ORGANIC NUTRIENT SCHEDULING IN SOILLESS VEGETABLE CULTIVATION

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by

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2013

DECLARATION

I hereby declare that this thesis entitled **"Organic nutrient scheduling in soilless vegetable cultivation"** is a bonafide record of research done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

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To

My Dear God,

Beloved Parents, Sisters and my Guide Dr. Usha C. Thomas

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CuckooRani.M

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LIST OF ABREVIATIONS

CD	-	Critical difference
Cm	-	Centimeter
DAS	-	Days After Sowing
et al	-	And others
Fig.	-	Figure
FYM	-	Farmyard manure
G	-	Gram
g $plant^{-1}$	-	Gram per plant
ha	-	Hectare
hrs	-	Hours
H_2SO_4	-	Sulphuric acid
i.e.	-	That is
K	-	Potassium
KAU	-	Kerala Agricultural University
KCl	-	Potassium chloride
Kg	-	Kilogram
Kg ha^{-1}	-	Kilogram per hectare
K_2HPO_4	-	Di potassium hydrogen phosphate
LAI	-	Leaf Area Index
M	-	Metre

LIST OF ABBREVIATIONS CONTINUED

Mt	-	Million tonne
Mg	-	Milligram
$MgSO_4.7H_2O$	-	Magnesium sulphate hepta hydrate
Min	-	Minutes
Ml	-	Milliliter
N	-	Nitrogen
$NaCl_2$	-	Sodium chloride
$NaNO_3$	-	Sodium nitrate
NS	-	Non significant
P	-	Phosphorus
pH	-	Negative logarithm of hydrogen ion concentration
POP	-	Package of practice
Rs	-	Rupees
SE	-	Standard error
t ha^{-1}	-	Tonnes per hactare
Var.	-	Variety
Viz	-	Namely
WUE	-	Water Use Efficiency

List of symbols

%	–	Per cent
°C	–	Degree Celsius
@	–	At the rate of

Introduction

1. INTRODUCTION

Vegetables are integral part of a balanced diet and are considered as protective foods. Vegetables are rich source of vitamins, minerals and dietary fibre. The requirement of vegetables is 300 g person $^{-1}$ day^{-1} but actual consumption is very low i.e. 174g person^{-1} day^{-1}(Gajanan and Hedge, 2009). Since vegetables are mostly consumed fresh or only partially cooked, they should be devoid of residual effect of chemicals. Organically grown vegetables are preferred for their flavor, taste, nutritive value and extended shelf life. Bhindi, *Abelmoschus esculentus* (L.) Moench (syn. Okra, lady's finger and gumbo) is an important warm season vegetable crop grown for its tender pods in tropical and sub tropical regions.

Since land available for cultivation is shrinking drastically especially in urban areas, it is becoming increasingly difficult to own and cultivate conventional type of vegetable gardens of even a few cents of land. Terrace cultivation of vegetables provides better time and space utilisation, for vegetable cultivation and above all availability of fresh, hygienic , safe and eco- friendly vegetables at low cost on the house terrace itself. Terrace cultivation of vegetable crops is gaining popularity in Kerala because of health concerns. A major constraint in promoting terrace cultivation is lack of availability of good quality soil and damage to structure of terrace due to heavy weight of soil.

Soilless growth media provide answer to these problems. Growing media are often formulated from a blend of different raw materials in order to achieve the ideal properties of the growth medium. Coirpith is the most commonly available material suitable for potting media preparation. Low density of coir pith coupled with good water holding capacity makes it a good potting media. It is assessed that around 7.5 mt of coirpith is being produced annually in India (Kamaraj, 1994). Kerala, also often called "Land Of Coconut Trees", is facing great problems with the disposal of coconut husks and coir fibre, which pollutes the land and water. Coirpith can be successfully utilized as a soilless medium for vegetable crops such as bhindi, tomato and brinjal (Jeyaseeli and Raj, 2010). Major problem associated with coir pith is wide C:N ratio and associated immobilization. Coirpith compost offers a promising alternate to be used as component of soilless potting media.

Farm yard manure is the traditional manure and is most readily available to farmers. Neopeat is an eco-friendly organic soil conditioner and soil substitute, and the best medium for green house farming, with a water holding capacity of 500 – 600%. It is highly suitable for commercial floriculture and horticulture.

With this background, the study was undertaken with the objectives of standardising soilless media and nutrient schedule for organic vegetable production (grown in containers) and to work out the economics of different treatments.

Review of Literature

2. REVIEW OF LITERATURE

The shortage of water resources and arable lands can be achieved only through the adoption of promising agricultural practices such as soilless culture. This study was undertaken to standardize soilless media and nutrient schedule for vegetable production (grown in containers) and to work out the economics of different treatments. As the studies on the soilless cultivation systems in Kerala was less, the available studies that are directly or indirectly related to the topic of research from various sources are reviewed in this chapter.

2.1. Soilless culture

Soilless culture is an artificial means of providing plants with support and reservoir for nutrients and water (Ghehsareh, et al.,2011). Soilless culture covers all methods and systems of production using mineral solution for the plant nutrition with another substrate or support than soil (Resh, 1989; Robin, 1998; Butt *et al.*, 2004; Sheikh, 2006; Gruda, 2009). Soilless culture can be water culture, gravel culture, aeroponics, tube culture and nutriculture (Schwarz, 1994). It can be done on open or closed system (Baas *et al.*, 1995; Papadopoulos et al., 1999).

It was advisable to gradually extend this agricultural practice due to its advantages (Jiang and Yu, 2004; Metin-Sezen *et al.*, 2006; Yetisir *et al.*, 2006). Indeed, it is an efficient tool to overcome problems associated with production factors (Verdonck, 1975;Abd El-Hady and El-Dardiry, 2006) and create possibility of cultivation with flexibility even in regions where natural growing conditions are hostile (Grillas *et al.*, 2001).

The choice of substrates for soilless cultivation, represents one of the key points to be considered (Leonardi, 2006) due to technical and economical implications (Giuffrida *et al.*, 2008). There is no univocal scheme for the choice of the growing media (Leonardi, 2006). But, the knowledge of its characteristics is very important for this selection, seeing that the properties of different materials used as growing substrates, exhibit direct and indirect effects on plant growth and production (Verdonck *et al.*, 1981). Physical properties concern aeration, drainage and water retention capacity (Blanc,1987; Lemaire *et al.*, 1989; Cabrera, 2003). Chemical and biological features are indicated, respectively, by not having toxic material and very limited and/or less pathogen and pest (Blanc, 1987). Nevertheless, several studies have attested that, growing medium constitutes the most promising and efficient substrate in soilless culture (Grudina *et al.*, 1994; Park *et al.*, 1999), it seems to be of great interest to search locally available and less costly substrates (Verdonck *et al.*, 1981; Klougart, 1983; Abd El-Hady and El-Dardiry, 2006; Abd El-Hady *et al.*, 2006; Giménez *et al.*, 2008; Tzortzakis and Economakis, 2008; Abo-Rezq *et al.*, 2009; Abd El-Hady and Shanan, 2010).

The selection of a particular material for substrate use depends on its availability, cost and local experience on its use.Use of suitable growing media or substrates is essential for production of quality horticultural crops. It directly affects the development and later maintenance of the extensive functional rooting system (Yahya *et al.*, 2009). Very limited information is available in India for selection of suitable soilless media. Therefore, an attempt has been made in present study to find out suitable soilless media for Bhindi under open condition.

