8.0 CI, 2.7 S, 0.04 Fe) was used as control treatment and compared to half strength Hoagland nutrient solution. In both of the season's total yield changed between 1030.78-1 149.90 g m^{-2} in dill, 604.73659.70 g m^{-2} parsley and leaf lettuce 162.60- 143 g plant respectively. They decided the effect of treatments on some quality parameters (dry weight, vitamin C, nitrate, pH and EC) and nutrients uptake by plant. They concluded that half strength nutrient solution decreased yield.

Demircan *et al.* (2017) studied comparison of cost and profitability of organic and conventional strawberry seedling growing media. This study was carried out in the Apricot Research Institute in Malatya province, Turkey. Albion and Sweet Charlie varieties were used in the experiment. The production costs of Albion and Sweet Charlie strawberry varieties were calculated in different growing media. Calculation of the production costs of the fresh plug strawberry seedlings was done in two steps. First, the production costs of strawberry runner plants were calculated, then the production costs of fresh plug strawberry seedlings were found. According to the results of the research, the cost of a runner plant was found to be the highest for the Albian Biodecal application, while the lowest was detected for Sweet Charlie Control application. According to different applications, the cost of strawberry branch plant was determined as 0.376, 0.341, 0.273, and 0.235 TL/unit for Albian Biodecal, Albian Control, Sweet Charlie Biodecal and Sweet Charlie Control applications, respectively (1 USD=3.02 TL in 2016, average). When the production costs of Albion and Sweet Charlie strawberry seedling obtained from Biodecal application were compared with the sale price, it can be said that production cost was lower than sale price for all the organic growing media, but in the conventional growing media, production costs was found to be higher than the sale price.

Name	Research	Design aspect
Sace and Estigoy (2015)	Lettuce Production in a Recirculating Hydroponic System.	It is recommended to establish a high-end market that will be willing to pay a higher price in exchange of safe and sustained supply of quality harvest, increase plant density, and optimize all inputs to maximize profit.
Duyar and Kilic (2016)	Production of baby leaf vegetables in floating system.	The effect of treatments on some quality parameters (dry weight, vitamin C, nitrate, pH and EC) and nutrients uptake by plant. They concluded that half strength nutrient solution decreased yield.
Demircan *et al.* (2017)	Comparison of cost and profitability of organic and conventional strawberry seedling growing media.	Production cost was lower than sale price for all the organic growing media.

Critique of study

From the reviewed literature, it is observed that scientists worked on the various substrate media used for soilless farming system. They also studied about different combinations of the media and their effect on crop growth. The reviewed literature shows that scientists have studied different media as vermiculite, perlite, hydroton, pumice and saw dusts etc. It is also found that these media are not easily, cheaply and locally available for users. Beside this, few scientists studied about particle size, porosity, bulk density, wettability of these media. Hence it is essential to identify easily and cheaply available local media for hydroponic cultivation. The cocopeat and vermicompost are locally and cheaply available media. Hence it is essential to study the physical and chemical properties of these media. Hence it is necessary to undertake the study of the locally available media. Also many scientists worked for the performance evaluation of the developed hydroponic technique. Some scientist of them carried out performance evaluation of closed recirculating soilless farming system while some of them worked on open type hydroponic system. From the review it was observed that the effect of planting densities, plant spacing and yield related parameters were studied by scientists. The literature shows that the study related to the total investment of the project, benefit cost ratio was also evaluated. The work of determination of water use efficiency, fertilizer use efficiency was performed by the researchers. However, it is essential to work out the feasibility of locally designed automatic hydroponic system, its benefit cost ratio, power consumption, maintains cost to make it profitable for end user.

CHAPTER III
MATERIALS AND METHODS

This chapter deals with the material used and methodology adopted to accomplish the requirement of the title and objectives. Section materials, soilless growing media under consideration, size of pots, instruments to calculate physical and chemical properties to accomplish the requirement of growing vegetables are covered. The section methodology as the physio-chemical properties of media as Cocopeat, Vermicompost, Perlite, Vermiculite and Hydroton for cultivation of crops in pots, its biometric observation and cost analysis is described.

3.1 Location, Climate and Weather Condition:

The study entitled "Performance Evaluation of Commercially Available Different Media on Vegetable Production in Pot Culture" was carried out on instructional farm of Department of Irrigation and Drainage Engineering, College of Agricultural Engineering and Technology, Dr Balasaheb Sawant Konkan Agricultural University, Dapoli. Geographically, the selected site is situated at 15°6′ N to 20°22′ N latitude and 72°39′ E to 73°48′ E longitudes. The climate of this region is humid. Its average annual rainfall is 3500 mm. the average minimum and maximum temperature is 7.5°C to 38.5° C, respectively. The relative humidity ranges from 46% to 99 % (www.dbskkv.org.).

3.2 Methodology

The methodology acquired for performance evaluation of commercially available growing media on vegetable production in pot culture. Detailed layout of the existing system is described in the sub section of 3.2. The pictorial view of the experimental set up is shown in plate 3.1.

Plate 3.1 Experimental setup

3.2.1 Selection of Pots for Experimental Unit

Plastic pots of truncated cone shape were used as the container for planting material. The size, thickness of pots was decided by considering its long life, cost effectiveness, light in weight and higher productivity of pot culture unit. The surface area and volume of pots are the important dimensions for find out requirement of media and crop growth. Similarly, the type of growing media, amount of water required also important parameters for choosing size of pots. The depth of growing media in a pot or containers influences the proportion of the pore space filled water or air; short containers hold more water than tall container. (Lopez- pozos *et al.,* 2011). Hence, it was decided to use the pot for experimental unit with top width of 13 cm, bottom width of 8.6 cm, height of 11.5 cm and diameter of pot is 12.6 cm. volume of the pot was 0.0014 m^3. The surface area of pot was 0.154m^2. The 60 pots were placed in experimental unit of pot culture. The proposed pots and their dimensions are shown in the plate 3.2.

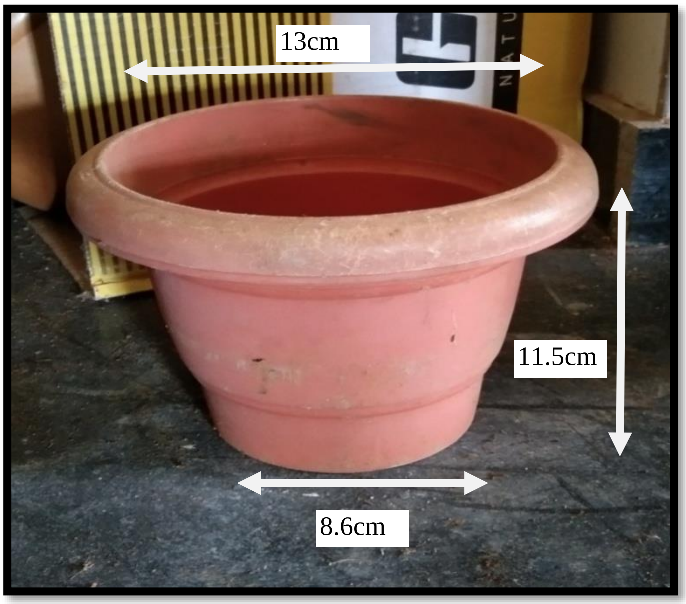

Plate 3.2 Grow pot

3.2.2 Selection of Crop for Study

3.2.2.1 Spinach

Spinach (*Spinacia oleracea*) is a hot season leafy vegetable grown all over India. This is being in grown environment as well as open field commercially. Spinach is known for rich in iron, vitamins and anti-oxidants.

3.2.2.2 Fenugreek

Fenugreek *(Trigonella foenum-graecum*) is mostly known as methi in India and used as relish agent for food preparation. The adolescent leaves are used and consumed as vegetable in daily cooking. The fenugreek is slightly rich in protein, minerals and vitamin C.

3.2.2.3 Green Amaranthus

Amaranthus *(Amaranthus cruentus)* is annual or short- lived perennial crop. The seed, oil and leaf of amaranthus used as food. Amaranthus is rich in antioxidants, including gallic acid and vanillic acid.

3.2.2 Media

In media-based pot culture, a soilless grow medium is normally used to help plant roots to support the weight of a growing plant. The soilless media should be inert and have suitable properties like good aeration, porosity and water holding capacity to enhance the growth and development of plants. Different types of organic and inorganic media are used in a soilless farming, including rock wool, coco coir, expanded clay, perlite, gravel, vermiculite, vermicompost, hydrotons and more. Eventually, the choice is made based on personal preference, budget, availability, system design, and irrigation methods. The type of growing media will help to determine the amount of water and nutrients to be supplied directly from water applied nutrients. The organic and inorganic media are generally used for soilless farming. Following media were selected according to physio-chemical properties, cost and their availability.

3.2.2.1 Cocopeat

Cocopeat is the non-fibrous, spongy, light weight, corky material that carries together the coir fibre in coconut husk. It is a 100 percent organic, natural and bio-degradable substance which is the outgrowth of Coconut fibre extraction process. Cocopeat is eco-friendly and sustainable growing medium, having high moisture retention and high cation exchange capacity. It is shown in Plate 3.3.

3.2.2.2 Vermicompost

Vermicompost is the product of the decomposition process are used in which several species of worms, generally red wigglers, white worms, and other earthworms, to create a mixture of decomposing vegetable or food waste and bedding materials. This process is called vermicomposting. Vermicompost contains water-soluble nutrients and is an excellent, nutrient-rich organic fertilizer and soil conditioner. It is used in gardening and supportableorganic farming. It is shown in Plate 3.4.

3.2.2.3 Perlite

Perlite is mainly composed of minerals that are subjected to very high heat, which then expand it like popcorn so it becomes very light weight, porous and absorbent. Perlite has a neutral pH, excellent wicking action, and is very porous. Perlite is used as it is, or mixed with other types of growing media. It is shown in Plate 3.5.

3.2.2.4 Vermiculite

Vermiculite is a water absorbent growing medium which uniformly distributes water using capillary action. As a growing media, vermiculite is similar to perlite except that it can hold nutrients for later use that means it has relatively high cation-exchange capacity. It is shown in Plate 3.6.

3.2.2.5 Hydroton

Hydroton is a growing medium composed of expanded clay pebbles. The hydroton growing media that is marketed has the characteristics of low water holding capacity. The addition of organic material in the form of husk charcoal, cocopeat, and compost clay can increase the water holding capacity of the hydroton so that plant productivity increases. It is shown in Plate 3.7.

Plate 3.3 Cocopeat (T1)

Plate 3.4 Vermicompost (T2)

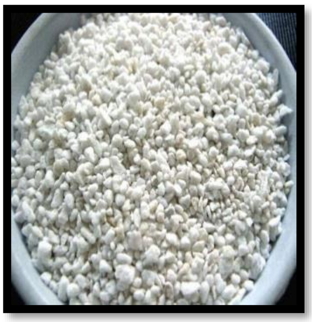

Plate 3.5 Perlite (T3)

Plate 3.6 Vermiculite (T4)

Plate 3.7 Hydroton (T5)

3.2.3 Evaluation of Different Media

Experimental details:

The experimentation entitled "Performance Evaluation of Commercially Available Different Media on Vegetable Production in Pot Culture" was carried out by using randomized block design (RBD). The treatment combination table is as follows:

Table 3.1 Treatment combination

	T1	**T2**	**T3**	**T4**	**T5**
R_1	T1R1	T2R1	T3R1	T4R1	T5R1
R_2	T1R2	T2R2	T3R2	T4R2	T5R2
R_3	T1R3	T2R3	T3R3	T4R3	T5R3
R_4	T1R4	T2R4	T3R4	T4R4	T5R4

Details of treatment are as follows:

T1 – Cocopeat media
T2 – Vermicompost media
T3 – Perlite media
T4 – Vermiculite media
T5 – Hydroton media
In this study total 20 treatment combinations were used for one crop.

3.2.4 Properties of Media

In soilless culture, the substrate is an important factor to obtain the best growth of vegetable plants. Many kinds of materials are used; organic and inorganic but, it is necessary to know its characteristics of that material. The properties of growing media such as physical and chemical properties of media need to be regulated to provide the compatible root environment for plant growth.

3.2.4.1 Physical Properties

Physical properties of media which includes Bulk density, Particle density, Porosity, Water holding capacity, Wettability and Air-filled porosity are determined by the methods given as follows

3.2.4.1.1 Bulk Density

Bulk density is defined as the density of the medium as it occurs. The bulk density is partly dependent on the actual moisture content. The measure of growing media nutrient holding capacity and porosity is the bulk density or weight per unit volume. Measurement of bulk density of media was carried out by standard procedure. The determination of bulk density was done by using following procedure and shown in Plate 3.8. Take down the internal dimensions and weight of the measuring jar. Measuring jar was filled with media up to top. The surplus media at the top was trimmed by scale. The weight of the media with measuring jar was measured and the bulk density was calculated by following formula,

$$\rho_b = \frac{W_b - W_r}{\frac{\pi h d^2}{4}} \quad \text{... (3.1)}$$

Where,

W_b- Weight of media and measuring jar, g

W_r- Weight of measuring jar, g

h- Height of measuring jar, cm and d- Diameter of measuring jar, cm

Plate 3.8 measurement of weight of individual media for bulk density

3.2.4.1.2 Particle Density

The weight of separate media particle per unit volume is called particle density. Particle density is the volumetric mass of the media and it does not include pore spaces. Generally, particle density is expressed in units of grams per cubic centimeter ($g.cm^{-3}$) and determined by the equation 3.2 and 3.3. The particle density was determined by using pycnometer method as shown in Plate 3.9

Determination of particle density:

i. Take down weight of empty pycnometer with stopper.

ii. Filled the pycnometer fully with the water and record its temperature.

iii. Wipe out the surface of pycnometer after filling water in it and take its weight with water.

iv. Empty the pycnometer and then transfer the 1 gm of media in it

v. Fill the half pycnometer with water and boil it to remove entrapped air.

vi. Keep it for cooling.

vii. Fill the remaining water in pycnometer and wipe out the surface of pycnometer.

viii. Note down the weight of pycnometer with media and water.

ix. Particle density was calculated by following formula,

$$\text{Particle density: } \frac{\text{Density of water}\left(\frac{kg}{m^3}\right)\times\text{Mass of oven dried media (kg)}}{\text{Mass of water displaced of media (g)}}\ (kg.m^{-3}) \quad ..(3.2)$$

$$\rho_s = \frac{\rho_w M_s}{M_{dw}} \quad ..(3.3)$$

Where,

ρ_s - Particle density, $g.cc^{-3}$

ρ_w - Density of water, $g.cc^{-3}$

Ms- Mass of oven dried media, g

Mdw- Mass of water displaced by media, g

Plate 3.9 Particle density of individual media by pycnometer method

3.2.4.1.3 Porosity

The space between particles which is not inhabited by solid material may be inhabited by either water or air is called porosity. Pore space determines the amount of water that a given volume of media can detain. Porosity of soilless media is determined using the known bulk density and particle density of media by the equation 3.4. It can be determined by following formula.

$$\text{Porosity} = 1-\left(\frac{\text{Bulk density}}{\text{Particle density}}\right) \quad ..(3.4)$$

3.2.4.1.4 Wettability

The capacity of each medium to absorb water is represented by its wettability. The wettability of a material determines its aptitude to rewet itself. It is particularly important property in the case of horticultural growing media since it determines initial water uptake of the substrate and their subsequent water movement following root water removal and evapotranspiration. The evaluation of the wettability was done by using method described by (Awang *et al*. 2012) as shown in plate 3.10. The following procedure was adopted for determination of wettability.

i. Each pot was filled with 100 gm media sample of cocopeat, vermicompost, perlite, vermiculite and hydroton.

ii. 2 cm depth of water was taken in the plastic tray.

iii. Pots were kept along with media in plastic tray for socking.

iv. Absorbed moisture content by the media was recorded for next 6 hours.

v. After every hour quantity of water needed to maintain the 2 cm depth in the plastic tray was recorded.

vi. End of every hour, samples of the media from the pots were collected for determination of moisture content

vii. Moisture content was calculated by gravimetric method.