2.1 Coirpith compost

Coirpith is an underutilized by-product of the coconut. Coirpith, which is abundantly available in Kerala as a byproduct from coir industries, is found to be a good source of organic manure after decomposing it with *Pleurotus eous* and *Schizophyllum commune* (Reeja, 2002). Composting of coir pith helps in detoxifying phenolic compounds, reducing the bulkiness of the material and converting the plant nutrient to a form more readily available to plant. The use of coirpith waste in agriculture as a rooting medium, mulch and soil conditioner to improve soil drainage has proved beneficial (Hume, 1949). India ranks third in the world in the production of coconuts. It is estimated that 0.5 million tonnes of coirpith is generated per annum in India. Coirpith constitutes about 70% of the coconut husk. Studies on the physical properties of the material have established that it has a porosity of about 70% and the water holding capacity is above 500% (Anida Das, 1992).

Properties of coir dust that make it suitable as substrate component include (Cresswell, 1992) high water- holding capacity; excellent drainage; absence of weeds and pathogens; physically resilient; renewable resource with no known ecological drawbacks; slow decomposition; acceptable pH, CEC, and electrical conductivity (EC);easily wettable, and no sticks or other extraneous materials. However, chemical and physical properties vary among coir dust sources (Evans *et al.*, 1996).

Addition of coirpith compost has been proved to be successful in the cultivation of groundnut (Nagarajan *et al.*, 1986) and horticultural plants (Theradi Mani and Marimuthu, 1992).

2.1.1 Effect of coirpith compost on growth characters

Suharban *et al.* (1997) in a pot culture experiment with bhindi reported that plant height was significantly influenced by coir pith compost treatment, where the maximum plant height of 1.37 m was noted in coir pith compost treated plants and lowest (0.97m) under POP recommendation.

2.1.2 Effect of coirpith compost on yield and yield attributes

Incorporation of composted coir pith along with farm yard manure (5t ha^{-1}) into the soil gave the highest fruit yield of tomato (19 t ha^{-1}) followed by 20 t ha^{-1} coir pith (16 t ha^{-1}) and the lowest in control plot (11t ha^{-1}) which were treated with neither farm yard manure nor coir pith (Ahmed, 1993). The result of a study conducted by Venkatakrishnan and Ravichandran (1996) on sesame revealed that the yield could be increased by 63 per cent with the application of composted coir pith, over farmer's practice. Suharban *et al.* (1997) in a pot culture experiment with bhindi reported that the treatment with coir pith compost alone gave the maximum yield of

5.923 kg plant^{-1} followed by treatment with half recommended dose of coir pith and fertilizer (5.13 kg plant^{-1}).

Venkitaswamy (2003) reported that application of 100 per cent of the nutrient supply in coconut as composted coir pith recorded the maximum nut yield in coconut as compared to that of fertilizer treated plots. Geetha *et al.* (2005) reported that in banana, fertilizer dose can be reduced to half by addition of coir pith compost @ 15 kg per plant.

However, Arunkumar (2000) reported that application of coir pith compost resulted in lower green yield in amaranthus as compared to FYM, poultry manure, vermicompost and POP. recommendation on equivalent N basis.

2.1.3 Effect of coirpith compost on quality attributes

Suja (2001) found that tuber quality of white yam in terms of starch and crude protein contents were markedly improved by coir pith compost application

2.1.4 Effect of coirpith compost on soil properties

Coirpith has got many enviable characteristics, making it a highly potential resource if used after proper composting. It has high potassium content and low bulk density and particle density. Increase in water holding capacity of the soil due to coir pith application has been reported by Bhowmic and Debnath (1985).

The low particle density is due to high specific surface and high specific surface gives it high cation exchange capacity (Mapa and Kumara, 1995). Coir pith has very high moisture retention capacity of 500-600 percent.

Loganathan (1990) reported that the application of coir dust resulted in improved soil physical characteristics like infiltration, total porosity and hydraulic conductivity of red soil with hard pan. The use of coir pith as a soil conditioner in tropical farming is well established (Nagarajan *et al.*, 1990).

Incorporation of composted coir pith significantly increased the soil moisture content and improved other physical constants of the soil compared to other organic amendments (Subbaraj and Ramaswami, 1992). Application of coir pith to soil can improve hydraulic conductivity, porosity, water infiltration rate, water holding capacity and nutrient storage capacity (Prabhu and Thomas, 2002). It can also suitably reduce the bulk density of heavy soils.

Nambiar *et al.* (1983) observed that continuous application of coir dust for 8years improved the organic carbon status of the soil. Increase in water holding capacity of the soil due to coir pith application has been reported by Bhowmic and Debnath (1985). The use of coir pith as a soil conditioner in tropical farming is well established (Nagarajan *et al.*, 1990). Incorporation of composted coir pith significantly increased the soil moisture content and improved other physical constants of the soil compared to other organic amendments (Subbaraj and Ramaswami, 1992).

Coir pith has high potassium content and low bulk density and particle density (Mapa and Kumara, 1995). High CEC, which varies from 38.9 to 60 meq/100g, enables it to retain large amounts of nutrients and the absorption complex has high contents of exchangeable K, Na, Ca and Mg (Verhagen and Papadopoulos, 1997). According to Mbah and Pdili (1998), the high CEC of coir pith is attributed to its high specific surface.

Application of coir pith to soil can improve hydraulic conductivity, porosity, water infiltration rate, water holding capacity and nutrient storage capacity (Prabhu and Thomas, 2002).Venkitaswamy (2003) reported that application of 100 per cent of the nutrient supply in coconut as composted coir pith recorded low pH and higher organic carbon content to that of fertilizer treated plots.

Coir pith acts in many ways in ensuring good nutrition to plants. Coir pith can curtail the loss of nitrogen through leaching and other ways by reducing the rate of nitrification due to the presence of nitrification inhibitors in it. It can also prevent the loss of nutrients because of its high nutrient storage capacity by virtue of high CEC (Prabhu and Thomas, 2002).

Application of coir pith can enhance the availability of micro and macronutrients and increase yields. As coir pith is rich in potash and being acidic, its application can enhance the release of fixed and mineral potassium in soil and hence the quantity of potash fertilizers can be reduced in agriculture (Savithri *et al.*,1993). As it decomposes slowly, potash will be available slowly for many years.

As a nutrient source, coir pith has not much value. But, it can be enriched by addition of specific nutrients and cultures of beneficial microbes capable of enhancing the availability of nutrients. Anand *et al.* (1998) reported that enrichment of coir pith compost with rock phosphate resulted in more labile fractions of phosphorus in the resultant compost. In addition, use of rock phosphate @ 20 kg per tonne of coir pith during composting resulted in greater percentage of carbon loss (Anand *et al.*, 1999).

Asha (1999) reported that addition of rock phosphate or bone meal and microbial inoculants (Azotobacter and Phosphobacter) reduced the decomposition period and improved the manurial value of enriched composts as compared to ordinary compost. Geetha *et al.* (2004) reported that coir pith could be composted using organic additives such as cow dung, poultry manure, bone meal and neem cake. Among various additives N content was found to be higher (0.58 %) with cow dung and bone meal.

Venkitaswamy (2003) reported that application of 100 per cent of the nutrient supply in coconut as composted coir pith recorded the highest value of leaf N and K status as compared to that of fertilizer treated plots. Higher leaf N and K status in 100 per cent composted coir pith treatment would have been due to the better uptake of N and K with composted coir pith application due to increased availability.

2.2 Farm yard manure

This is the traditional organic manure and is most readily available to farmers. On an average, well rotten FYM contains 0.5 per cent nitrogen, 0.2 per cent phosphorous and 0.5 per cent potassium (Gaur *et al.*, 1971). Farm yard manure (FYM), supplies both major and minor plant nutrients, improves physical condition in the soil and supplies substances that stimulate plant growth. Among the different sources, FYM is the best known and commonly used traditional organic manure in India (Gaur, 1994). Organic manures like farm yard manure (FYM) seems to act directly in increasing crop growth and yield either by accelerating respiratory process with increasing cell permeability and hormonal growth action or by combination of all these process which supplies nitrogen, phosphorus and sulphur in available form through biological decomposition and improves physical properties of soil such as aggregation, permeability and water holding capacity (Purakayastha and Bhatnagar, 1997). FYM improved the soil fertility status and increased organic carbon content (Hemalatha *et al.*, 2000). Meerabai and Raj (2001) estimated that an average dressing of 25 t ha^{-1} FYM supplies 112 kg N, 56 kg P_2O_5 and 112 kg K_2O.

2.2.1 Effect of farm yard manure on growth of characters

Cerna (1980) found that FYM favourably influenced the vegetative mass dry weight, plant height and rate of dry matter increment per unit area in capsicum. In potato, plant height and number of leaves per plant were increased by the application of FYM (Sahota, 1993). Arunkumar (1997) found that FYM application was superior to vermicompost in increasing plant height, root biomass production, leaf area index and leaf yield in amaranthus. Joseph (1998) reported that in snakegourd growth characters *viz.*, weight of the root per plant and dry matter production per ha were highest in FYM treated plants as compared to poultry manure or vermicompost treated plants.

Senthilkumar and Sekar (1998) observed increased DMP of bhindi crop with FYM application as an organic amendment. Veena (2000) confirmed that the application of FYM at 20 t ha^{-1} in arrow root resulted in increased plant height, leaves per plant and dry matter production. In tomato application of FYM (10 and 20 t ha^{-1}) significantly increased plant height and number of branches per plant over control (Sharma and Sharma, 2004). According to Sharma and Abraham (2010) a significant difference in plant height and dry matter production was recorded with 10 t FYM ha^{-1} over control at maturity in blackgram.

The results of the above studies indicate that application of FYM stimulates the growth characters in different crops.

2.2.2 Effect of farm yard manure on yield and yield attributes

Gomes *et al.* (1993) reported higher efficiency of FYM in producing higher yield and improving chemical properties of soil compared to castor oil cake and urea. Senthilkumar and Sekhar (1998) observed that the fruit yield per plant in bhindi was increased markedly by FYM. According to Joseph (1998) in snakegourd, yield attributing characters like length, weight and number of fruits per plant were highest in FYM treated plants. The combined inoculation of *Azospirillum*, Phosphobacteria and AMF each at 2kg ha^{-1} with FYM 30 t ha^{-1} increased fruit size, number of fruits and tender fruit yield in cucumber (Nirmala *et al.*, 1999). FYM application recorded 25.9 and 19.6% more seed and straw yield in french bean respectively over no manure addition. The increase in yields due to FYM application was due to its favourable effect on growth and yield attributes of the plant. In terms of economics, FYM application also recorded higher net returns (Purushottam kumar and Puri, 2002).

These reviews indicate that FYM helps to improve the yield and yield attributing characters in various crops.

2.2.3 Effect of farm yard manure on quality attributes

Increased shelf life of spinach leaves due to application of 20t FYM/ha was reported by Kansal *et al.* (1981). He opined that application of 20 t FYM ha^{-1} increased the ascorbic acid content in spinach leaves. Montagu and Ghosh (1990) found that fruit color of tomato was significantly increased as a result of application of organic manures of animal origin. Abusaleha (1992) recommended equal quantity or more organic form of nitrogen for getting good quality okra fruits. Bhadoria *et al.* (2002) found that protein and total mineral content of okra fruit was high when treated with the FYM. Singh (2002) obtained high grain yield, high protein and vitamin C content by the application of FYM + dense organic manure in french bean. Omae *et al.* (2003) reported that cattle compost application increased freshness and vitamin C content in melon.

Majumdar *et al.* (2005) reported that application of FYM significantly increased the crude protein and oleoresin content of ginger. Shelf life was also prolonged under ambient storage condition by this treatment. The lowest crude fibre content in bhindi was recorded by the treatment receiving 20 t ha^{-1} FYM compared to the lower levels (Sekhar and Rajasree, 2009).

2.2.4 Effect of farm yard manure on soil properties

The favourable effect of FYM application on the structural properties of the soil was observed by several workers. Increase in soil moisture retention due to addition of FYM was observed by Salter and Williams (1963). Biswas *et al.* (1969) observed that application of FYM in a rice fallow rotation for ten years improved the water retention characteristics of an alluvial sandy loam soil. Havanagi and Mann (1970) reported that FYM application increased the organic carbon content and decreased the bulk density of soil.

According to Kanwar and Prihar (1982) continuous use of FYM increased the organic carbon as well as the nitrogen content of the soil. According to Badanur *et al.*

(1990) available phosphorus content of soil was significantly increased with the incorporation of subabul, sunhemp loppings and farmyard manure. Krishnaswami *et al.* (1984) reported that application of FYM or compost (15 t ha^{-1}) had a significant effect on increasing the available P from the native and applied source.

Swarup (1984) reported that application of FYM increased the availability of both native and applied micronutrient cations. These cations form stable complexes with organic ligands which decrease their susceptibility to adsorption and fixation.. Srivastava (1985) observed that increased use of nitrogenous fertilizer decreased organic C content and total N, while FYM increased the above parameters. Aravind (1987) observed that when FYM was applied as an organic source of nitrogen, bulk density of soil lowered form 1.30 to 1.06 g cc^{-1} compared to the poultry manure application, which lowered the same from 1.30 to 1.10 g cc^{-1}.

Lal and Mather (1988) reported that application of N, P and K fertilizers reduced the pH from 5.5 to 3.8, but FYM application maintained or increased the pH of the soil, while the combination of fertilizers and manures decreased the pH. Udayasoorian *et al.* (1988) reported that carbon content of soil increased from 0.91 to 1.58 per cent by the continuous application of organic manures and among the organic manures FYM had a significant influence. Increase in cation exchange capacity by the application FYM alone or in combination with fertilizers or lime and a reduction in CEC by the application of fertilizers alone was noticed in the permanent manurial experiment conducted by Sharma *et al.* (1988) at Chotanagpur.

Loganathan (1990) reported an increase in total soil porosity from 42.6 to 44.0 per cent when the rate of application of FYM was raised from 2.5 to 5 t ha^{-1}. Raju *et al.* (1991) observed FYM to be more effective in increasing N uptake in chickpea. Singh and Tomar (1991) reported that application of FYM and K had a positive effect on the uptake of Ca and Mg by wheat crop. Gupta *et al.* (1992) found FYM as a good source of P and attributed increased levels of enzyme activities and microbial biomass due to the decomposition products of the manure. Higher efficiency of FYM in producing higher yield and improving chemical properties of soil compared to castor oil cake and urea was revealed in a study conducted by Gomes *et al.* (1993) in cassava.

Goyal *et al.* (1993) reported that the application of FYM increased the microbial biomass, C and also the enzyme activities. According to Dhanokar *et al.* (1994) continuous use of FYM raised available K_2O by 1.3 to 5.4 fold over no manure application in vertisol. FYM application resulted in lowest acidity due to the decrease in exchangeable and soluble aluminum in soil (Nambiar, 1994). Minhas and Sood (1994) found that application of FYM was beneficial in enhancing the uptake of phosphorus by potato and maize.