Plate 3.10 Wettability of individual media

3.2.4.1.5 Water Holding Capacity

The water holding capacity can be defined as the total amount of water media can hold. Water-holding capacity is one of the most important featured to consider in the irrigation frequency and volume management. Determination of water holding capacity was determine by using following procedure and equation 3.5 and shown in Plate 3.11.

i. Record the weight of five empty KR (Keen Roczkowski) box.

ii. Record the weight of wetted filter paper for once and add that weight in remaining KR box weight.

iii. Transferred the media into the KR box and tap the box gently during filling for uniform packing.

iv. Sliced off extra media on the top of KR box.

v. Record the weight of KR box with filter paper and media.

vi. Place KR box in 2 cm of water in water filled tray (Petri dish) and allow it to saturate for next 24 hr.

vii. Take out the box from tray and allow it to drain for 30 min.

viii. Record the weight of KR box with saturated media

$$\text{WHC} = \frac{\text{weight of moist media} - \text{weight of dried soil}}{\text{weight of dried soil}} \times 100 \qquad ..(3.5)$$

Plate 3.11 Water holding capacity of individual media

3.2.4.1.6 Air Filled Porosity

Air-Filled Porosity (AFP) was calculated using saturation and drainage method after saturation. The pots, filled with 100 gm of the respective medium (without plants), were irrigated by submerging them into the water. The medium was considered saturated when the water has drained out from that media. The saturated medium was removed quickly to a funnel with a 500 ml water. The volume of water drained from the pot was supposed to be taking by an equivalent volume of air and therefore the volume of water collected represents the amount of air diffused into the media. The percentage of AFP was calculated by dividing the volume of water collected with the volume of the media (Awang *et al*. 2012).

3.2.4.2 Chemical Properties

Chemical properties of media include electrical conductivity and pH which decides its relevance of media in crop cultivation.

3.2.4.2.1 Electrical Conductivity

The electrical conductivity is measure of a material's ability to carry an electric current. The unit of electrical conductivity is desisiemen per meter (dSm^{-1}). Following procedure was used to determine the electrical conductivity of media as follows and shown in Plate 3.12:

i. Prepare a 1:10 media and distilled water by weighing 5 gm of media into the beaker and add 50 ml distilled water in it. shake it for half an hour

ii. Calibrate the conductivity meter with 0.01 normal KCl reference solutions according to manufacturer's instruction to obtain the cell constant.

iii. Measure the electrical conductivity of a 0.01M KCl reference solution.

iv. Measure the electrical conductivity of media suspension at the same temperature as 0.01M KCl reference solution.

3.2.4.2.2 pH

The pH is the measure of acidity or alkalinity of an aqueous solution. The term pH refers to the potential hydrogen/hydroxyl ion content of a solution. If a solution has more positive (hydrogen) ions than negative (hydroxyl) ions then it is acidic and it has a pH in the range of 0 to 6.9. Alternatively, if a solution has more positive (hydrogen) ions than negative (hydroxyl) ions then it is alkaline with a pH in the range of 7.1 to 14. The procedure to determine the pH of media is as follows and shown in Plate 3.13:

i. The pH meter was calibrated with buffer solution 4.0 and 9.2 pH.

ii. Weight 5 gm of media and transfer it into 100 ml beaker.

iii. Add 50 ml of distilled water and stir well with the help of glass rod for half an hour.

iv. Immerse the electrode of pH meter was into the beaker and record the pH value from the automatic display of pH meter.

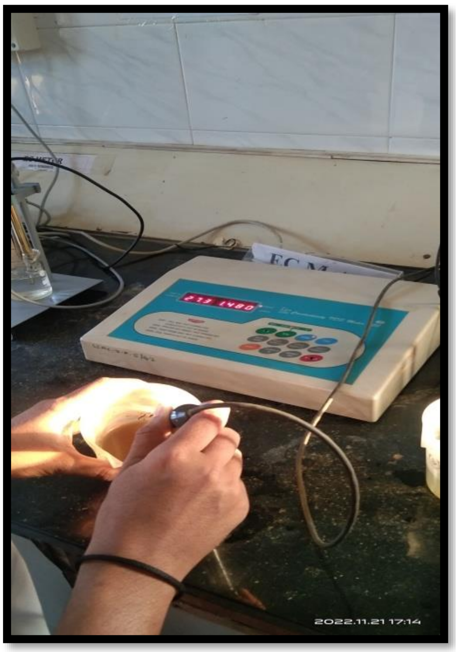

Plate 3.12 EC of individual media **Plate 3.13 pH of individual media**

3.2.5 Water Management

Water is a crucial component of vegetable crop production. An adequate water supply is important to maximize both yield and quality of produce. It is also an important management tool for enhancing crop establishment, chemical weed control and harvesting of root vegetables. However, water has to be applied at the correct time in sufficient quantities with consolation for the environment as a whole. The water management of the pot culture system was done on the basis of volume of media combination for which plastic pots was used.

3.2.6 Fertilizer Management

The required recommended dose of fertilizer for each pot was given through irrigation on daily basis.

3.4 Biometric and yield observation of the crops under study

The biometric observations as a productivity variable of the leafy vegetable crop are very important quantitative characteristic of crop condition and are an effective parameter for forecasting yield capacity. Observations of the inputs to the pot culture unit in terms of growth and biometric parameters of the crop were recorded. The height of crop, number of leaves, stem girth, root length and yield of each crop were measured as shown in Plate 3.14.

3.4.1 Plant Height

The plant height was recorded with the help of a measuring scale. The plant height was measured from the surface of pot to the top of completely open leaf. Observations were taken at an interval of 15 days.

3.4.4 Stem Girth

The stem girth of Spinach at the base of stem was measured by using micrometer screw gauge. Observations were taken at an interval of 15 days.

3.4.5 Number of Leaves

On each randomly selected plant, number of leaves were counted and recorded at 15 days interval up to maturity stage

3.4.3 Root Length

The length from base of stem to the longest point on plant root was measured after harvesting. The root length was recorded with the help of a measuring scale.

3.4.6 Total Yield

The total yield of crops according to the treatment combinations applied was recorded.

Plate 3.14 Biometric observations of crop.

3.4.7 Statistical Analysis

Data collected was analyzed using Statistical Analysis System and analysis of Variance (ANOVA) is applied to test the significant differences among the treatment combinations. On each treatment, data from one randomly selected plants were used for statistical analysis. The mean standard error (SE+) and critical difference (CD) at 5 percent level of significance for each treatment and their interactions was worked out.

3.5 Cost of Production

The cost of production was worked out by calculating the seasonal fixed cost which comprises material cost of designed pot culture unit and total operating cost. The total operating cost includes variable cost which was paid out cost on hired human labour, seeds and interest on working capital.

3.5.1 Gross Monetary Returns

The gross monetary returns were calculated by considering the total production of the vegetables produced during experimentation.

3.5.2 Net Income

For designed pot culture unit, the net income was worked out by subtracting the cost of production from gross monetary returns.

3.5.3 Benefit Cost Ratio

The benefit: cost ratio was worked out using the equation as given below.

$$\text{B: C Ratio} = \frac{\text{Gross monetary returns}}{\text{Cost of production}} \quad \text{.. (3.6)}$$

CHAPTER IV
RESULTS AND DISCUSSION

This chapter deals with physio-chemical properties of commercially available media and its performance evaluation on vegetable production in pot culture. It also describes the material required for build-up of pot culture unit, its size and shape parameters. The chemical and physical properties of the media and their use are described neatly under this chapter. The performance evaluation of the designed hydroponic system was carried out at the Instructional farm of department of Irrigation and Drainage Engineering, College of Agricultural Engineering and Technology, Dr. Balasaheb Sawant Konkan Agricultural University, Dapoli and results of the study are presented in this chapter. The required data was collected, analyzed and the results are presented and interpreted in the suitable scientific manner. Results are discussed under the following sections of this chapter to fulfill the objectives of the present study**.**

4.1 Physio-chemical Properties of Media

4.1.1 Physical properties of media

The different physical properties of growing media the well suited root environment for the plant growth were determined. The results regarding physical properties such as bulk density, particle density, porosity, Wettability, air filled porosity and water holding capacity are presented in given section.

4.1.1.1 Bulk density of media

The average bulk density of individual media were determined and presented in Table 4.1, Fig 4.1 and in appendix I. From the data, it is revealed that the maximum average bulk density was observed to be of vermicompost i.e., (594.00 $kg.m^{-3}$) followed by cocopeat (207.17 $kg.m^{-3}$), perlite (167.0 $kg.m^{-3}$), vermiculite (548.00 $kg.m^{-3}$) media. The minimum density was observed to be of hydroton i.e., (166.42 $kg.m^{-3}$). In the high organic matter based media, as the bulk density increases (range of 0.3 to 0.9 $g.cm^{-3}$) the nutrient holding capacity also increases (Patil *et al.* 2020). The present study revealed that lower bulk density of hydroton gives less water and nutrient holding capacity while higher bulk density of vermicompost gives high water and nutrient holding capacity. Similar results for vermicompost were obtained by, Moon *et al*. 2019 and are with close agreement. The bulk density of media was determined and shown in Table 4.1.

Table 4.1 Bulk density of individual media

Media	**-Bulk density $kg.m^{-3}$**
Cocopeat	207.1
Vermicompost	594.0
Perlite	167.0

Vermiculite	548.0
Hydrotons	166.4

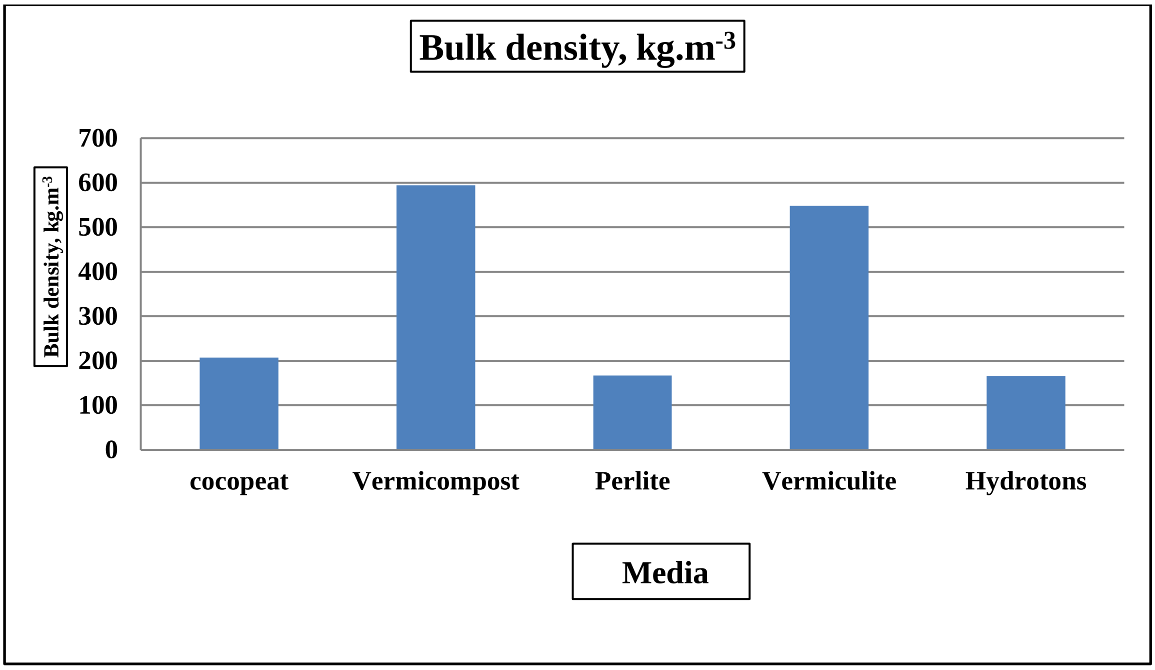

Fig 4.1Bulk density of individual media

4.1.1.2 Particle density of individual media

The particle density of individual media was determined and presented in Table 4.2, Fig. 4.2 and in appendix I. Table 4.2 and data interpretation in Fig. 4.2, it is observed that the particle density is ranging from 400 to 2000 kg.m^{-3}. The maximum particle density was observed to be of vermicompost (1600 kg.m^{3}) followed by cocopeat (440 kg.m^{-3}), perlite (1240 kg.m^{-3}), vermiculite (941 kg.m^{-3}) and hydrotons (480 kg.m^{-3}) media. It is found that the minimum particle density which indicates larger particle size along with less porosity, the minimum particle density was observed to be of cocopeat (440 kg.m^{-3}) and hydrotons (480 kg.m^{-3}).

Table 4.2 Particle density of individual media

Media	Particle density Kg.m^{-3}
Cocopeat	440
Vermicompost	1600
Perlite	600
Vermiculite	941
Hydrotons	480

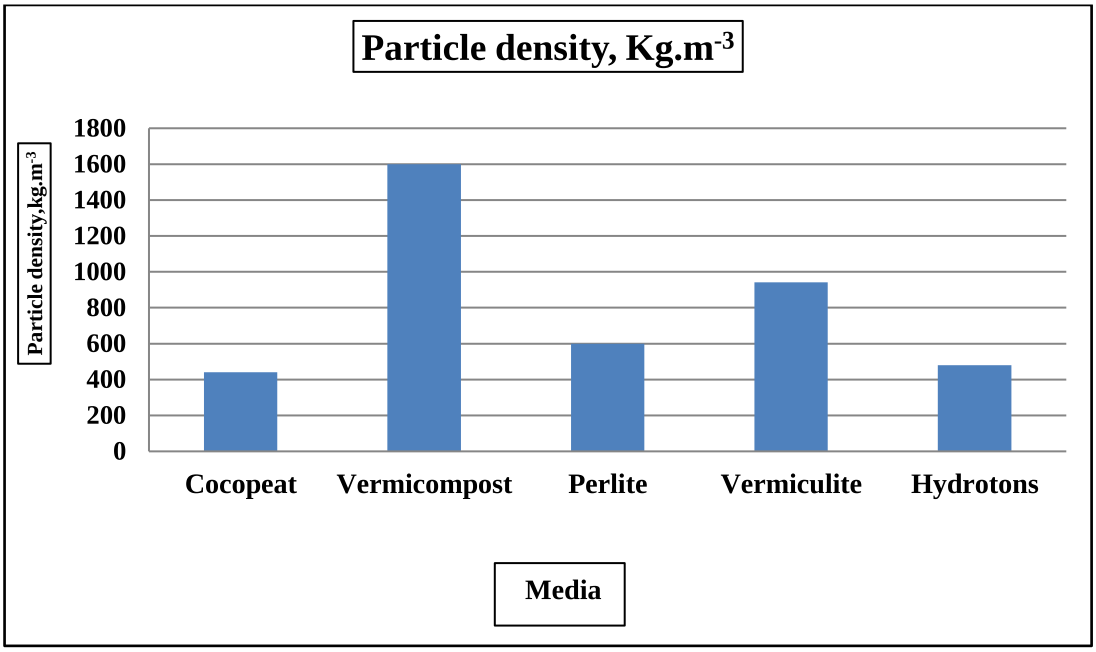

Fig 4.2 Particle density of individual media

4.1.1.3 Porosity of individual media

The porosity of media combinations was determined by adopting the standard procedure as described in section 3.2.4.1.3. The porosity of individual media was determined and presented in Table 4.3 and in Fig. 4.3. It is found that lower the bulk density and higher the particle density then porosity of media is found to be higher. In the present study maximum porosity was observed to be of media combination hydroton (78 %) which has bulk density and particle density (166.4 kg.m^{-3} and 480 kg.m^{-3}), followed by vermicompost (63%), cocopeat (53%), perlite (72.3%) and vermiculite (42%) media. The minimum Porosity was observed to be of vermiculite i.e, 27%, which has bulk density and particle density (548.0 kg.m^{-3} and 941 kg.m^{-3}).