Issac (1995) noted that available N, P_2O_5 and K_2O contents in the soil after the harvest were highest with the application of 12 t of FYM along with vermicompost as a source of nitrogen in bhindi. Joseph (1998), in a field experiment in snake gourd reported that organic carbon content was highest in FYM applied plots compared to poultry manure and vermicompost treated plots. A decrease in soil bulk density value from 1.55g cc^{-1} to 1.38g cc^{-1} with the application of FYM @ 32 t ha^{-1} was reported by Maheswarappa *et al.* (1999).

Application of FYM significantly brought down the bulk density of both surface and subsurface soil in comparison with the control. However application of different levels of fertilizer did not affect the bulk density. Singh *et al.* (2000) noticed an increase in total porosity from 42.6 to 44.0% when the rate of application of FYM was raised from 2.5 to 5 t ha^{-1}. Addition of FYM or decomposed rice straw improved the N, P and K status of soil (Bandgopadhyay and Puste, 2002). FYM application along with different levels of S, Mo, Fe, Zn and Co increased the uptake of major and micronutrients in cowpea at harvest (Sharma *et al.*, 2002).

Sreekala (2004) observed that soil physical characters viz., bulk density, particle density, WHC and soil aggregate index were superior for FYM + green leaf treatment as compared to that of vermicompost and neemcake. Increased organic carbon content due to FYM application as compared to that of poultry manure and neemcake was also reported by Sreekala (2004).

From the above reviews it can be concluded that FYM has a favourable effect on physical and chemical properties of soil.

2.4 Oil cake

Oil cakes are the residues left after the extraction of oil from oil seeds. About 0.3 million tonnes of non edible cake is produced annually. Oil cakes of non edible types like castor, neem and karanj are widely used as organic manure. Increase in plant height of Bhindi due to oil cake application was reported by Singh and Sitaramaiah (1963). Most of the non edible oilcakes are valued much due to their alkaloid content which inhibits the nitrification process of nitrogen transformation in soil. Islam and Haque (1992) mentioned the application of oilcakes as an organic manure during land preparation of brinjal, chilli and Bhindi for getting higher yield.

2.4.1 Effect of oil cake on growth of characters

Singh and Sitaramaiah (1963) reported increased plant height in bhindi due to oil cake application. Chinnaswamy (1967) observed better growth in tomato plants with the application of FYM and groundnut cake in organic mixture. Som *et al.* (1992) observed maximum plant height in brinjal with neem cake application (50 q ha^{-1}) as compared to other oil cakes. Sharu (2000) reported that in chilli the growth characters like plant height, number of branches and dry matter accumulation as a result of neem cake application was found to be on par with that of the POP recommendation of Kerala Agricultural University.

2.4.2 Effect of oil cake on yield and yield attributes

Islam and Haque (1992) considered oil cake as a good organic manure to be applied during land preparation of brinjal, chilli and bhindi for getting higher yield. Som *et al.* (1992) while studying the influence of organic manures on growth and yield in brinjal found that maximum fruit length and diameter were recorded when mahua cake and neem cake were applied @ 50q ha^{-1} produced the maximum fruit weight of 125.38g highest per plant yield of 1.43 kg and highest fruit yield of 22.56 t ha^{-1}. Asha (1999) reported that in bhindi, growth characters like plant height, LAI, DMP, yield attributes like fruit number per plant, fruit weight, fruit length and fruit yield were higher in neem cake treated plants as compared to that of FYM, poultry manure, green leaf and enriched compost on equivalent N basis.

Arunkumar (2000) reported that in amaranthus, application of neem cake produced higher yield as compared to that of chemical fertilizers on equivalent N basis, but was inferior to that of FYM, vermicompost and poultry manure. Asha (2006) observed that in amaranthus, highest green yield of 15.07 t ha^{-1} was recorded in neem cake applied plots compared to enriched vermicompost.

2.4.3 Effect of oil cake on quality attributes

Saharawat and Mukherjee (1997) reported that application of mahua cake improved the grain protein content in rice.

2.4.4 Effect of oil cake on soil properties

Biswas *et al.* (1969) found that application of groundnut cake in a rice fallow rotation for ten years improved the water retention characteristics of an alluvial sandy loam soil. The application of neem cake added organic carbon and potash to the soil (Sadanandan and Iyer, 1986). Sadanandan and Hamza (1998) reported improved physical condition of the soil as a result of neem cake application in ginger. Asha (2006) reported that in amaranthus, the residual effect of neem cake along with microbial inoculation improved porosity and WHC of the soil.

According to Sathianathan (1982) in cassava, neem and mahua cake treatments were efficient in retaining more nitrogen in the ammoniacal form under field condition. These oil cakes reduced leaching losses and extended the period of availability of nitrogen to the crop from applied N. The neem, mahua, karanj and castor oil cakes have great value as means of immobilizers, thus conserving the applied and soil nitrogen and mineralizing steadily over a longer period. They could aid in metered supply of nitrogen over a stipulating period of crop growth (Hulagur, 1996). Asha (1999) reported that, in bhindi, available N content in soil was highest for neem cake application as compared to that of FYM, poultry manure and compost. Significant increases in crop yield and N uptake were obtained by using cereal straw and neem cake in the proportion of 3:1 in maize crop (Gaur and Mathur, 1979). In bhindi, N and P uptake and available N in soil were highest for neem cake application as compared to FYM, poultry manure and compost (Asha, 1999).

Materials and Methods

3. MATERIALS AND METHODS

The present pot culture experiment entitled "Organic nutrient scheduling in soilless vegetable cultivation" has been carried out at College of Agriculture, Vellayani during the year 2012-13. The study was carried out to standardize soilless media and nutrient schedule for organic vegetable production (grown in containers) and to work out the economics of different treatments, and also to assess the effect of growth media on growth, yield and quality of bhindi. The investigation has two parts (1) Standardization of different growth media for soilless culture and (2) Nutrient scheduling for soilless culture. The details of the experimental site, season, weather conditions, materials used and the methods adopted are briefly presented in this chapter.

3.1 MATERIALS

3.1.1 EXPERIMENT SITE

The experiment was carried out at College of Agriculture,Vellayani. The site is situated at 8^0 30 N latitude and 76^0 54 E longitude and at an altitude of 29 m above MSL.

3.1.2 GROWING MEDIA

The growing media used in the experiment was various combinations of coirpith and coirpith compost with FYM, neopeat and potting mixture. For all combinations except potting mixture, 4 kg media was filled in pots having 7 litre capacity. The media was filled compactly to avoid lodging of plants. In the case of potting media, 6 kg media was filled in pots.

3. 1.3 WEATHER

Data on weekly averages of the weather parameters viz, maximum and minimum temperature, relative humidity and rainfall received during the cropping

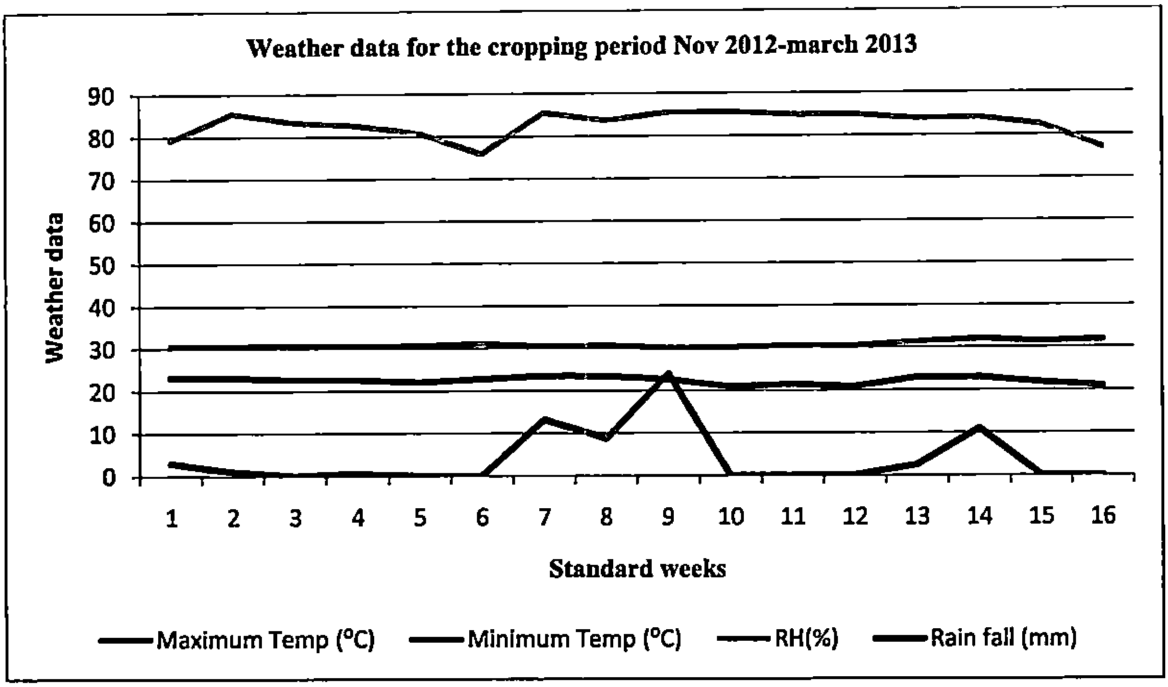


Fig 1a. Weather parameters during the cropping period (Bhindi) (Nov 2012 to March 2013)

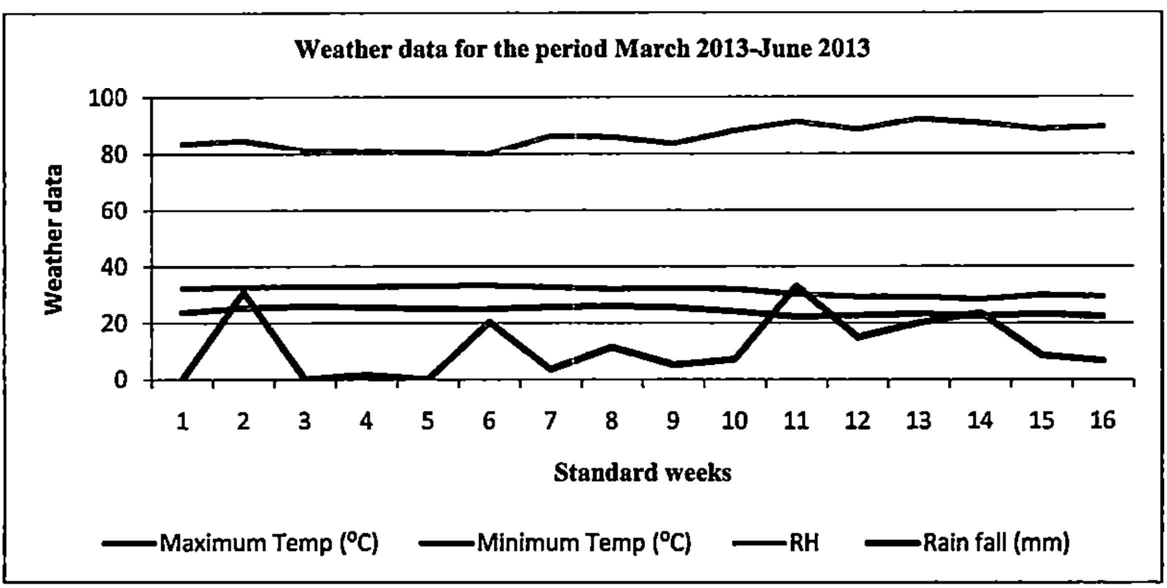


Fig 1b. Weather parameters during the cropping period (Bhindi) (Mar 2013 to Jul 2013)

period were collected from the Agro-meteorological observatory attached to the Department of Agronomy, College of Agriculture, Vellayani .

3. 1.4 SEASON

The experiment was conducted during the period 2012-2013.

3.1.5 Cultivar used/ Variety

The cultivar/variety of Bhindi used for the experiment is Varsha Uphar released from Chaudhary Charan Singh Haryana Agricultural University , Hissar by inter varietal hybridization between 'Lam Selection 1' and 'Parbhani Kranti' following pedigree selection in 1996.

Varsha Uphar is a green fruited, early yielding variety, with a duration of 105 days and resistant to Yellow Vein Mosaic disease.

3.1.6 Source of Seeds

Seeds of the variety Varsha Uphar were obtained from Department of Olericulture, College of Agriculture, Vellayani.

3.1.7 Pseudomonas culture

Pseudomonas culture was obtained from the Department of Microbiology, College of Agriculture,Vellayani.

3.1.8 Manures and Fertilizers

Top dressing was done using ground nut cake.

3.2 METHODS

PART 1

3.2.1 Design and Layout

Part I: Standardization of different growth media for soilless culture

The lay out of the experiment is presented in Fig 1

General view of the experimental field is given in Plate 1.

Design	: CRD
Treatment combinations	: 7
Replications	: 3
Number of pots	: 105
Season	: Summer 2012/2013
Crop	: Bhindi
Variety	: Varsha Uphar

Fig.1. Lay out plan of the experiment

E ↑

M_1	M_4	M_7	M_3	M_6	M_2	M_5
M_2	M_5	M_1	M_4	M_7	M_3	M_6
M_3	M_6	M_2	M_5	M_1	M_4	M_7

3.2.2 Treatments

Growth Media (M)

M_1 : Coir pith + FYM (1:1ratio by weight)

M_2 : Coir pith + FYM (1:2 ratio by weight)

M_3 : Coir pith compost + FYM (1:1 ratio by weight)

M_4 : Coir pith compost + FYM (2:1 ratio by weight)

M_5 : Coir pith compost alone (by weight)

M_6 : Compressed coir pith (Neopeat) (by weight)

M_7 : Potting mixture -1:1:1 soil, sand and FYM (ratio by weight)

The best media with respect to yield and economics will be selected for Part II study.

Part II

Nutrient scheduling for soilless culture

Design	: CRD
Treatment combinations	: 3X 2
Replications	: 4
Season	: Summer 2012/2013

Nutrient levels (N)

N_1: KAU Package of practices recommendations for organic crop production (KAU POP)

N_2: 75 % of POP as organic

N_3: 125 % of POP as organic

KAU POP as organic- Top dressing with ground nut cake 1kg/10 liters (50kg/ha) at 10-15 days interval.

Method of application for top dressing (T)

T_1: Direct application to growth media

The measured quantity of fermented ground nut slurry mixed with water was poured to media.

T_2: Foliar application

The measured quantity of fermented ground nut slurry mixed with water was sprayed to leaves.