Table 4.3 Porosity of individual media

Media	Porosity (%)
Cocopeat	53
Vermicompost	63
Perlite	73
Vermiculite	42
Hydroton	66

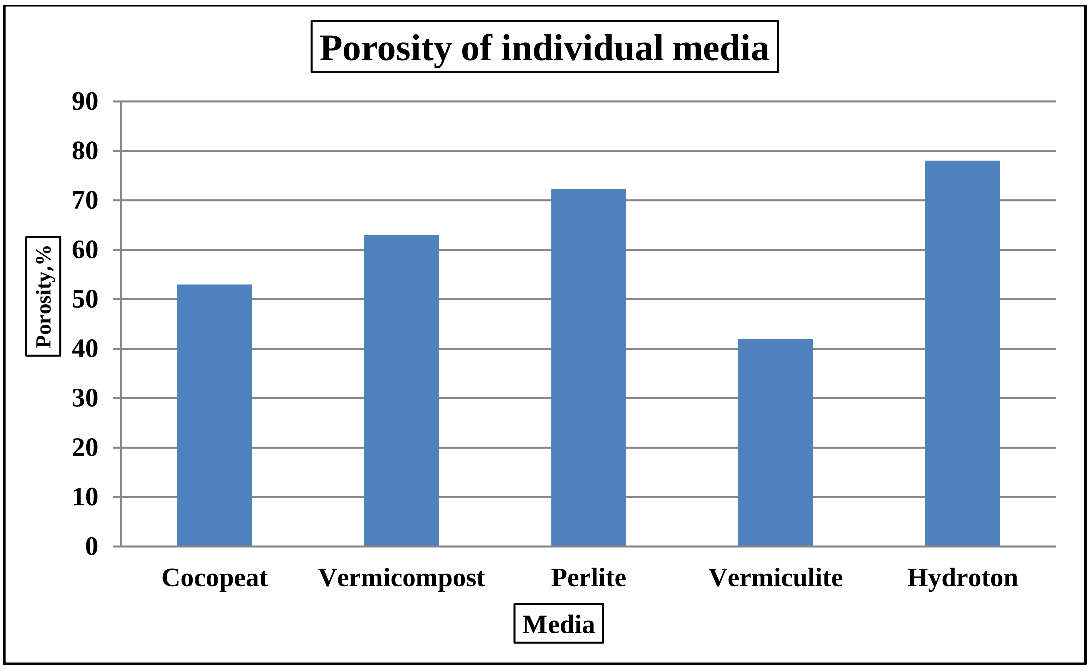

Fig 4.3 Porosity of individual media

4.1.1.4 Wettability of individual media

The wettability for cocopeat, vermicompost, perlite, vermiculite and hydroton were determined by adopting the standard procedure as described in section 3.2.4.1.4. The results of the study are presented in Table 4.4, Fig 4.4 and in appendix I. The wettability of the media differed remarkably and behaves differently over time of course as indicated by remarkable interaction between media and its duration of soaking. It is observed that highest cumulative water absorbing capacity after 6 hr. was occurred in hydroton (2720 ml) followed by cocopeat (1210 ml), perlite (2230 ml), vermiculite (1075 ml) and vermicompost (2355 ml). The rate of absorption of the all the media reduces as time passed from 0 to 6 hours. After 6 hours the rate of absorption discontinued to exist and media gets constant moisture content. Wettability has direct relation with bulk density and particle density. Awang *et al*. (2012) also found results in close agreement with the result of this study. In present study hydroton has lower bulk and particle density and have higher Wettability. Vermicompost has higher bulk and particle density and have lower Wettability. Similar results for vermicompost had been obtained by Patil *et al.* (2020).

Table 4.4 Wettability of individual media

Time hr.	Cocopeat		Vermicompost		Perlite	
	Quantity of water absorbed, ml	Cumulative water absorbed, ml	Quantity of water absorbed, ml	Cumulative water absorbed, ml	Quantity of water absorbed, ml	Cumulative water absorbed, ml
0	0	0	0	0	0	0
1	320	320	450	450	420	420
2	220	540	420	870	410	830

3	210	750	390	1260	400	400
4	180	930	370	1630	350	1580
5	150	1080	365	1995	340	1920
6	130	1210	360	2355	310	2230

Time hr.	**Vermiculite**		**Hydrotons**	
	Quantity of water absorbed, ml	**Cumulative water absorbed, ml**	**Quantity of water absorbed, ml**	**Cumulative water absorbed, ml**
0	0	0	0	0
1	200	200	510	510
2	195	395	490	1000
3	190	585	470	1470
4	180	765	460	1930
5	160	925	400	2330
6	150	1075	390	2720

4.1.4.1 Wettability and Moisture content

The observations on wettability and moisture contents of the material used for media were recorded by assuming the standard method as described in section 3.2.4.1.4 and presented in Table 4.4 and Fig 4.4. It is revealed from Table 4.4 and Fig 4.4 that the moisture content increases speedily from first 0 to l and 1 to 2 hours in all media due to higher absorption. The moisture content increases fairly during 2-3 and 3-4 hours due to reduced water absorption rate. The percent increase in the moisture content at 0-0, 0-1, 1-2, 2-3, and 3-4 hours after soaking was found to be for cocopeat 0, 26.9,28.2, 29.1, 32.8, 33.1and 34.0 then for vermicompost 0, 11.2, 22.0, 26.6,27.5, 30.2 and 31.7 then for perlite 0, 13.9, 21.3,26.2,30.5, 34.6 and 39.4 then for vermiculite 0, 38.0, 38.3, 44.0,44.4, 47.0 and48.0 and for hydroton 0, 16.8,22.0,22.2,32.1, 34.6 and 39.8 percent respectively. The cocopeat, vermicompost, perlite, vermiculite and hydroton media samples acquired nearly constant moisture content after 5 hours indicating the absorption is either end to exist or recompense the evaporation losses. The maximum cumulative moisture content after 6 hours was found to be in vermiculite (48.0%) followed by cocopeat (34.0%), perlite (39.4), vermicompost (31.7) and hydroton (39.8) and minimum was found in the vermicompost (31.7%). The moisture content was found nearly stable after 5 hours after soaking of the media.

Table 4.5 Wettability and Moisture content

Time hr	**Cocopeat**	**Vermicompost**	**Perlite**	**Vermiculite**	**Hydrotons**

0-0	27.0	11.2	13.9	38.0	16.8
0-1	28.2	22.0	21.3	38.3	22.0
1-2	29.1	26.6	26.2	44.0	22.2
2-3	32.8	27.5	30.5	44.4	32.1
3-4	33.1	30.2	34.6	47.0	34.6
4-5	34.0	31.7	39.4	48.0	39.8
5-6	34.0	31.7	39.4	48.0	39.8

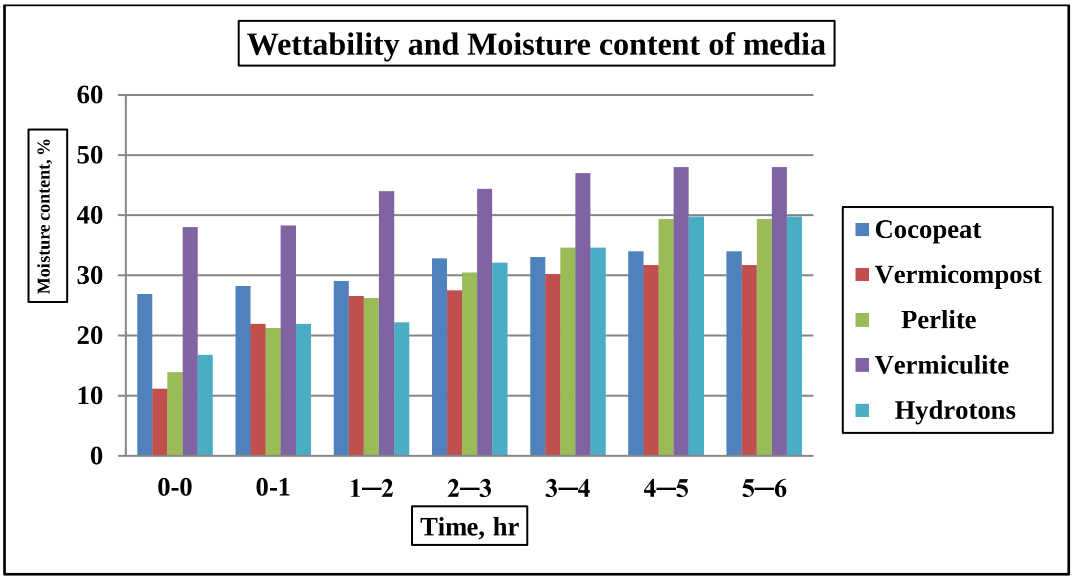

Fig 4.4 Wettability and Moisture content of individual media

4.4.6 Water holding capacity

The water holding capacity for cocopeat, vermicompost, perlite, vermiculite and hydroton were determined by adopting the standard procedure as described in the section 3.2.4.1.5 of chapter 3. The observations were recorded and presented in Table 4.7, Fig 4.6 and in appendix I. From the Table 4.7, it is observed that water-holding capacity is the amount of water remaining after water stops draining following saturation. The Maximum WHC (water holding capacity) was found in vermicompost (731%) followed by perlite (121 %), cocopeat (387%), vermiculite (109%) and minimum were found in hydroton (43%). Cocopeat is known for its high water holding capacity while vermicompost due to its smaller particle size have large number of microspores which will raise its water holding capacity. The volume of water that saturates a given volume of substrate is known as its effective pore space (EPS) or air volume. Large pores generally favour rapid drainage and adequate aeration for plants, while water is mainly held in small pores. Therefore, adequate pore size and distribution are critical for a good medium. However, other factors also have an impact. The pore size distribution of a growing medium is not only influenced by substrate type, but also by particle size, substrate compression ,container size and height, volume loss during a growth cycle, and plant growth and root development.(Gruda and Schnitzler, 2004).

Table 4.6 Water holding capacity of individual media

Media	Water holding capacity (%)
Cocopeat	387
Vermicompost	731
Perlite	121
Vermiculite	109
Hydroton	43

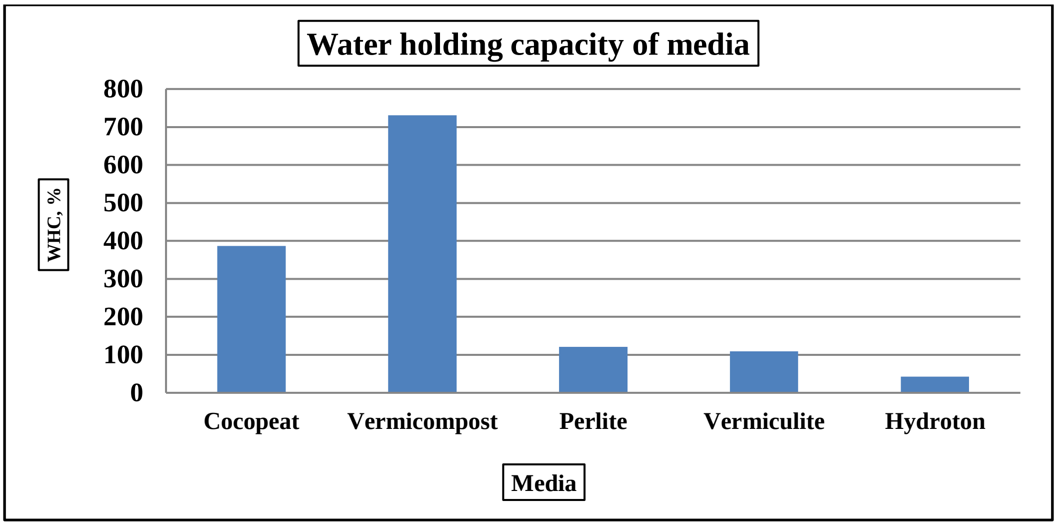

Fig 4.5 Water holding capacity of individual media

4.1.5 Air Filled Porosity

The air filled porosity (AFP) for cocopeat, vermicompost, perlite, vermiculite and hydroton were determined by adopting the standard procedure as described in section 3.2.4.1.6. The observations were recorded and presented in Table 4.8 and Fig 4.7. From Table 4.8, it is revealed that the moisture content on the basis of AFP status of the cocopeat, vermicompost, perlite, vermiculite and hydrton was determined by soaking the media for saturation of 12 h. The observation of the moisture replaced by the air was started by opening the drain valve to allow removal of excess water. The moisture content on the basis of AFP of the media sample was determined after water drainage stop. The media was subjected to moisture removal at 8.30 am when moisture content was 100 % (saturated), the moisture content on the basis of AFP was 0 for all media. After draining of water was stopped the maximum moisture content found in vermiculite media (23.9%). Respectively, moisture content of media on the basis of AFP as follows cocopeat (23.22%), vermicompost (22.33%), perlite (14.82%) and hydroton (5.4).

Table 4.7 Moisture content of media on the basis of AFP

Media	Moisture content (%)
Cocopeat	23.22
Vermicompost	22.33

Perlite	14.82
Vermiculite	23.9
Hydrotons	5.4

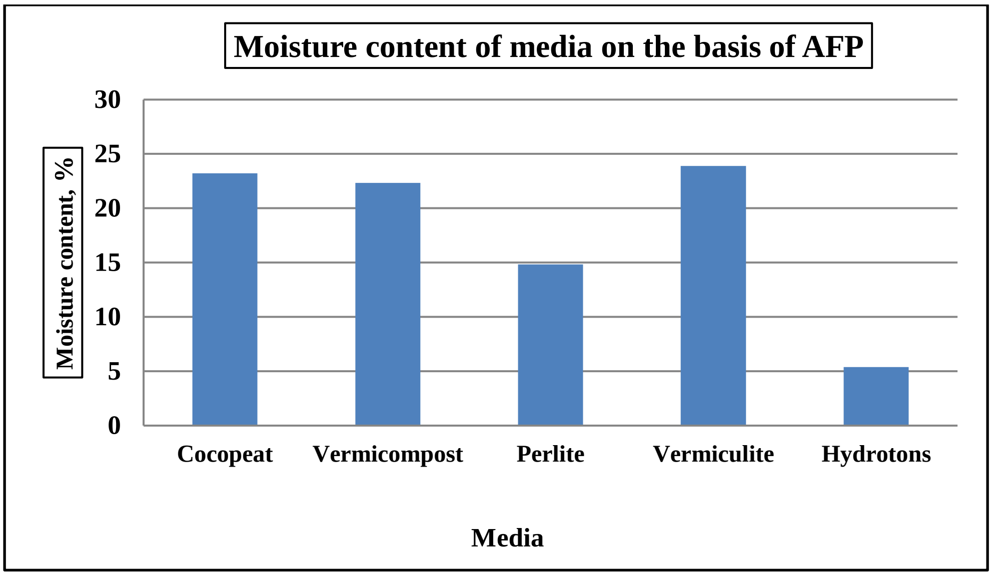

Fig 4.6 Moisture content of media on the basis of AFP

4.2 Chemical properties of media

Chemical properties of media include electrical conductivity and pH of the different media combinations with respect to the different crops to be sown are as follows.

4.2.1 Electrical conductivity of individual media

The electrical conductivity was measured by the electrical conductivity meter as discussed in section 3.2.4.2.1 and presented as given below.

4.2.1.1 Spinach

The values of electrical conductivity of different media used for spinach crop are shown in Table 4.8 and Fig. 4.7. The electrical conductivity of media before washing is higher in cocopeat (1.44 dS/m) followed by vermicompost (1.09 dS/m), perlite (0.36 dS/m), hydroton (0.93 dS/m) and minimum in vermiculite (0.12 dS/m). Then the electrical conductivity of media after washing is higher in cocopeat (0.79 dS/m) as compared to vermicompost (0.65 dS/m), perlite (0.21 dS/m), hydroton (0.52 dS/m) and minimum in vermiculite (0.10 dS/m). After washing, electrical conductivity of all media was decreased. The spinach crop was planted in the media on 15th January 2023. Water soluble fertilizer 19:19:19 (N: P: K) was applied after 10 days of planting at 2g/ lit. of water through the water spray. The entire crop was harvested on 1st March 2023. After harvesting of the crop the electrical conductivity of the media was measured. Due to the application of fertilizer the electrical conductivity was found to be increased in all media. Then the electrical conductivity of media after harvesting is higher in hydroton (1.46 dS/m) followed by cocopeat (1.07 dS/m), vermicompost (1.02 dS/m), perlite (0.66 dS/m), and minimum in vermiculite (0.19 dS/m).

Table 4.8 EC of media for Spinach

Media	Before washing dS/m	After washing dS/m	After harvesting dS/m
Cocopeat	1.44	0.79	1.07
Vermicompost	1.09	0.65	1.02
Perlite	0.36	0.21	0.66
Vermiculite	0.12	0.10	0.19
Hydroton	0.93	0.52	1.46

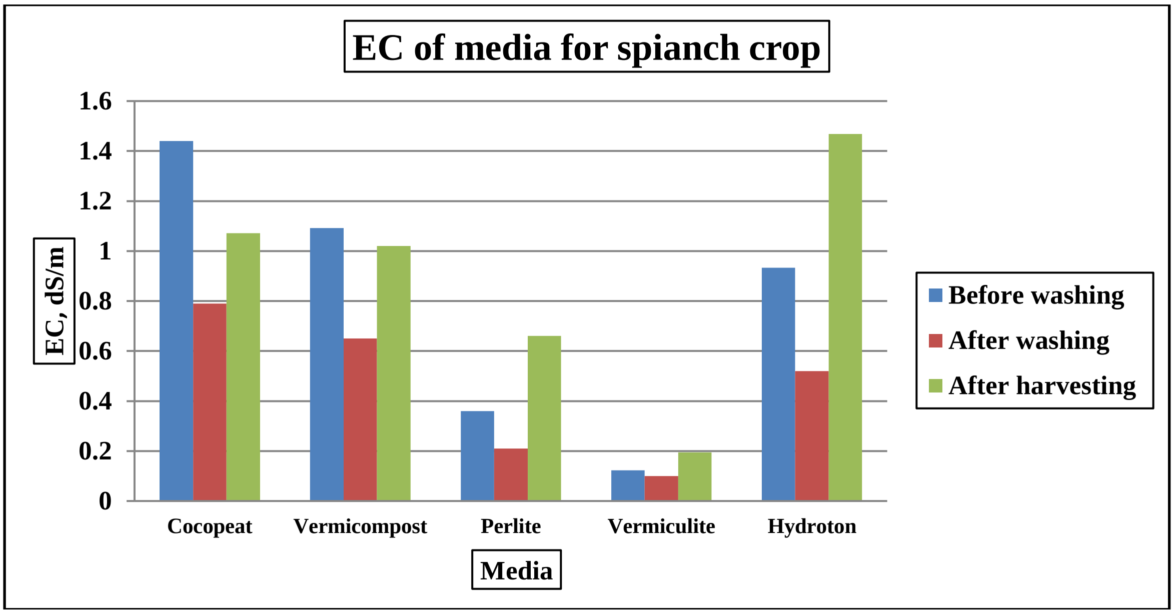

Fig 4.7 EC of media for Spinach crop

4.2.1.2 Fenugreek

The values of electrical conductivity of different media used for fenugreek crop are shown in Table 4.9 and Fig. 4.8. The electrical conductivity of media before washing is higher in cocopeat (1.44 dS/m) followed by vermicompost (1.09 dS/m), perlite (0.36 dS/m), hydroton (0.93 dS/m) and minimum in vermiculite (0.12 dS/m). whereas the electrical conductivity of media after washing is higher in cocopeat (0.79 dS/m) as compared to vermicompost (0.65 dS/m), perlite (0.21 dS/m), hydroton (0.52 dS/m) and minimum in vermiculite (0.10 dS/m). After washing, electrical conductivity of all media was decreased. The fenugreek crop was planted in the media on 15th January 2023. Water soluble fertilizer 19:19:19 (N: P: K) were applied after 10 days of planting at 2g /lit. of water through the water spray. The entire crop was harvested on 2nd March 2023. After harvesting of the crop the electrical conductivity of the media was measured. Due to the application of fertilizer the electrical conductivity was found to increase in all media. whereas the electrical conductivity of media after harvesting is higher in hydroton (1.86 dS/m) followed by cocopeat (0.98 dS/m), vermicompost (1.04 dS/m), perlite (0.34 dS/m), and minimum in vermiculite (0.14 dS/m).

Table 4.9 EC of media for Fenugreek crop

Media	Before washing dS/m	After washing dS/m	After harvesting dS/m
Cocopeat	1.44	0.79	0.98
Vermicompost	1.09	0.65	1.04
Perlite	0.36	0.21	0.34
Vermiculite	0.12	0.10	0.14
Hydroton	0.93	0.52	1.86

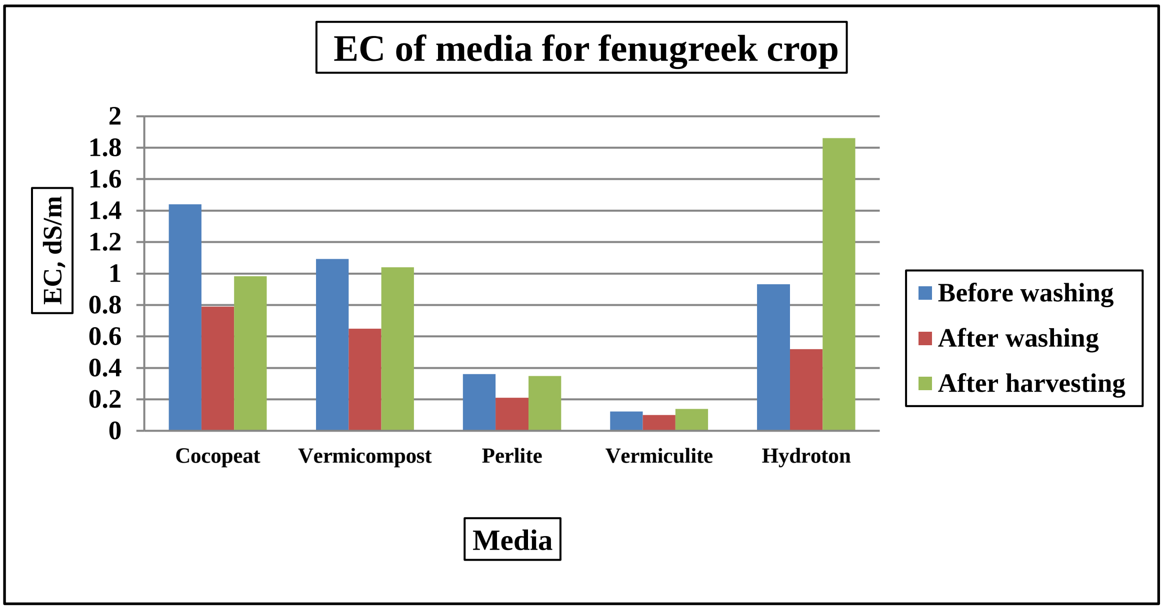

Fig. 4.8 EC of media for Fenugreek crop

4.2.1.3 Amaranthus

The values of electrical conductivity of different media used for amaranthus crop are shown in Table 4.10 and Fig. 4.9. The electrical conductivity of media before washing is higher in cocopeat (1.44 dS/m) as compared to vermicompost (1.09 dS/m), perlite (0.36 dS/m), hydroton (0.93 dS/m) and minimum in vermiculite (0.12 dS/m). Then the electrical conductivity of media after washing is higher in cocopeat (0.79 dS/m) followed by vermicompost (0.65 dS/m), perlite (0.21 dS/m), hydroton (0.52 dS/m) and minimum in vermiculite (0.10 dS/m). After washing, electrical conductivity of all media was decreased. The amaranthus crop was planted in the media on15th January 2023. Water soluble fertilizer 19:19:19 (N: P: K) was applied after 10 days of planting at 2g/ lit. of water through the water spray. The entire crop was harvested on 3rd March 2023. After harvesting of the crop the electrical conductivity of the media was measured. Due to the application of fertilizer the electrical conductivity was found to be enhanced in all media. Then the electrical conductivity of media after harvesting is higher in hydroton (3.12 dS/m) followed by cocopeat (0.89 dS/m), vermicompost (1.20 dS/m), perlite (0.34 dS/m), and minimum in vermiculite (0.19 dS/m).

Table 4.10 EC of media for Amaranthus

Media	Before washing dS/m	After washing dS/m	After harvesting dS/m
Cocopeat	1.44	0.79	0.89
Vermicompost	1.09	0.65	1.20
Perlite	0.36	0.21	0.34
Vermiculite	0.12	0.10	0.19
Hydroton	0.93	0.52	3.13

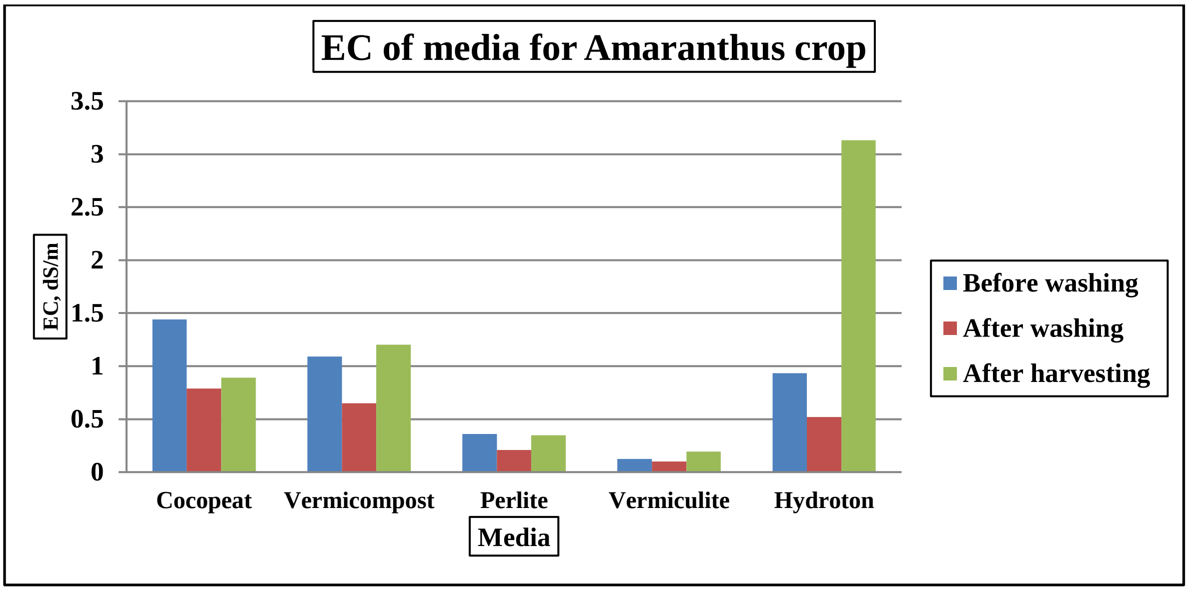

Fig. 4.9 EC of media for Amaranthus

4.2.2 pH of individual media

The values of the pH of the different media were worked out as per the procedure given in 3.2.4.2.2 section and presented as given below.

4.2.2.1 Spinach

The values of pH of different media for the spinach crop are shown in Table 4.11 and in Fig 4.10. The pH of vermiculite is higher than other media (7.2) followed by cocopeat (6.5), vermicompost (6.1), perlite (6.5) and hydrotons (5.8). All the media were washed by normal tap water to maintain the favourable range of pH for proper plant growth. After washing, pH of cocopeat, vermicompost, perlite and hydroton has increased and pH of vermiculite media has decreased. The spinach crop was planted in the media on 15th January 2023. Water soluble fertilizer 19:19: 19 (N: P: K) was applied after 10 days of planting at 2g/litre of water through the water spray. The entire crop was harvested on 1st March 2023. After the harvesting of the crop, the pH of the media was measured. Due to the application of fertilizer the pH was found to be decreased in all media combinations. The minimum pH was found in cocopeat (6.2).

Table 4.11 pH of media for spinach

Media	Before washing	After washing	After harvesting
Cocopeat	6.5	6.7	6.2
Vermicompost	6.1	6.2	6.4
Perlite	6.5	6.7	6.7
Vermiculite	7.2	6.9	6.6
Hydroton	5.8	6.1	6.0

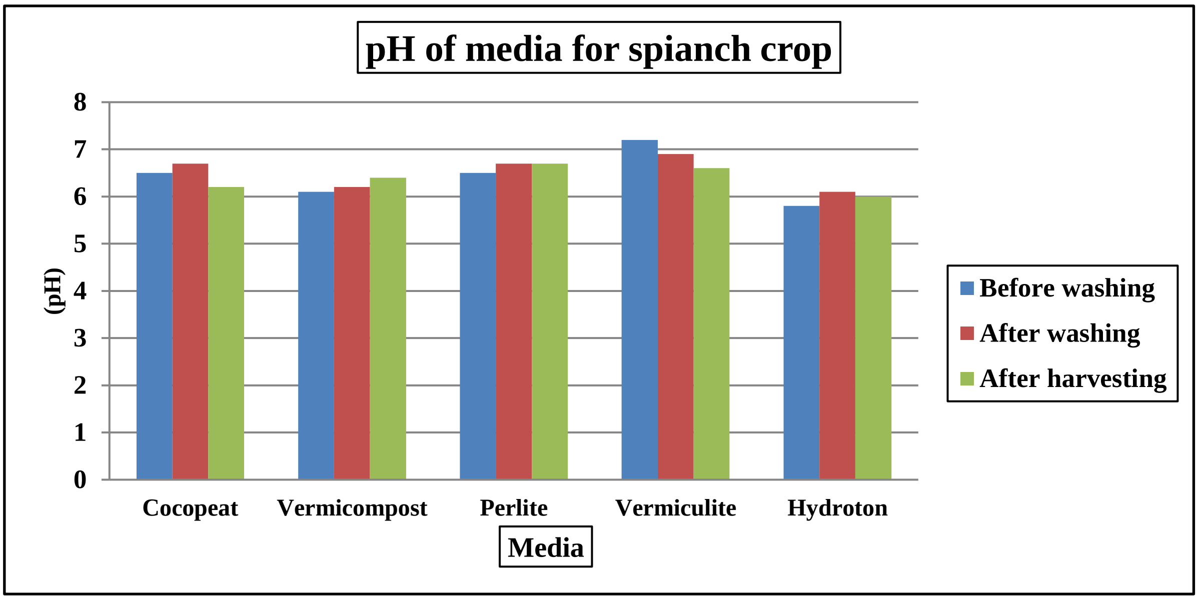

Fig. 4.10 pH of media for Spinach

4.2.2.2 Fenugreek

The values of pH of different media for the fenugreek crop are shown in Table 4.12 and in Fig 4.11. Before washing the pH of vermiculite is higher than other media (7.2) followed by cocopeat (6.5), vermicompost (6.1), perlite (6.5) and hydrotons (5.8). All the media were washed by normal tap water to maintain the favourable range of pH for proper plant growth. After washing, pH of cocopeat, vermicompost, perlite and hydroton has increased and pH of vermiculite media has decreased. The fenugreek crop was planted in the media on 15th January 2023. Water soluble fertilizer 19:19: 19 (N: P: K) was applied after 10 days of planting at 2g/lit. of water through the water spray. The entire crop was harvested on 2nd March 2023. After the harvesting of the crop, the pH of the media was measured. Due to the application of fertilizer the pH was found to be decreased in all media combinations. The minimum pH was found in cocopeat (5.3).

Table 4.12 pH of media for fenugreek

Media	Before washing	After washing	After harvesting
Cocopeat	6.5	6.7	5.3
Vermicompost	6.1	6.2	6.3

Perlite	6.5	6.7	6.4
Vermiculite	7.2	6.9	6.8
Hydroton	5.8	6.0	5.9

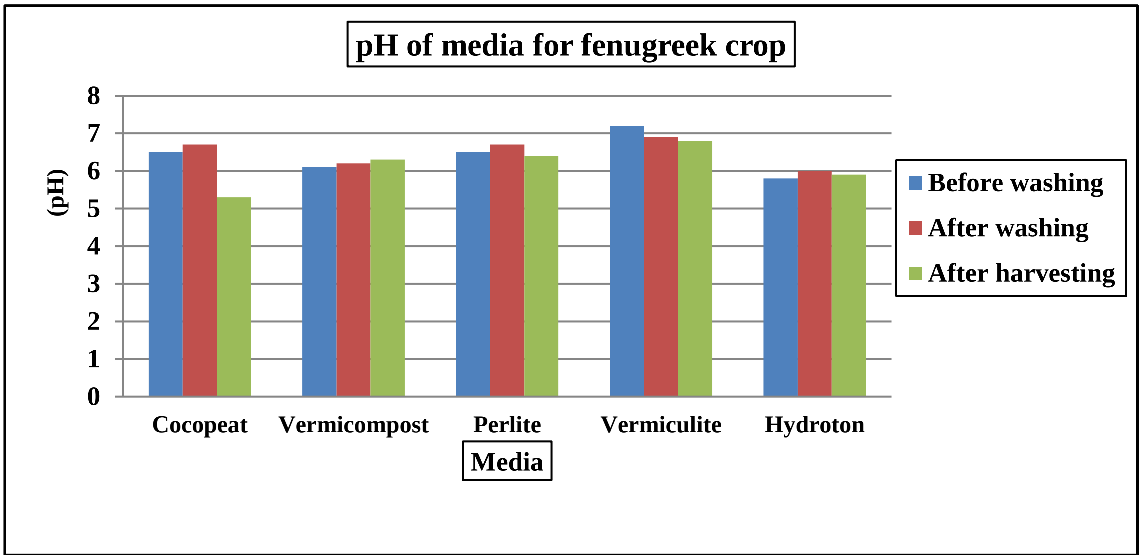

Fig. 4.11 pH of media for Fenugreek

4.2.2.2 Amaranthus

The values of pH of different media for the amaranthus crop are shown in Table 4.13 and in Fig 4.12. Before washing the pH of vermiculite is higher than other media (7.2) followed by cocopeat (6.5), vermicompost (6.1), perlite (6.5) and hydrotons (5.8). All the media were washed by normal tap water to maintain the favourable range of pH for proper plant growth. After washing, pH of cocopeat, vermicompost, perlite and hydroton has increased and pH of vermiculite media has decreased. The amaranthus crop was planted in the media on 15th January 2023. Water soluble fertilizer 19:19: 19 (N: P: K) was applied after 10 days of planting at 2g/lit.of water through the water spray. The entire crop was harvested on 3rd March 2023. After the harvesting of the crop, the pH of the media was measured. Due to the application of fertilizer the pH was found to be decreased in all media combinations. The minimum pH was found in perlite (5.8).