3.3. Crop husbandry

3.3.1 Land preparations

The experimental area was cleared of weeds and stubbles. The pots were arranged at a spacing of 60 × 30 cm

3.3.2 Inoculation with Pseudomonas

Seeds were soaked in water (12 hrs) before sowing and then it was inoculated with *Pseudomonas* for half an hour before sowing.

3.3.3 Application of Manures and Fertilizers

Ground nut cake (6.3% N, 0.69 % P, and 1.4 % K) was used for top dressing.

3.3.4 Other management practices

Measured quantity of water was poured to pots.

3.3.5. Plant protection

For controlling leaf hoppers, white flies and aphid, neem oil - garlic emulsion (2%) was applied.

3.3.6. Harvest

Harvest of the fruit was started from 60 DAS and was repeated on alternate days. Maturity of the fruits for harvest was decided by visual appearance (usually 7 days after flowering).

3.4 Observations

Biometric observations

Six plants were selected in observational plants for observing biometric observations.

3.4.1 Growth characters

3.4.1.1 Height of the plant (cm)

Height of the plant was measured from base of the plant to the terminal leaf bud at 15 days interval and expressed in centimeters.

3.4.1.2 Number of branches

The number of the branches per plant was recorded from the observation plants at 15 days intervals and the average was worked out.

3.4.1.3. Number of leaves

From the observational plants, the number of leaves was counted and average was calculated.

3.4.1.4 Leaf area index (LAI)

LAI was computed using the formula suggested by Watson (1952) at 30 days interval.

LAI = Leaf area/Land area

3.4.1.5. Duration of the crop

Duration is the number of days from sowing to final harvest of the plant.

3.4.1.6. Lodging percentage

From the observation plants, number of plants lodged was counted and expressed as percentage.

3.4.2. Yield and yield attributes

Yield and yield attributes were recorded from observational plants.

3.4.2.1 Number of flowers per plants

Flowers from the observation plants were recorded and the average was worked out.

3.4.2.2 Number of fruits per plants

Number of fruits harvested from observation plants were counted and the mean values were worked out.

3.4.2.3. Setting percentage (%)

Setting percentage was calculated by dividing the total number of fruits with the total number of flowers produced in the same plant. This was worked out in the observation plants and the mean values were worked out.

Setting percentage was worked out by the formula:-

Setting percentage = Number of fruits / Number of flowers opened X 100

3.4.2.4 Length of fruit (cm)

Length of the fruits harvested from observation plants was measured and the mean length was worked out and expressed in centimeters.

3.4.2.5 Girth of the fruit (cm)

The fruits used for measuring the length were used for recording the girth. Girth was measured by winding a thread around the individual fruits at the centre.

3.4.2.6. Number of harvests

Number of harvests from the observational plants was recorded and the mean values were computed.

3.4.2.7. Fruit yield per plant (g plant^{-1})

Fruit yield per plant was computed by adding the weights of fruits of each harvest of the observational plants and the mean values were worked out and expressed as g plant^{-1}.

3.4.2.8. Fruit yield (t ha^{-1})

Weights of the fruits harvested were noted for the observational plants from each pot at the end of the cropping season. The mean values were recorded and converted into per hectare yield.

3.4.2.9. Number of malformed fruits

Out of the total number of fruits formed, the number of malformed fruits was counted.

3.4.3 Root characteristics

3.4.3.1 Root length

Length of taproot was recorded at final harvest and expressed in cm.

3.4.3.2 Root spread

The length of the largest lateral root on both sides of the taproot was measured, the mean worked out and expressed in cm

3.4.3.3 Root volume

Volume of roots per plant was estimated by displacement method and expressed in cm^3 plant^{-1}.

3.5 Analytical procedures

3.5.1 Potting media analysis

Samples of potting media were air dried, ground, passed through 2 mm sieve and analysed for chemical properties. Fresh samples were used for biological analysis using standard procedure given in Table 1.

Table 1. Analytical procedures followed in potting media analysis

Sl. No.	Properties	Method	Reference
	A. Physical properties		
1	pH	pH meter	Jackson(1973)
2	EC	Conductivity meter	Jackson(1973)
	B. Chemical properties		
1	Organic carbon	Walkley and Black rapid titration method(1934)	Jackson(1973)
2	Available N	Alkaline permanganate method	Subbiah and Asija (1956)
3	Available P	Extraction with Bray and estimation by colorimetry	Jackson(1973)
4	Available K	Flame photometry	Jackson(1973)
	C. Microbial properties		
5	Microbial count a. fungi b. Bacteria c. Actinomycetes	Serial dilution plate technique	Timonin (1940)

Table 2 .Chemical properties of potting mixture

Sl.No.	Properties	Potting mixture
1	Organic carbon (%)	2.17
2	Available Nitrogen (kg/ha)	179.80
3	Available Phosphorus (kg/ha)	52.80
4	Available Potassium (kg/ha)	133.10
5	pH	6.50
6	EC (dS/m)	1.17

3.5.2 Analysis of manures

Manures used for preparation of potting media were analyzed for pH, EC, organic carbon, total nitrogen, total phosphorus, total potassium and microbial count using standard procedures and data are presented in Table.3

Table . 3 Analytical procedures followed in growth media analysis

Sl No.	Parameters	Methods	Reference
1	Organic carbon	Walkley and Black rapid titration method(1934)	Jackson(1973)
2	Nitrogen	Wet digestion by H_2SO_4 and microkjedahl method	Jackson(1973)
3	Phosphorus	Digestion with H_2SO_4 and phosphomolybdate yellow colour method	Jackson(1973)
4	Potassium	Digestion with H_2SO_4 and flame photometry	Jackson(1973)

5	pH	pH meter method	Jackson(1973)
6	EC	Conductivity meter method	Jackson(1973)
7	Microbial count	Serial dilution plate technique	Timonin(1940)

Table 4. Chemical properties of the growth media

Sl. No.	Properties	Growth media					
		M_1	M_2	M_3	M_4	M_5	M_6
1	Organic carbon (%)	8.50	8.25	7.50	8.17	7.25	11.00
2	Nitrogen	1.66	1.49	1.30	1.37	1.21	0.74
3	Phosphorus	0.54	0.34	0.19	0.46	0.16	0.069
4	Potassium	0.17	0.15	0.13	0.11	0.09	0.92
5	pH	6.67	6.61	6.67	6.66	6.7	6.5
6	EC	1.00	0.67	1.00	0.93	0.83	1.43

3.5. Water use efficiency

Water use efficiency was found out by the formula:-

WUE (kg/pot/l) = Yield / (Duration X Quantity of water applied)

3.6. Microbial load in the media before and after the experiment

Total microbial load *ie.*, fungal, bacterial and actinomycetes load were calculated before and after the experiment. Media samples were taken randomly from the experimental pots before the experiment.

The microbial population in the rhizhosphere was estimated by the serial dilution plate technique (Johnson and Curl, 1972). One gram of media was taken and transferred to 100 ml of sterile water and shaken for 5-10 minutes using a rotary shaker. From this stock suspension, different dilutions of 10^{-2}, 10^{-3}, 10^{-4}, $10^{-5}$and 10^{-6} were prepared. The fungal population was estimated at 10^{-4} dilution while 10^{-6} dilution was used for bacterial and 10^{-3}actinomycetes population.

The numbers of colony forming units (cfu) of microbes were calculated using the formula,

$$\text{cfu} = \frac{\text{Average number of colony developed X dilution factor}}{\text{Weight of soil taken (g)}}$$

3.6.1 Total bacterial load

The media used to find out the bacterial load was nutrient agar.

Table 5 Chemical composition of nutrient agar

Sl.No.	**Ingredients**	**Quantity**
I	Beef extract	3g
2	Peptone	5g
3	$NaCl_2$	5g
4	Agar	20g
5	Distilled Water	1000 ml
6	pH	7

3.6.2 Total fungal load

The media used was rose bengal agar and the total fungal load was calculated.

Table 6. Chemical composition of rose bengal agar

Sl.No.	Ingredients	Quantity
1	Glucose	10.00 g
2	Peptone	5.00g
3	K_2HPO_4	1.00g
4	$MgSO_4.7H_2O$	0.5 g
5	Streptomycin	30.00mg
6	Agar	20.00 g
7	Rose Bengal	0.035 g
8	Distilled water	1000ml
9	pH	7.0

3.6.2 Total actinomycetes load

Total actinomycetes load was calculated using ken knight's media.

Table 7. Chemical composition of Ken knight's media

Sl.No.	Ingredients	Quantity
1	Dextrose	1.0 g
2	K_2HPO_4	0.01g
3	$NaNO_3$	0.01g
4	KCl	0.01g
5	$MgSO_4.7H_2O$	0.01g
6	Agar	15.0 g
7	Distilled water	1000ml
8	pH	7.0

Table 8. Microbial load in the media before the experiment

Sl.No.	Microbial count($cfug^{-1}$)	Growth media						
		M_1	M_2	M_3	M_4	M_5	M_6	M_7
1	Bacteria, 10^6	125.00	32.00	41.00	32.00	15.67	30.33	145.00
2	Fungi, 10^4	10.33	4.67	5.33	3.67	8.67	3.33	20.33
3	Actinomycetes, 10^3	8.33	6.33	4.00	4.00	0.00	12.00	26.67

3.7. Pest and disease incidence

Incidence of pests and diseases were noted at regular intervals and timely control measures were taken.

For controlling Jassids, leaf hoppers, white flies and aphids, neem oil - garlic emulsion (nimbicidine-2%) was applied

For controlling fruit and shoot borers and leaf rollers *Beauveria bassiana* was applied.

3.8. Plant analysis

Sample plants collected from each pot at harvest were chopped, sun dried and oven dried (70^{0}C) to a constant weight .Samples were ground to pass through a 0.5mm mesh in a Willey Mill and the required quantity of samples were digested and used for nutrient content analysis.

3.8.1 Uptake of nitrogen

The nitrogen content in plant samples was estimated by the modified microkjeldhal method (Jackson, 1973) and the uptake of nitrogen was calculated by multiplying the nitrogen content of plant sample with the total dry weight of plants. The uptake values were expressed in g per plant.

3.8.2 Uptake of phosphorus

The phosphorus content in the plant sample was colorimetrically determined by wet digestion of the sample and developing colour by yellow colour method and read in Spectrophotometer (Piper, 1967).The uptake of phosphorus was calculated by multiplying the phosphorus content of plant sample with the total dry weight of plants. The uptake values were expressed in g per plant.

3.8.3 Uptake of potassium

The potassium content in the plant sample was determined by flame photometer method and expressed in percentage (Piper, 1967). The uptake of potassium was calculated by multiplying the potassium content of plant sample with the total dry weight of plants. The uptake values were expressed in g per plant.

3.9 Economic analysis

Economics of cultivation was worked out for the pot culture experiment after taking into account the cost of cultivation and prevailing market price of Bhindi.

The net income and B:C ratio were calculated as follows.

Net income = Gross income – Total expenditure

Benefit : Cost ratio = Gross income/ Total expenditure

3.10 Statistical Analysis

Data generated from the experiment were subjected to statistical analysis applying ANOVA technique and significance was tested by 'F' test (Snedecor and Cochran, 1975). In the cases where the effects were found to be significant, CD was calculated using standard techniques.

Results

4. RESULT

A pot culture experiment to standardize organic nutrient scheduling for soilless culture was conducted at Instructional farm, College of Agriculture, Vellayani during the period 2012-2013. The experimental data collected were statistically analyzed and the results obtained are presented below.

Part 1.Standardization of different growth media for soilless culture

4.1.1 Growth Characters of Bhindi

4.1.1.1 Height of the plant (cm)

The average height of the plants recorded at 15, 30, 45,60,75,90 and 105 DAS is presented in table 9.

The result showed that different growth media significantly influenced the plant height at all growth stages. At 15 DAS M_4 was found to be on par with all the treatments except M_6. At 30 DAS M_4 was on par with M_1 (25.15 cm), M_3 (23.37 cm) and M_5 (23.06 cm). At 75 DAS M_4 was on par with M_7 (56.15) and was significantly superior to all the other treatments. At 45, 60, 90 and 105 DAS, M_7 recorded maximum height (45.10 cm, 51.15 cm, 70.10 cm and 80.67 cm respectively). At 45, 90 and 105 DAS, M_7 was significantly superior to all other treatments. At 60 DAS and 75 DAS, M_7 was on par with M_4 (47.93 cm).

4.1.1.2 Number of branches

Data recorded on number of branches in bhindi, shown in table 10 revealed that growth media has no significant influence on branching.

4.1.1.3 Number of leaves

The average number of leaves plants^{-1} recorded at 15, 30, 45, 60, 75, 90 and 105 DAS are presented in table 11.

The results showed that different growth media significantly influenced the number of leaves at all growth stages except at 15 DAS. M_7 recorded the highest

Table 9. Effect of different growth media on height of the plant, cm

Growth media	Days After Sowing, DAS						
	15	30	45	60	75	90	105
M_1	15.35	25.15	32.25	44.22	53.02	59.35	63.68
M_2	16.92	22.73	33.23	45.83	51.78	55.83	60.75
M_3	16.22	23.37	33.13	43.45	50.40	54.90	63.02
M_4	17.32	25.55	39.28	47.93	61.00	62.88	68.37
M_5	16.53	23.06	36.77	43.77	51.67	58.08	64.85
M_6	8.20	9.60	7.23	7.27	7.75	9.23	12.83
M_7	16.40	21.52	45.10	51.15	56.15	70.10	80.67
SE	0.66	0.88	1.38	1.34	1.82	1.40	2.21
CD (0.01)	1.99	2.66	4.18	4.06	5.52	4.24	6.71

M_1 : Coir pith + FYM 1:1
M_2 : Coir pith + FYM 1:2
M_3 : Coir pith compost + FYM 1:1
M_4 : Coir pith compost + FYM 2:1
M_5 : Coir pith compost alone
M_6 : Compressed coir pith (neopeat)
M_7 : Potting mixture (1:1:1 soil, sand and FYM)

Table 10. Effect of different growth media on number of branches of the plant

Growth media	Number of branches
M_1	1.00
M_2	1.00
M_3	1.00
M_4	1.00
M_5	1.00
M_6	1.00
M_7	1.00
SE	0.00
CD (0.01)	NS

M_1 : Coir pith + FYM 1:1
M_2 : Coir pith + FYM 1:2
M_3 : Coir pith compost + FYM 1:1
M_4 : Coir pith compost + FYM 2:1
M_5 : Coir pith compost alone
M_6 : Compressed coir pith (neopeat)
M_7 : Potting mixture (1:1:1 soil, sand and FYM)