Table 4.13 pH of media for amaranthus

Media	Before washing	After washing	After harvesting
Cocopeat	6.5	6.7	6.4
Vermicompost	6.1	6.2	6.1
Perlite	6.5	6.7	5.8
Vermiculite	7.2	6.9	6.8

Hydroton	5.8	6.1	5.9

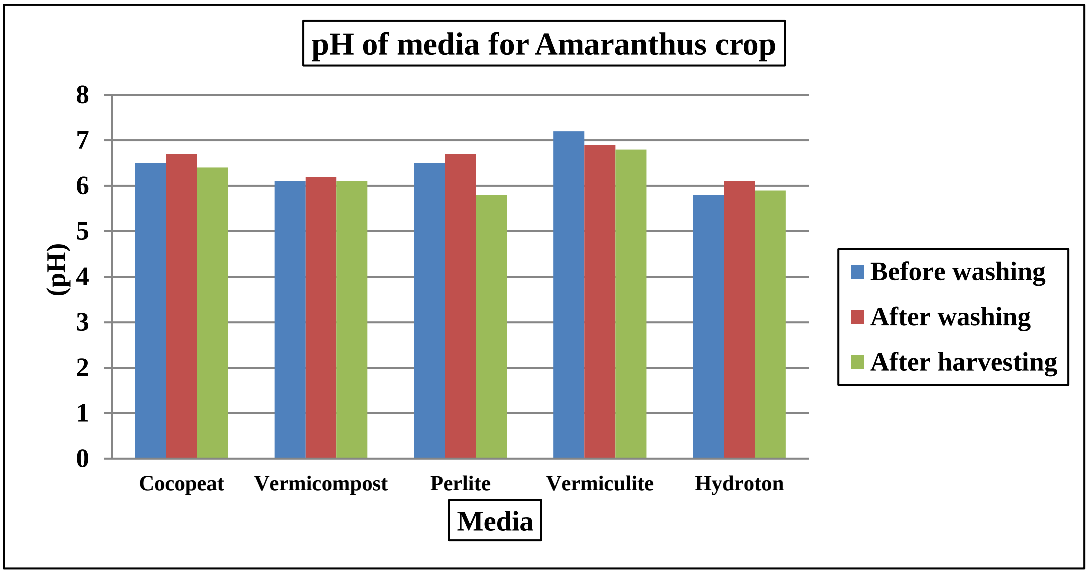

Fig. 4.12 pH of media for Amaranthus

4.2 Performance evaluation of different media on vegetable production.

4.2.1 Vegetative Parameters

Observation of the inputs to the pot culture unit in terms of water and media on the growth and biometric parameters of each crop was recorded. The stem girth, height of crop, number of leaves, root height and yield of each crop were measured. The observations of vegetative parameters are as follows.

4.2.1.1 Spinach

4.2.1.1.1 Stem height

The stem height of plants in every media was recorded for spinach crop. The Table 4.14, Fig. 4.13 and appendix II show the stem height of spinach crop in experimental unit. In 20 pots of media, seeds of spinach were sown randomly. The observations of stem height of spinach crop were recorded for 10-15 seeds sown in 0.154 m^2 area in each pot. Four replications from each treatment were recorded on the 15 days interval till the harvesting. The maximum stem girth of 15 days and 30 days interval was observed in treatment T2R2 which has a vermicompost media. The minimum stem height of spinach crop was recorded in treatment T5R3 which has hydroton media. The maximum stem height of 45 days interval was observed in a vermicompost media (T2R4) and minimum stem height of spinach crop was recorded in hydroton media (T5R3). From Table 4.14, Maximum stem height of spinach crop was observed in vermicompost media as compared to the other media at the time of harvesting. It was found from statistical analysis, more significant result for stem height obtained from T1, T2, T3 and T4 treatment in 15days, 30 days and 45 days interval.

Table 4.14 Stem height (cm)

Treatment	15 DAS	30 DAS	45 DAS
T1R1	1.5	3	5
T1R2	2.5	2.5	3
T1R3	1	3.5	4
T1R4	1.6	4	6
T2R1	1.5	5	16
T2R2	3	7	14
T2R3	1	6	15
T2R4	1.6	5.5	18
T3R1	0.8	3	5
T3R2	0.9	4	6
T3R3	0.8	2.5	4
T3R4	0.9	3.5	4
T4R1	2.5	4.5	6
T4R2	2.4	6	6
T4R3	2.3	5	6
T4R4	2.5	5.5	6.5
T5R1	0	0	0
T5R2	0	0	0
T5R3	0.7	2	2
T5R4	0	0	0
SE	0.3	0.5	0.8
CD	0.7	1.1	1.8

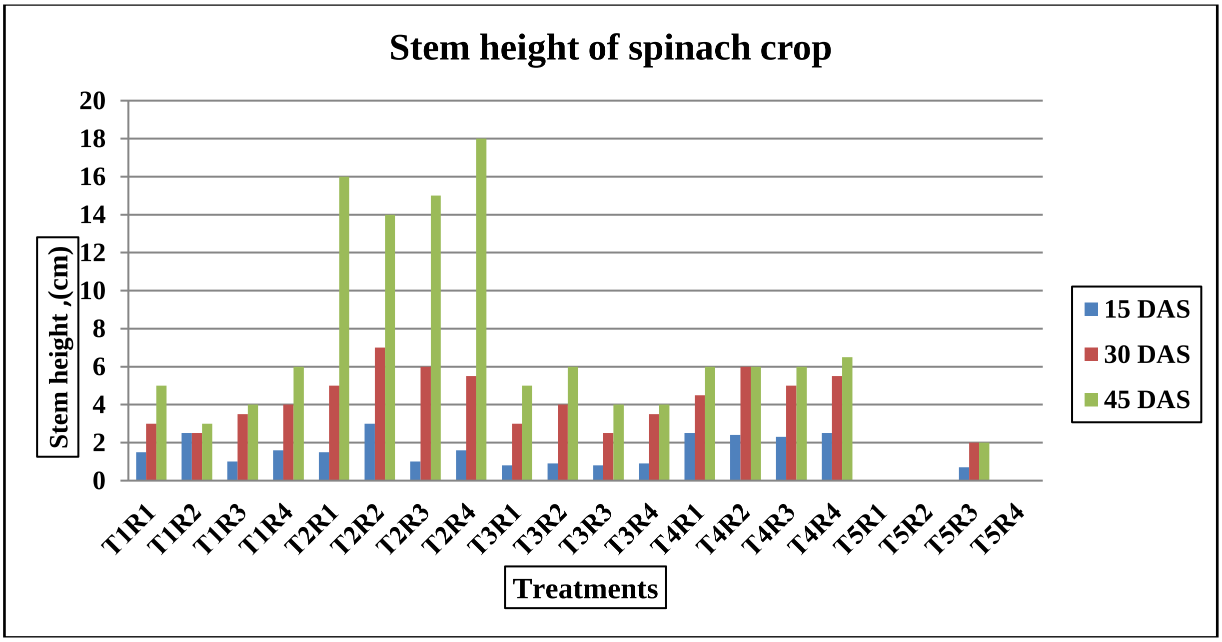

Fig. 4.13 Stem height of Spinach crop

4.2.1.1.2 Stem girth

The stem girth of plants in every media was recorded for spinach crop. The Table 4.15, Fig

4.14 and appendix II show the stem girth of spinach crop in experimental unit. In five media seeds of spinach were sown randomly. The observations of stem girth of spinach crop were recorded for 10-15 seeds sown in 0.154 m^2 area in each pot. Four replications from each treatment were recorded on the 15 days interval till the harvesting. The maximum stem girth of 15 days interval was observed in treatment T2R1 which has a vermicompost media. The minimum stem girth of spinach crop was recorded in treatment T5R3 which has hydroton media. The maximum stem girth of 30 days interval was observed in treatment T2R2 which has a vermicompost media. The minimum stem girth of spinach crop was recorded in treatment T5R3 which has hydroton media. The maximum stem girth of 45 days interval was observed in a vermicompost media and minimum stem girth of spinach crop was recorded in hydroton media. From Table 4.15, Maximum stem girth of spinach crop was observed in vermicompost media as compared to the other media at the time of harvesting. It was found from statistical analysis, none significant result obtained for stem girth in 15days, 30 days and 45 days interval.

Table 4.15 Stem girth (cm)

Treatment	15 DAS	30 DAS	45 DAS
T1R1	0.1	0.3	0.4
T1R2	0.2	0.2	0.4
T1R3	0.1	0.2	0.3
T1R4	0.1	0.4	0.4
T2R1	0.3	0.5	0.7
T2R2	0.2	0.6	0.6
T2R3	0.1	0.4	0.7
T2R4	0.2	0.5	0.7
T3R1	0.09	0.3	0.3
T3R2	0.1	0.2	0.3
T3R3	0.1	0.3	0.4
T3R4	0.09	0.3	0.4
T4R1	0.1	0.3	0.4
T4R2	0.1	0.4	0.4
T4R3	0.1	0.5	0.6
T4R4	0.1	0.3	0.4
T5R1	0	0	0
T5R2	0	0	0
T5R3	0.07	0.09	0.09
T5R4	0	0	0
SE	0.1	0.3	0.3
CD	0.4	0.6	0.6

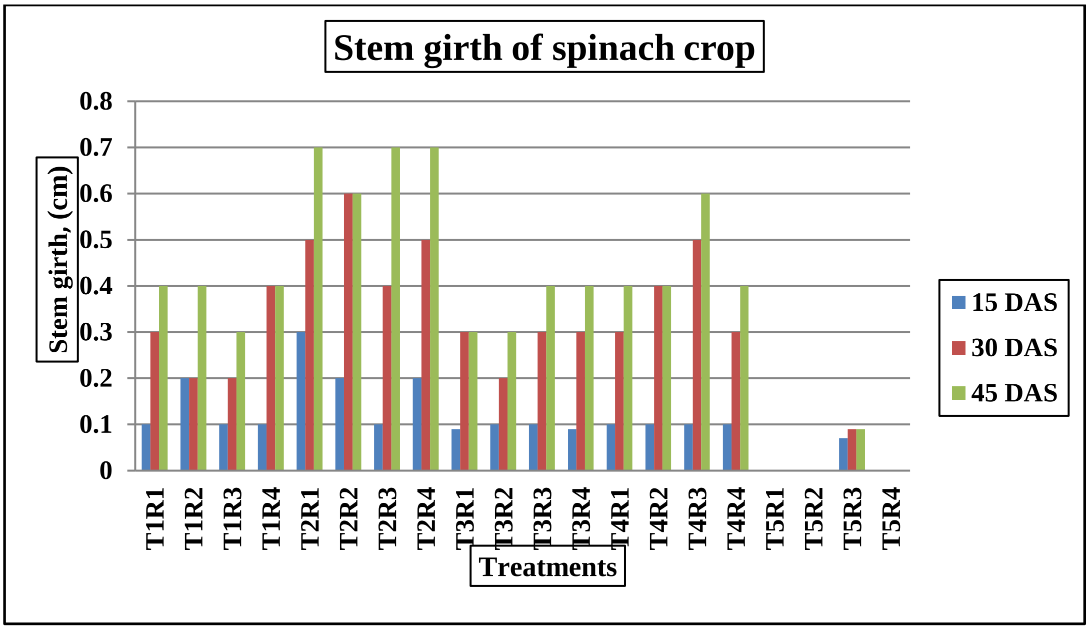

Fig. 4.14 Stem girth of Spinach crop

4.2.1.1.3 Number of leaves

The number of leaves of plants in every media was recorded for spinach crop. The Table 4.16, Fig 4.15 and appendix II show the number of leaves of spinach crop in experimental unit. In five media seeds of spinach were sown randomly. The observations of number of leaves of spinach crop were recorded for 10-15 seeds sown in 0.154 m^2 area in each pot. Four replications from each treatment were recorded on the 15 days interval till the harvesting. The maximum number of leaves of 15 days interval was observed in treatment T2R2 which has a vermicompost media. The minimum number of leaves of spinach crop was recorded in treatment T5R3 which has hydroton media. The maximum number of leaves of 30 days and 45 days interval was observed in treatment T2R4 which has a vermicompost media. The minimum number of leaves of spinach crop was recorded in treatment T5R3 which has hydroton media. From Table 4.16, Maximum number of leaves of spinach crop was observed in vermicompost media as compared to the other media at the time of harvesting. It was found from statistical analysis, more significant result for number of leaves obtained from T1, T2, T3 and T4 treatment in 15days, 30 days and 45 days interval. None significant result for number of leaves obtained from T5 treatment for R1, R2, R4 replications.

Table 4.16 Number of leaves

Treatment	15 DAS	30 DAS	45 DAS
T1R1	2	4	5
T1R2	3	4	6
T1R3	2	5	5

T1R4	2	4	6
T2R1	3	7	7
T2R2	4	6	6
T2R3	3	7	6
T2R4	2	8	8
T3R1	2	4	6
T3R2	2	3	5
T3R3	3	4	5
T3R4	2	4	6
T4R1	2	5	7
T4R2	2	4	5
T4R3	2	5	5
T4R4	2	6	7
T5R1	0	0	0
T5R2	0	0	0
T5R3	2	2	3
T5R4	0	0	0
SE	0.4	0.4	0.7
CD	0.9	0.9	1.7

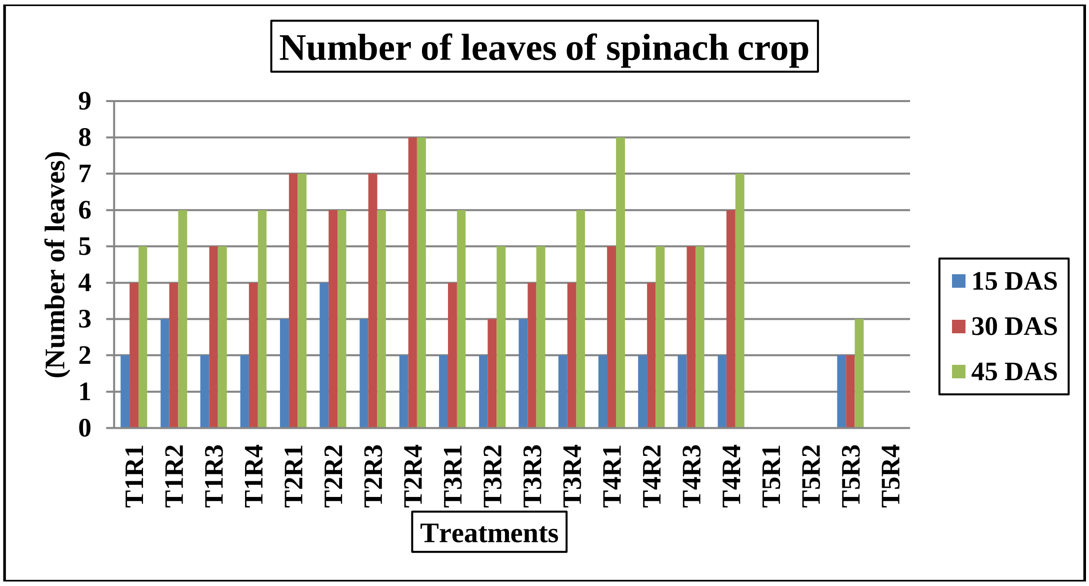

Fig. 4.15 Number of leaves of Spinach crop

4.2.1.2 Fenugreek

4.2.1.2.1 Stem height

The stem height of plants in every media was recorded for fenugreek crop. The Table 4.17, Fig 4.16 and appendix II show the stem height of fenugreek crop in experimental unit. In five media seeds of fenugreek were sown randomly. The observations of stem height of fenugreek crop were recorded for 10-15 seeds sown in 0.154 m^2 area in each pot. Four replications from each treatment were recorded on the 15 days interval till the harvesting. The maximum stem girth of 15 days and 30 days interval was observed in treatment T2R2 which has a vermicompost media. The minimum stem height of fenugreek crop was recorded in treatment T5R3 which has hydroton media. The maximum stem height of 45 days interval was observed in a vermicompost media (T2R4) and minimum stem height of fenugreek crop was recorded in hydroton media (T5R3). From Table 4.17, Maximum stem height of fenugreek crop was observed in vermicompost media as compared to the other media at the time of harvesting. It was found from statistical analysis, more significant result for stem height obtained from T1, T2, T3 and T4 treatment in 15days, 30 days and 45 days interval. None significant result for stem height obtained from T5 treatment for R4 replication.

Table 4.17 Stem height (cm)

Treatment	15 DAS	30 DAS	45 DAS
T1R1	1.5	4	9
T1R2	2.5	5	10
T1R3	1.2	3	11
T1R4	2	4	10
T2R1	1.5	4	13.5
T2R2	1.8	4.5	11.5
T2R3	1.2	3	9
T2R4	2.5	4.5	6
T3R1	1	5	20
T3R2	1	5.5	17
T3R3	1	4	17.5
T3R4	2	4.8	14
T4R1	2	4.5	8
T4R2	1.8	6	8
T4R3	2	5	9
T4R4	2	4	8.5
T5R1	0.6	1.5	3
T5R2	0.7	2	4
T5R3	0.7	1.3	3
T5R4	0	0	0
SE	0.3	0.3	1.2
CD	0.6	0.8	2.6

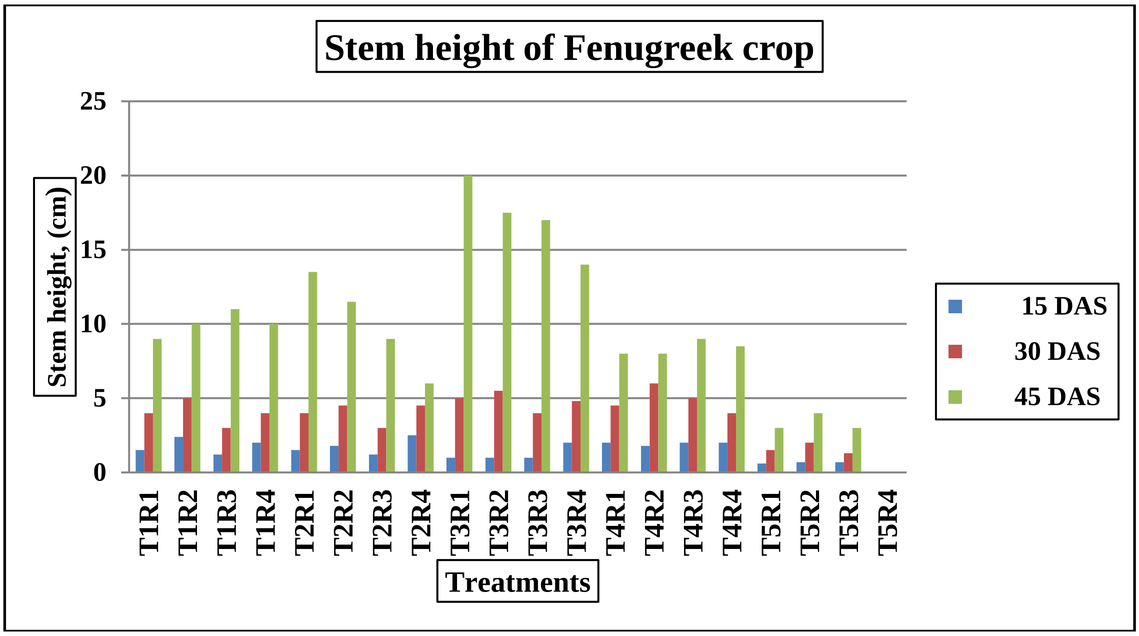

Fig. 4.16 Stem height of Fenugreek crop

4.2.1.2.2 Stem girth

The stem girth of plants in every media was recorded for fenugreek crop. The Table 4.18, Fig 4.17 and appendix II show the stem girth of fenugreek crop in experimental unit. In five media seeds of fenugreek were sown randomly. The observations of stem girth of fenugreek crop were recorded for 10-15 seeds sown in 0.154 m^2 area in each pot. Four replications from each treatment were recorded on the 15 days interval till the harvesting. The maximum stem girth of 15 days interval was observed in treatment T2R1 which has a vermicompost media. The minimum stem girth of fenugreek crop was recorded in treatment T5R3 which has hydroton media. The maximum stem girth of 30 days interval was observed in treatment T2R2 which has a vermicompost media. The minimum stem girth of fenugreek crop was recorded in treatment T5R3 which has hydroton media. The maximum stem girth of 45 days interval was observed in a vermicompost media and minimum stem girth of fenugreek crop was recorded in hydroton media. From Table 4.18, Maximum stem girth of fenugreek crop was observed in vermicompost media as compared to the other media at the time of harvesting. It was found from statistical analysis, more significant result for stem girth obtained from T1, T2, T3 and T4 treatment in 15days, 30 days and 45 days interval. None significant result for stem girth obtained from T5 treatment for all replication.

Table 4.18 Stem girth (cm)

Treatment	15 DAS	30 DAS	45 DAS
T1R1	0.3	0.4	0.4
T1R2	0.2	0.3	0.3
T1R3	0.2	0.3	0.3
T1R4	0.3	0.4	0.4
T2R1	0.3	0.4	0.4
T2R2	0.3	0.5	0.6
T2R3	0.2	0.3	0.3
T2R4	0.3	0.4	0.4
T3R1	0.2	0.3	0.4
T3R2	0.1	0.4	0.6
T3R3	0.1	0.3	0.4
T3R4	0.1	0.2	0.2
T4R1	0.1	0.3	0.3
T4R2	0.1	0.3	0.5
T4R3	0.1	0.2	0.3
T4R4	0.1	0.3	0.4
T5R1	0.02	0.05	0.3
T5R2	0.03	0.07	0.2
T5R3	0.05	0.06	0.3
T5R4	0	0	0
SE	0.02	0.04	0.06
CD	0.06	0.09	0.1

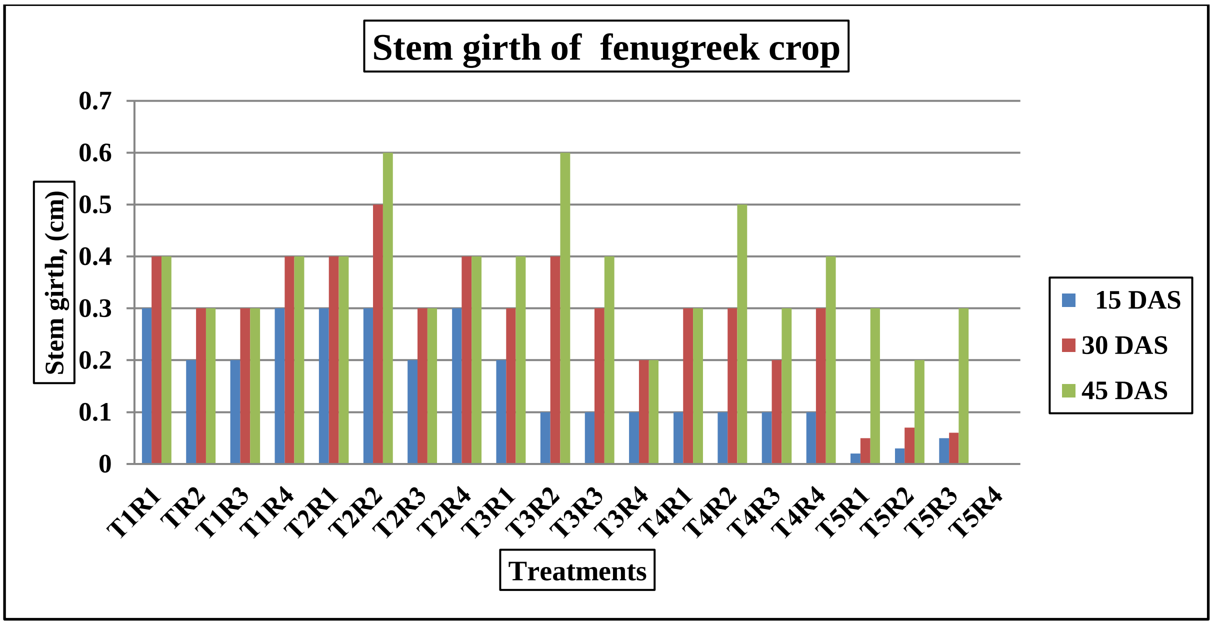

Fig. 4.16 Stem girth of Fenugreek crop

4.2.1.2.3 Number of leaves

The number of leaves of plants in every media was recorded for fenugreek crop. The Table 4.19, Fig 4.18 and appendix II show the number of leaves of fenugreek crop in experimental unit.

In five media seeds of fenugreek were sown randomly. The observations of number of leaves of fenugreek crop were recorded for 10-15 seeds sown in 0.154 m^2 area in each pot. Four replications from each treatment were recorded on the 15 days interval till the harvesting. In between 15 days of interval the number of leaves in all treatment was approximately same. The maximum number of leaves of 30 days and 45 days interval was observed in treatment T2R3 which has a vermicompost media. The minimum number of leaves of fenugreek crop was recorded in treatment T5R3 in between 30 days of interval which has hydroton media and in between 45 days of interval minimum number of leaves of fenugreek crop was recorded in T1R2 which has cocopeat media. From Table 4.19, Maximum number of leaves of fenugreek crop was observed in vermicompost media as compared to the other media at the time of harvesting. It was found from statistical analysis, more significant result for number of leaves obtained from T1, T2, T3, T4 and T5 treatment in 15days, 30 days and 45 days interval.

Table 4.19 Number of leaves

Treatment	15 DAS	30 DAS	45 DAS
T1R1	3	11	10
T1R2	2	10	8
T1R3	2	17	17
T1R4	2	13	13
T2R1	3	23	21
T2R2	3	20	19
T2R3	2	25	24
T2R4	2	22	13
T3R1	2	12	22
T3R2	2	15	15
T3R3	2	14	17
T3R4	2	10	19
T4R1	2	8	15
T4R2	2	10	19
T4R3	2	7	16
T4R4	2	6	17
T5R1	2	2	11
T5R2	2	3	10
T5R3	2	2	11
T5R4	0	0	0
SE	0.3	1.4	2.6
CD	0.7	3.1	5.6

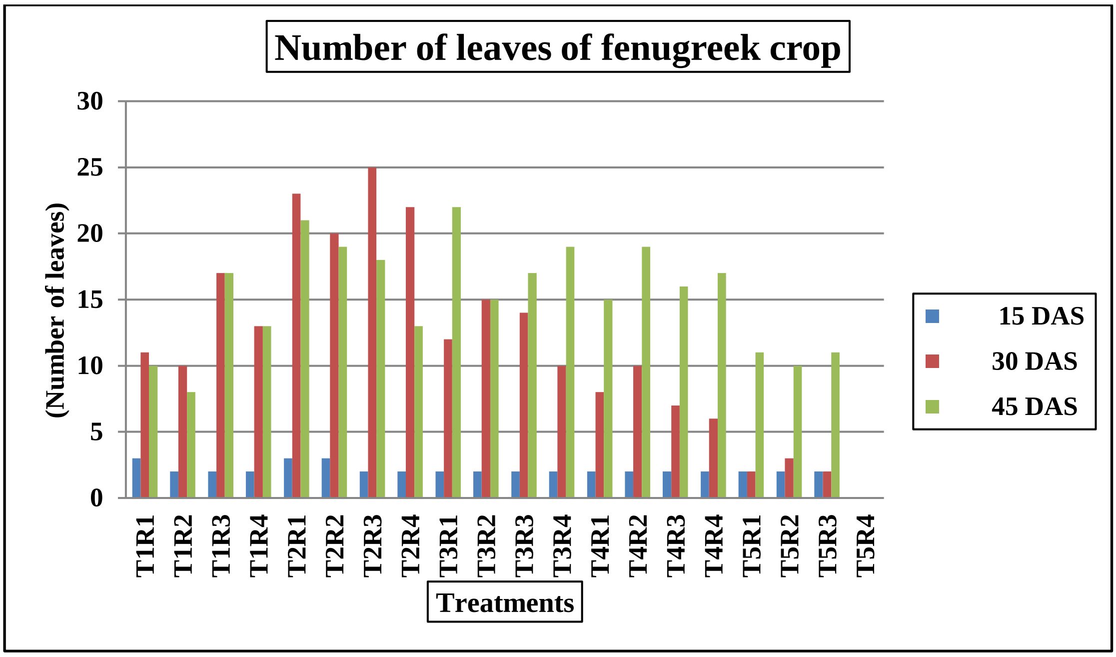

Fig. 4.17 Number of leaves of Fenugreek crop

4.2.1.3 Amaranthus

4.2.1.3.1 Stem height

The stem height of plants in every media was recorded for amaranthus crop. The Table 4.20, Fig 4.19 and appendix II show the stem height of amaranthus crop in experimental unit. In five media seeds of amaranthus were sown randomly. The observations of stem height of amaranthus crop were recorded for 10-15 seeds sown in 0.154 m^2 area in each pot. Four replications from each treatment were recorded on the 15 days interval till the harvesting. The maximum stem girth of 15 days, 30 days and 45 days of interval was observed in treatment T2R4 which has a vermicompost media. The minimum stem height of amaranthus crop was recorded in treatment fifth which has hydroton media. From Table 4.20, Maximum stem height of amaranthus crop was observed in vermicompost media as compared to the other media at the time of harvesting. It was found from statistical analysis, more significant result for stem height obtained from T1, T2, T3 and T4 treatment in 15days, 30 days and 45 days interval. None significant result for stem height obtained from T5 treatment for all replication.

Table 4.20 Stem height (cm)

Treatment	15 DAS	30 DAS	45 DAS
T1R1	0.2	0.4	3
T1R2	0.2	0.4	2.5
T1R3	0.3	0.5	3.5
T1R4	0.2	0.3	2
T2R1	1.4	5	35
T2R2	1	6	30
T2R3	1	5.5	31
T2R4	1.5	6.3	39
T3R1	0.9	1	4
T3R2	0.8	0.9	4.5
T3R3	0.9	1	4.7
T3R4	0.7	0.9	4.5
T4R1	0.9	1.5	7
T4R2	0.9	2	5
T4R3	0.8	2.5	8
T4R4	0.7	3	7
T5R1	0.09	2	3
T5R2	0.07	1	4
T5R3	0.08	0.09	3
T5R4	0.05	0.08	3
SE	0.1	0.4	1.2
CD	0.2	0.9	2.8

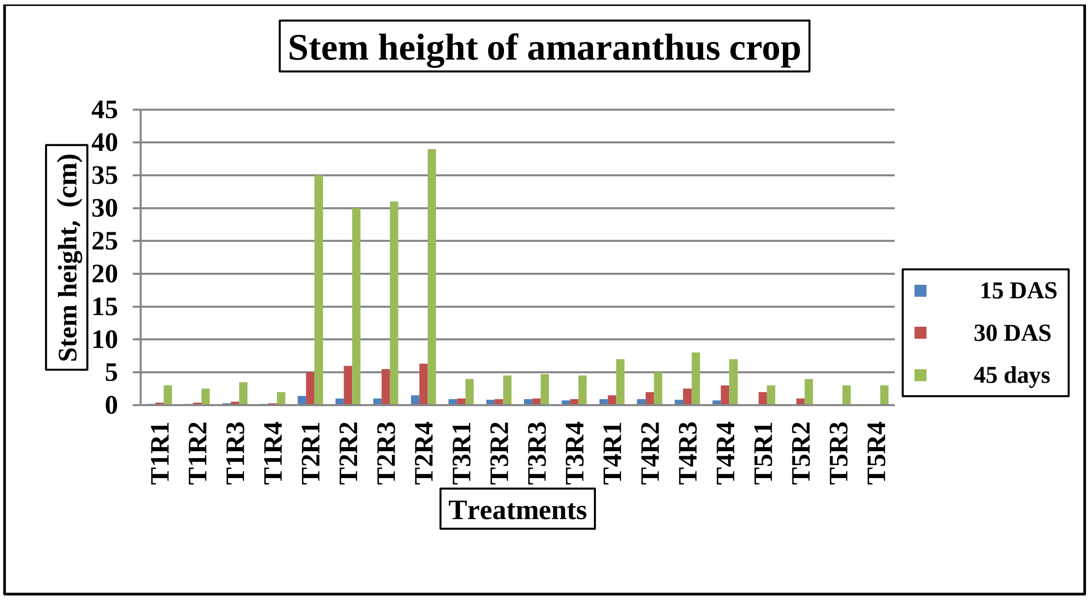

Fig. 4.19 Stem height of Amaranthus crop

4.2.1.2.2 Stem girth

The stem girth of plants in every media was recorded for amaranthus crop. The Table 4.21, Fig 4.20 and appendix II show the stem girth of amaranthus crop in experimental unit. In five media seeds of amaranthus were sown randomly. The observations of stem girth of amaranthus crop were recorded for 10-15 seeds sown in 0.154 m^2 area in each pot. Four replications from each treatment were recorded on the 15 days interval till the harvesting. The maximum stem girth of 15 days, 30 days and 45 days interval was observed in vermicompost media. The minimum stem girth of amaranthus crop was recorded in hydroton media. From Table 4.21, Maximum stem girth of amaranthus crop was observed in vermicompost media as compared to the other media at the time of harvesting. It was found from statistical analysis, none significant result obtained for stem girth in 15days, 30 days and 45 days interval.

Table 4.21 Stem girth (cm)

Treatment	15 DAS	30 DAS	45 DAS
T1R1	0.02	0.04	0.08
T1R2	0.02	0.02	0.09
T1R3	0.02	0.03	0.1
T1R4	0.02	0.03	0.05
T2R1	0.07	0.3	0.7
T2R2	0.05	0.3	0.8
T2R3	0.04	0.4	0.9
T2R4	0.05	0.2	0.6
T3R1	0.07	0.07	0.08
T3R2	0.09	0.09	0.1
T3R3	0.07	0.08	0.09
T3R4	0.06	0.07	0.07
T4R1	0.07	0.08	0.08
T4R2	0.02	0.07	0.09
T4R3	0.07	0.08	0.08
T4R4	0.05	0.06	0.07
T5R1	0.01	0.06	0.07
T5R2	0.02	0.03	0.05
T5R3	0.01	0.03	0.03
T5R4	0.03	0.04	0.04
SE	0.02	0.02	0.03
CD	0.04	0.05	0.08

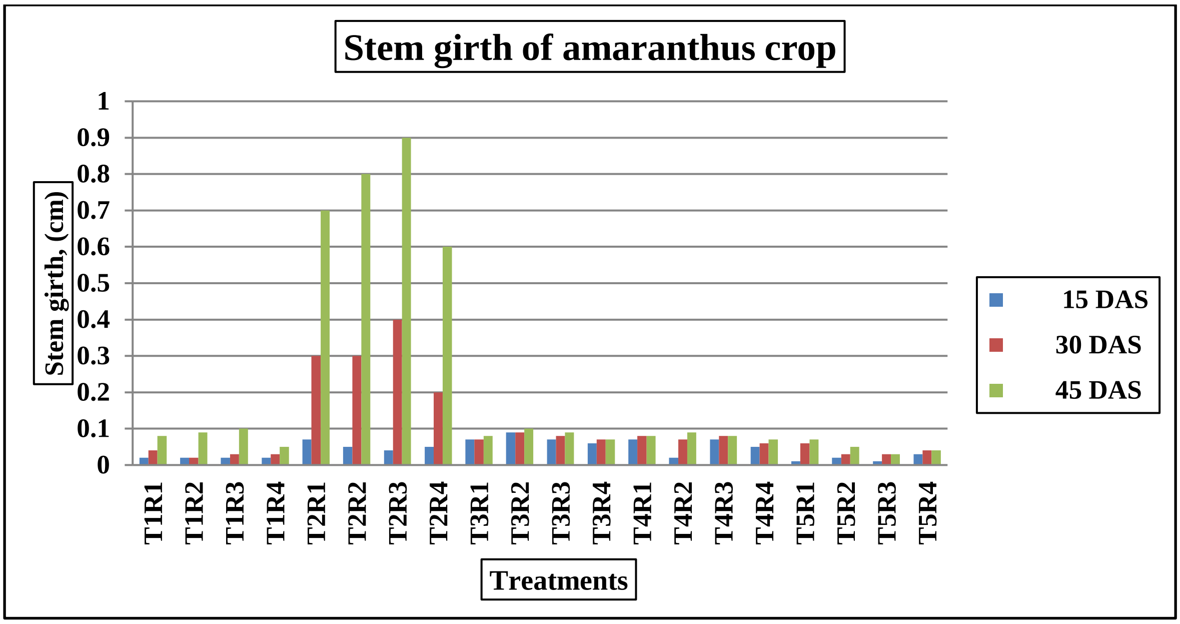

Fig. 4.20 Stem girth of Amaranthus crop

4.2.1.3.3 Number of leaves

The number of leaves of plants in every media was recorded for amaranthus crop. The Table 4.22, Fig 4.21 and appendix II show the number of leaves of amaranthus crop in experimental unit.

Table 4.22 Number of leaves

Treatment	15 DAS	30 DAS	45 DAS
T1R1	2	2	6
T1R2	2	3	7
T1R3	2	3	8
T1R4	2	3	4
T2R1	4	7	28
T2R2	4	8	30
T2R3	5	6	41
T2R4	3	10	27
T3R1	2	4	5
T3R2	2	4	6
T3R3	3	3	7
T3R4	2	2	7
T4R1	2	4	7
T4R2	4	4	6
T4R3	3	3	7
T4R4	2	4	7
T5R1	2	2	5
T5R2	2	2	4
T5R3	2	2	5
T5R4	2	2	6
SE	0.3	0.6	2.0
CD	0.8	1.4	4.4

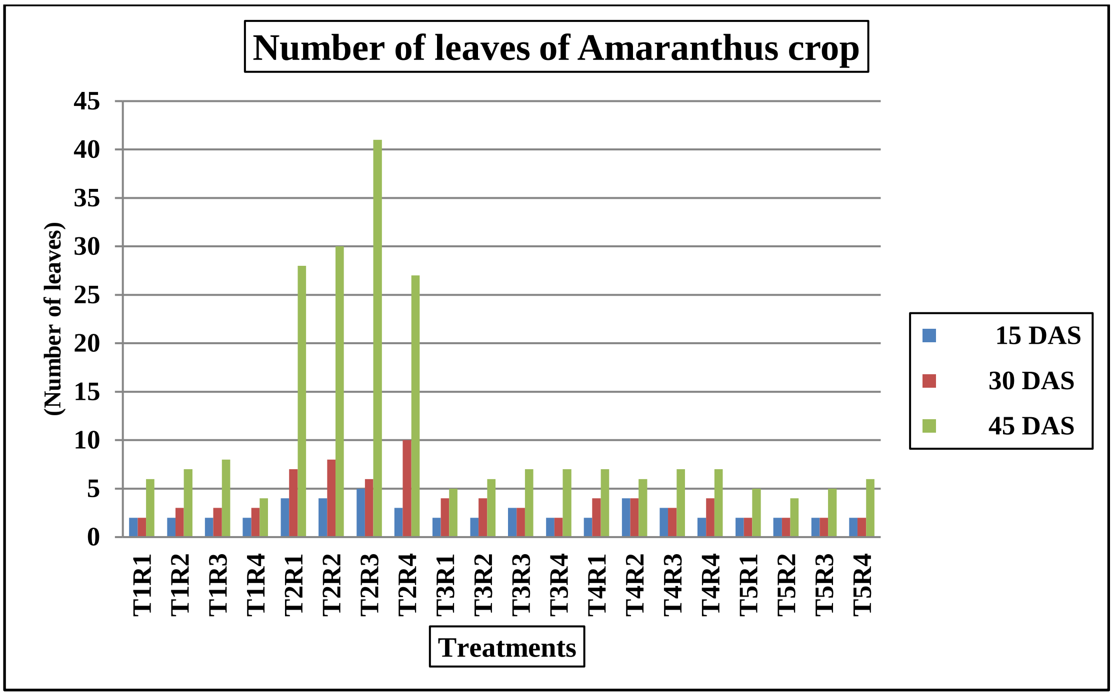

Fig.4.21 Number of leaves of Amaranthus crop

In five media seeds of amaranthus were sown randomly. The observations of number of leaves of amaranthus crop were recorded for 10-15 seeds sown in 0.154 m^2 area in each pot. Four replications from each treatment were recorded on the 15 days interval till the harvesting. In between 15 days of interval the number of leaves in all treatment was approximately same. The maximum stem girth of 15 days, 30 days and 45 days interval was observed in vermicompost media. The minimum stem girth of amaranthus crop was recorded in hydroton media. From Table 4.11, Maximum number of leaves of amaranthus crop was observed in vermicompost media as compared to the other media at the time of harvesting. It was found from statistical analysis, more significant result for number of leaves obtained from T1, T2, T3, T4 and T5 treatment in 15days, 30 days and 45 days interval.

4.2.1.4 Total yield of crops

The total yield in every treatment which has four replications in each treatment was recorded for spinach crop. The Table 4.23, Fig 4.22 and plate 4.1, 4.2 and 4.3 show the total yield of spinach crop in experimental unit. In five media seeds of spinach were sown randomly. The observations of total yield of spinach crop were recorded for 10-15 seeds sown in 0.154 m^2 area in each pot. Maximum yield of Spinach, Fenugreek and Amaranthus was observed in second treatment which included vermicompost media (640 gm), (105 gm) and (630 gm). The treatment T2 is shown higher yield due to significant biometric parameters over other treatment.

Table 4.23 Total yield of crops

Treatment	Yield of Spinach	Yield of Fenugreek (gm)	Yield of Amaranthus (gm)

	(gm)		
T1	90	38.5	23
T2	640	105	630
T3	73	70	45
T4	120	60	120
T5	1.5	9.5	3.7
Total yield	**925**	**283**	**821.7**

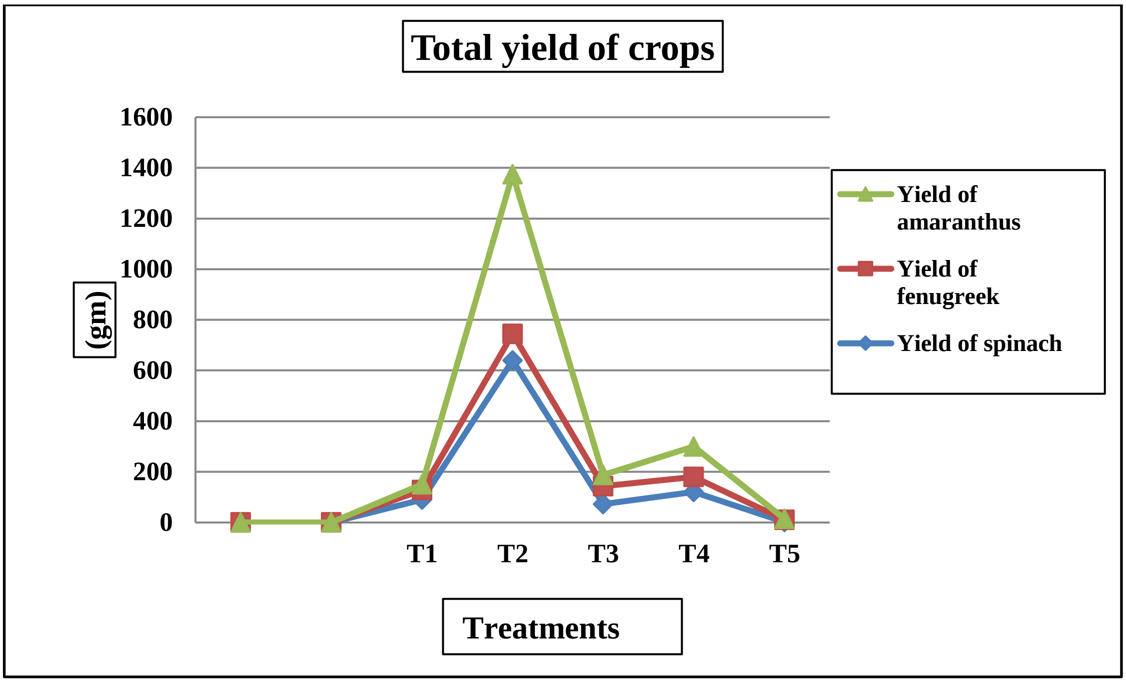

Fig.4.22 Total yield of crops

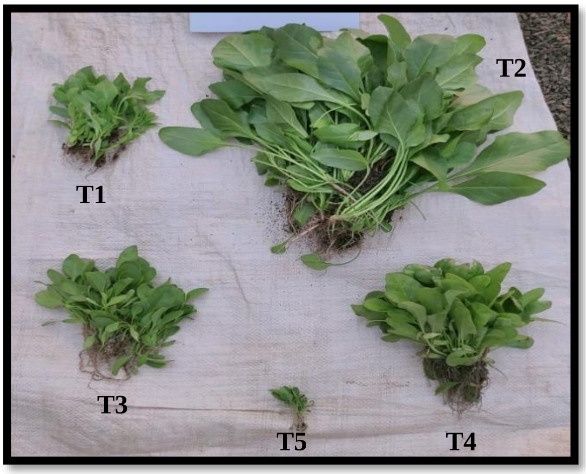

Plate 4.1 Total yield of Spinach **Plate 4. 2 Total yield of Fenugreek**

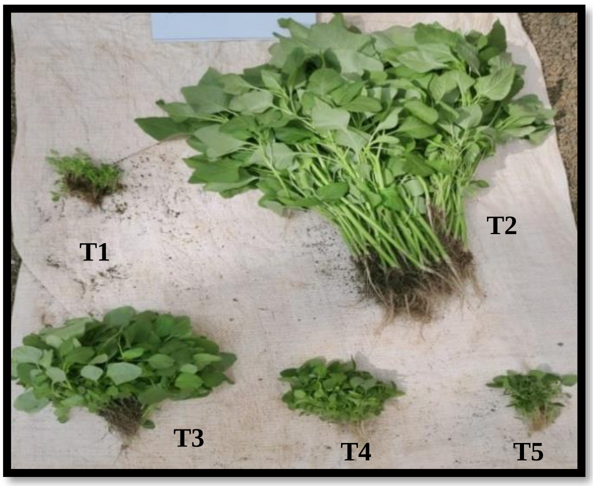

Plate 4.3 Total yield of Amaranthus

4.2.1.5 Length of roots after harvesting

The length of roots after harvesting of crops in every treatment which has four replications in each treatment was recorded for spinach crop. The Table 4.24, Fig 4.23 and appendix II show the length of roots after harvesting of crops in experimental unit. Maximum length of roots after harvesting of crops (Spinach, Fenugreek, Amaranthus) was observed in second treatment which included vermicompost media. It was found from statistical analysis, more significant result for length of roots obtained from T1, T2, T3 and T4 treatment in 15days, 30 days and 45 days interval. None significant result for length of roots obtained from T5 treatment for all replication in 15 days and 30 days interval. Significant result for length of roots obtained from T5 treatment for all replication in 45 days interval.

Table 4.24 Length of roots of crops

Treatment	Root length of Spinach (cm)	Root length of Fenugreek (cm)	Root length of Amaranthus (cm)
T1R1	5	4	2.5
T1R2	3.5	4	2.6
T1R3	5.5	2	2.9
T1R4	4.5	3	2
T2R1	7.5	3.5	7
T2R2	9	6.1	6.5
T2R3	12	4	5.5
T2R4	8	9	6
T3R1	7	5	4
T3R2	11	7	3.5
T3R3	9	7.5	3
T3R4	9	6.5	3.5
T4R1	9	5	5.5
T4R2	11	3.5	5
T4R3	9	4	6
T4R4	7	4.5	5.7
T5R1	0	0.5	5
T5R2	0	0.4	6
T5R3	3	0.5	3.5
T5R4	0	0.3	4
SE	0.9	0.9	0.8
CD	2.1	2.1	1.7

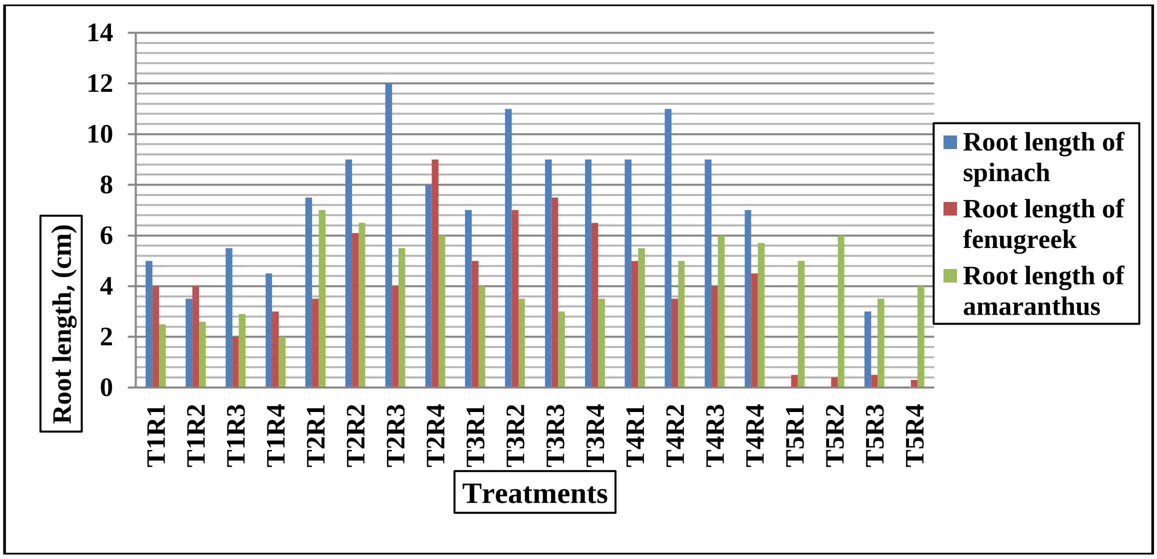

Fig4.23 Root length of crops

4.2.2 Water management

The plastic container was used to irrigate the crop in individual. The water management was done on the basis of volume of media under consideration.

Net volume of pot filled with media = 0.0014 m^3 (Appendix I)

Quantity of water requirement depends on porosity of the media to saturate the whole media.

1) For Cocopeat media, 53 % water needed to keep it at saturation, as it has 53% porosity (Appendix I).

= Volume of media × Porosity %

= 1.4×10^{-3} m^3 × (53/100)

= 0.74×10^{-3} m^3

Hence, 0.74×10^{-3} m^3 = 0.74 litres water was required to saturate the media.

2) For Vermicompost media, 63 % water needed to keep it at saturation, as it has 63% porosity (Appendix I).

= Volume of media × Porosity %

= 1.4×10^{-3} m^3 × (63/100)

= 0.88×10^{-3} m^3

Hence, 0.88×10^{-3} m^3 = 0.88 litres water was required to saturate the media.

3) For Perlite media, 72.3 % water needed to keep it at saturation, as it has 72.3% porosity (Appendix I).

= Volume of media × Porosity %

= 1.44×10^{-3} m^3 × (72.3/100)

= 1.0×10^{-3} m^3

Hence, 1.0×10^{-3} m^3 = 1.0 litres water was required to saturate the media.

4) For Vermiculite media, 42 % water needed to keep it at saturation, as it has 42 % porosity (Appendix I).

= Volume of media × Porosity %

= 1.44×10^{-3} m^3 × (42/100)

= 0.5×10^{-3} m^3

Hence, 0.5×10^{-3} m^3 = 0.5 litres water was required to saturate the media.

5) For Hydroton media, 78 % water needed to keep it at saturation, as it has 78 % porosity (Appendix I).

= Volume of media × Porosity %

= 1.44×10^{-3} m^3 × (78/100)

= 1.0×10^{-3} m^3

Hence, 1.09×10^{-3} m^3 = 1.09 litres water was required to saturate the media.

After saturation, each media is allowed to attain the field capacity and daily irrigation was applied to maintain moisture content near to field capacity. The daily crop water requirement was computed by using penmen monteith method show in appendix II.

4.2.3 Cost Analysis

The cost estimation of the pot culture unit has been determined by using the current rates of the materials available in the market as described in chapter 3 in section 3.5 and reported in the Table 4.28.

4.2.3.1 Net income

The detailed cost estimation is reported in Table 4.25 and appendix III. It is observed that the maximum net income of Rs. 62.0 per 1.00 m^2 area was recorded for crop production in a vermicompost media. The minimum net income of Rs. -17.1 per 1.00 m^2 area was recorded for crop production in a hydroton media. Net income for crop production in following media was recorded as Rs -1.8 per 1.00 m^2 for cocopeat media, Rs -14.3 per 1.00 m^2 for perlite media and Rs -16.4 per 1.00 m^2 for vermiculite media.

4.2.3.1 Benefit Cost ratio

The benefit cost ratio was calculated by taking the ratio of gross monetary returns to the cost of production for one season. From Table 4.25 and Fig. 4.24, the maximum benefit cost ratio of 4.3 was recorded for crop production in a vermicompost media and minimum benefit cost ratio of 0.2 per was recorded in a hydroton media. Benefit cost ratio for crop production in following media was recorded as 0.9 for cocopeat media, 0.6 for perlite media and 0.6 for vermiculite media.

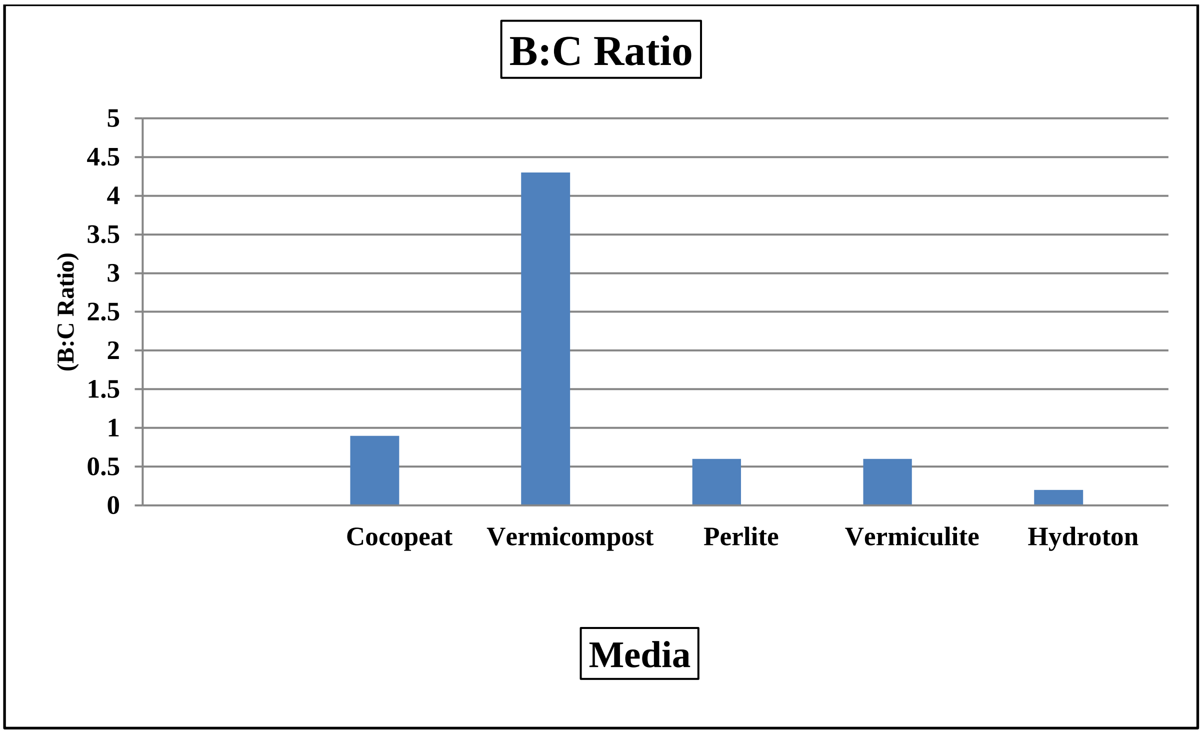

Fig 4.24 B: C Ratio

Table 4.25 Benefit cost ratio for different media on vegetable production in pot culture

Sr. no.	Particulars	Cocopeat 12 pots	Vermicompost 12 pots	Perlite 12pots	Vermiculite 12 pots	Hydroton 12 pots
1.	Seasonal fixed cost, Rs/1.00m^2	430	430	430	430	430
2.	Total variable cost Rs/1.00m^2	674.1	634	1975	2521	840
3.	Interest on working capital Rs/1.00m^2 (3% of total variable cost)	20.2	19.0	59.2	75.6	25.2
4.	Total operating cost per season Rs/1.00m^2 (2+3)	694.3	653	2034.2	2596.6	865.2
5.	Cost of production, Rs/1.00m^2	1124.3	1083	2464.2	3026.6	1295.2
6.	Lifespan 1) for10 years	1124.3	1083	2464.2	3026.6	1295.2
	2) for1 year (6 seasons)	112.4	108.3	246.4	302.6	129.5
	3) for1 season	18.7	18.5	41.0	50.4	21.5
7.	Yield kg/1.00m^2	Spinach+ fenugreek+ amaranthus	Spinach+ fenugreek+ amaranthus	Spinach+ fenugreek+ amaranthus	Spinach+ Fenugreek+ amaranthus	Spinach+ Fenugreek+ amaranthus
	Total	**0.15**	**1.34**	**0.27**	**0.31**	**0.04**
8.	Selling Price Rs/kg	100+150+100	100+150+100	100+150+100	100+150+100	100+150+100
9.	Gross monetary returns, Rs/1.00m^2	16.9	80.5	26.75	34	4.45

	(7*8)					
10.	Net income, Rs/1.00m^2 [9-6(3)]	-1.8	62.0	-14.3	-16.4	-17.1
11.	B:C Ratio[9/6 (iii)]	0.9	4.3	0.6	0.6	0.2

CHAPTER V
SUMMARY AND CONCLUSION

The experiment on "Performance evaluation of commercially available different media on vegetable production in pot culture." was carried out at the Instructional Farm and in the laboratory of Department of Irrigation and Drainage Engineering. College of Agricultural Engineering and Technology, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. The research work aimed with specific objectives to study of physio-chemical properties of media under consideration, performance evaluation of media on vegetable production and cost analysis. The findings of the study are summarized under the following sections of this Chapter.

5.1 Summary

The project investigation carried out at Department of Irrigation and Drainage Engineering, College of Agricultural Engineering and Technology, Dapoli concluded that cultivation of fresh vegetables with high productivity can be obtained within a small area with a little care with maximum water use efficiency along with good and healthy growth of crops in pot culture unit by using different media. Five media were selected viz. cocopeat, vermicompost, perlite, vermiculite and hydroton to study the growth of Spinach, Fenugreek and Amaranthus.

The physical properties of media under consideration were studied. It was found that the bulk density of cocopeat is 207.1 kg/m^3, followed by vermicompost (594 kg/m^3), perlite (165.8 kg/m^3), vermiculite (548.0 kg/m^3) and bulk density of hydrotons is 166.4 kg/m^3.It was found that the particle density of cocopeat is 440 kg/m^3, followed by vermicompost (1600 kg/m^3), perlite (600 kg/m^3), vermiculite (941 kg/m^3) and hydrotons is 480 kg/m^3. It was found that the porosity of cocopeat is 53 %, followed by vermicompost (63 %), perlite (73 %), vermiculite (42 %) and hydrotons (66 %). It was found that the moisture content on the basis of air-filled porosity of cocopeat is 23.2 %, followed by vermicompost (22.3 %), perlite (14.8 %), vermiculite (23.9 %) and hydrotons (5.4 %). It was found that the moisture content on the basis of wettabiity of cocopeat is 34.0 %, followed by vermicompost (31.7 %), perlite (39.4 %), vermiculite (48.0 %) and hydrotons (39.8 %). It was found that the water holding capacity of cocopeat is 387 %, followed by vermicompost (731 %), perlite (121 %), vermiculite (109 %) and hydrotons (43 %).

The chemical properties of media under consideration were studied. It was found that pH of cocopeat before washing is 6.5, after washing is 6.7, pH of vermicompost before washing is 6.16, after washing is 6.2, pH of perlite before washing is 6.5, after washing is 6.7, pH of vermiculite before washing is 7.2, after washing is 6.9, pH of hydrotons before washing is 5.8, after washing is 6.1. It was found that pH of cocopeat for spinach crop after harvesting is 6.2, followed by vermicompost (6.4), perlite (6.7), vermiculite (6.6), hydrotons (6.7). It was found that pH of cocopeat for fenugreek crop after harvesting is 5.3, followed by vermicompost (6.3), perlite (6.4), vermiculite (6.8), hydrotons (5.9). It was found that pH of cocopeat for amaranthus crop after harvesting is 6.4, followed by vermicompost (6.1), perlite (5.8), vermiculite (6.8), hydrotons

(5.9). It was found that EC of cocopeat before washing is 1.44 dS/m, after washing is 0.79 dS/m, EC of vermicompost before washing is 1.09 dS/m, after washing is 0.65 dS/m, EC of perlite before washing is 0.36 dS/m, after washing is 0.21 dS/m, EC of vermiculite before washing is 0.12 dS/m, after washing is 0.10 dS/m, EC of hydrotons before washing is 0.93 dS/m, after washing is 0.52 dS/m. It was found that EC of cocopeat for spinach crop after harvesting is 1.07 dS/m, followed by vermicompost (1.02 dS/m), perlite (0.66 dS/m), vermiculite (0.19 dS/m), hydrotons (1.46 dS/m). It was found that EC of cocopeat for fenugreek crop after harvesting is 0.98 dS/m, followed by vermicompost (1.04 dS/m), perlite (0.34 dS/m), vermiculite (0.14 dS/m), hydrotons (1.86 dS/m). It was found that EC of cocopeat for amaranthus crop after harvesting is 0.89 dS/m, followed by vermicompost (1.20 dS/m), perlite (0.34 dS/m), vermiculite (0.19 dS/m), hydrotons (3.13 dS/m).

It was found in biometric observation the stem height of spinach crop after 15 days of sowing it was maximum in T4, after 30 days it was maximum in T2 and after 45 days it was maximum in T2. The stem girth of spinach crop after 15 days of sowing it was maximum in T4, after 30 days it was maximum in T2 and after 45 days it was maximum in T4. Number of leaves of spinach after 15 days of sowing was maximum in T4, after 30 days it was maximum in T2 and after 45 days it was maximum in T1, T2 and T4. It was found in biometric observation the stem height of fenugreek crop after 15 days of sowing it was maximum in T4, after 30 days it was maximum in T4 and after 45 days it was maximum in T3. The stem girth of fenugreek crop after 15 days of sowing it was maximum in T2, after 30 days it was maximum in T2 and after 45 days it was maximum in T2. Number of leaves of fenugreek after 15 days of sowing was maximum in T2, after 30 days it was maximum in T2 and after 45 days it was maximum in T2 and T3. It was found in biometric observation the stem height of amaranthus crop after 15 days of sowing it was maximum in T2, after 30 days it was maximum in T2 and after 45 days it was maximum in T2. The stem girth of amaranthus crop after 15 days of sowing it was maximum in T3, after 30days it was maximum in T2 and after 45 days it was maximum in T2. Number of leaves of amaranthus after 15 days of sowing was maximum in T2, after 30 days it was maximum in T2 and after 45 days it was maximum in T2.

The maximum production of spinach (640 gm) was obtained from the vermicompost media, followed by fenugreek (105 gm) and amaranthus (630 gm). The vertical hydroponic structure found to be more suitable for small family. If one more member added to the family of four persons one or two more pots in pot culture unit should be added to fulfill the requirement of small family.

5.2 Conclusions

The following conclusions can be drawn from the results:

1. The vermicompost is the best media for crop growth followed by Cocopeat, Perlite, Vermiculite And Hydrotons.

2. The maximum net income of Rs. 62.0 per 1.00 m^2 area can be obtained under vermicompost media.

3. Crop production under vermicompost can give the maximum B: C ratio of 4.3.

5.3 Suggestion for further work

Growth of plants in hydroton media was not good as compared to other media. Hence, instead of individual hydroton media, experimental trials on hydroton media with oasis cubes for better growth should be conducted.

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THESIS ABSTRACT

The present investigation entitled, "Performance evaluation of commercially available different media on vegetable production in pot culture." was carried out at the Instructional Farm and in Laboratory of Department of Irrigation and Drainage Engineering, College of Agricultural Engineering and Technology, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. Healthy soil is essential for healthy plant growth, human nutrition. Healthy soil supports a landscape that is more resilient to the impacts of drought, flood, or fire. Soil helps to balance the Earth's climate and stores more carbon. Day by day our country facing the issues related to the soil erosion, compaction, nutrient imbalance, pollution, acidification, water logging, loss of soil biodiversity and increasing the salinity have been affecting soil, reducing its ability to support plant life period.

Land degradation has become a serious issue in both non-irrigated as well as irrigated areas of India. India is losing a more amount of money from these degraded lands. To control over this problem we can shift to soil less farming. Plants grown in soil-less culture gives higher yield with superior quality consistently. With an objective of using different growing media for growing fresh vegetables along with free or minimum inorganic chemicals and selective healthy vegetables, it was felt necessary to do study on soil-less pot culture unit for cultivation of leafy vegetables in limited space.

Total five media were used in pot culture unit viz. cocopeat, vermicompost, perlite, vermiculite and hydroton to study the growth of spinach, fenugreek and amaranthus. The physical and chemical properties of media such as bulk density, particle density, porosity, Wettability, air filled porosity, water holding capacity, electrical conductivity and pH were determined by using standard procedures. The best results of vermicompost media among all five media in the developed pot culture units having electrical conductivity of 0.65 dS/m, pH of 6.2, bulk density of 207.1kg.m^{-3}, particle density of 1600 kg.m^{-3}, porosity of 63%, water holding capacity of 731% and moisture content on the basis of AFT is 22.3% for each crop were observed. Growth of the plants was found to be favorable when better environment and maximum surface area was provided to the crop. The biometric observations of crop were taken at 15 days of interval. The best results of biometric observation were found in vermicompost media (stem height, stem girth, no. of leaves and root length after harvesting).

The maximum net income of Rs. 62.0 per 1.00 m^2 area was recorded for crop production in a vermicompost media. The minimum net income of Rs. -17.1 per 1.00 m^2 area was recorded for crop production in a hydroton media. Net income for crop production in following media was recorded as Rs -1.8 per 1.00 m^2 for cocopeat media, Rs -14.3 per 1.00 m^2 for perlite media and Rs -16.4 per 1.00 m^2 for vermiculite media respectively.

THESIS ABSTRACT

a)	Title of the thesis	: PERFORMANCE EVALUATION OF COMMERCIALLY AVAILABLE DIFFERENT MEDIA ON VEGETABLE PRODUCTION IN POT CULTURE.
b)	Full name of the student	: Miss SONAL POPAT KARANDE
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d)	Degree to be awarded	: M.Tech. (Irrigation and Drainage Engineering)
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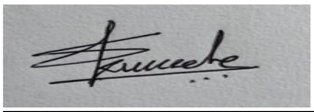
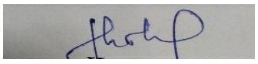
i)	Signature of student	: 
j)	Signature, Name and address of forwarding authority	: 

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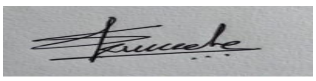

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