Table 11.Effect of different growth media on number of leaves of the plant

Growth media	Days After Sowing, DAS						
	15	30	45	60	75	90	105
M_1	5.17	6.33	7.17	7.00	8.00	9.67	8.33
M_2	5.50	5.83	7.50	7.17	8.83	8.83	8.33
M_3	5.50	4.50	6.33	7.83	10.50	9.50	8.17
M_4	6.00	6.33	7.67	8.27	9.83	9.83	9.00
M_5	5.83	6.83	7.00	8.33	8.67	8.50	8.67
M_6	4.17	4.17	4.33	4.67	4.50	5.17	5.33
M_7	6.17	6.93	8.17	7.17	9.83	9.67	9.83
SE	0.33	0.38	0.46	0.44	0.54	0.59	0.49
CD(0.01)	1.01	1.14	1.39	1.34	1.63	1.80	1.48

M_1 : Coir pith + FYM 1:1
M_2 : Coir pith + FYM 1:2
M_3 : Coir pith compost + FYM 1:1
M_4 : Coir pith compost + FYM 2:1
M_5 : Coir pith compost alone
M_6 : Compressed coir pith (neopeat)
M_7 : Potting mixture (1:1:1 soil, sand and FYM)

Table 12. Effect of different growth media on leaf area index of the plant

Growth media	Days After Sowing, DAS		
	30 DAS	60 DAS	90 DAS
M_1	0.29	0.60	1.15
M_2	0.18	0.62	0.91
M_3	0.17	0.68	0.98
M_4	0.29	0.74	1.17
M_5	0.32	0.76	0.84
M_6	0.15	0.34	0.41
M_7	0.33	0.34	1.15
SE	0.010	0.011	0.023
CD(0.01)	0.031	0.034	0.072

Table 13. Effect of different growth media on duration of the plant, days

Growth media	Crop duration
M_1	106.33
M_2	106.83
M_3	107.67
M_4	99.33
M_5	105.83
M_6	117.83
M_7	102.00
SE	2.59
CD(0.01)	7.87

number of leaves at 30 DAS (6.93), 45 DAS (8.17) and 105 (9.83) DAS. At 30 DAS it was found to be on par with M_1 (6.33), M_2 (5.83), M_4 (6.33) and M_5 (6.83). At 45 DAS, M_7 was on par with M_1 (7.17), M_2 (7.50), M_4 (7.67) and M_5 (7.0). At 60 DAS and 90 DAS, M_4 recorded the highest number of leaves (8.27 and 9.83 respectively) and at both stages was on par with all other treatments except M_6. At 75 DAS, M_3 (10.50) recorded highest number of leaves and was on par with M_4 (9.83) and M_7 (9.83). At 105 DAS and 45 DAS, it was found to be on par with M_4 (9.00) and M_5 (8.67).

4.1.1.4 Leaf area index

The average leaf area index of the plants calculated at 30,60 and 90 DAS is presented in table 12.

At 30 DAS, M_7 (0.33) recorded the highest LAI and was on par with M_5 (0.32), M_1 (0.29) and M_4 (0.29). At 60 DAS, M_5 (0.76) and at 90 DAS, M_4 (1.17) recorded significantly superior LAI.

4.1.1.5 Duration of the crop (Days)

The average duration of the crop given in table 13 revealed that different growth media has significant influence on the duration of the crop. M_6 (117.83) recorded the highest duration, which is followed by M_3 (107.67). The minimum duration was noticed in M_4 (99.33).

4.1.1.6 Lodging percentage

In the pot experiment, none of the plants showed lodging.

4.1.2 Yield attributes and yield

4.1.2.1 Flowers per plant

The number of flowers per plant recorded is presented in table 14.

The results showed that number of flowers per plant was significantly influenced by different growth media. M_4 recorded highest number of flowers per plant (21.30) which was on par with M_7 (20.17). The lowest number of flowers per plant was recorded by M_6 (6.67).

Table 14. Effect of growth media on yield characters of the plant

Growth media	Flowers/plant	Fruits/plant	Setting %	No.of harvest
M_1	16.00	7.67	48.34	6.83
M_2	16.33	10.17	60.61	7.67
M_3	17.83	9.83	56.06	8.33
M_4	21.30	12.33	56.18	9.33
M_5	17.00	8.33	62.97	7.50
M_6	6.67	3.33	50.95	3.33
M_7	20.17	13.00	64.43	9.00
SE	0.91	0.77	4.62	0.36
CD(0.01)	2.75	2.12	14.03	1.08

M_1 : Coir pith + FYM 1:1
M_2 : Coir pith + FYM 1:2
M_3 : Coir pith compost + FYM 1:1
M_4 : Coir pith compost + FYM 2:1
M_5 : Coir pith compost alone
M_6 : Compressed coir pith (neopeat)
M_7 : Potting mixture (1:1:1 soil, sand and FYM)

4.1.2.2 Number of fruits per plant

The number of fruits per plant recorded is shown in table 14.

Different growth media has significant influence on number of fruits per plant. M_7 recorded highest number of fruits per plant (13) which was on par with M_4 (12.33). The minimum number of fruits per plant was recorded by M_6 (3.33).

4.1.2.3 **Setting percentage**

Data presented in the table 14 showed that different growth media significantly influenced the setting percentage. The treatment M_7 (64.43) recorded highest setting percentage and was on par with M_5 (62.97) and M_2 (60.61).The minimum setting percentage was recorded by M_1 (48.34).

4.1.2.4 **Number of harvests**

The data on number of harvests recorded in table 14 revealed that different growth media significantly influenced the number of harvests. M_4 recorded the maximum number of harvest (9.33) and was on par with M_7 (9) and M_3 (8.33). The minimum number of harvests was recorded in M_6 (3.33).

4.1.2.5 Length of fruit (cm)

The data on length of fruit recorded in table 15, revealed that different growth media has significant influence on length of fruit. M_7 recorded the highest fruit length (15.61cm) and was on par with M_4 (15.16).The minimum fruit length was recorded by M_6 (9.31).

4.1.2.6 Girth of fruit(cm)

The data on girth of fruit is recorded in table 15.

It can be seen that growth media significantly influenced the girth of fruits. M_4 (5.53) recorded highest fruit girth and was on par with M_7 (5.30), M_1 (5.28) and M_3 (5.14) and minimum fruit girth was recorded by M_6 (4.55).

4.1.2.6 Fruit yield per plant (g/plant)

The average fruit yield/plant was recorded and the data is given in table 15.

Table 15. Effect of growth media on yield and yield attributes of the plant

Growth media	Length of fruit(cm)	Girth of fruit(cm)	Fruit yield/plant (g/plant)	Total fruit yield (t/ha)	Number of malformed fruits
M_1	13.50	5.28	122.82	6.75	1.67
M_2	12.73	4.81	142.90	7.86	1.00
M_3	12.66	5.14	162.62	8.94	1.00
M_4	15.16	5.53	227.92	12.53	1.67
M_5	12.13	4.93	162.82	8.96	1.67
M_6	9.31	4.55	25.44	1.40	1.00
M_7	15.61	5.30	229.78	12.64	1.33
SE	0.58	0.19	5.74	5.29	0.76
CD(0.01)	1.77	0.56	17.41	10.79	0.25

M_1 : Coir pith + FYM 1:1
M_2 : Coir pith + FYM 1:2
M_3 : Coir pith compost + FYM 1:1
M_4 : Coir pith compost + FYM 2:1
M_5 : Coir pith compost alone
M_6 : Compressed coir pith (neopeat)
M_7 : Potting mixture (1:1:1 soil, sand and FYM)

The result showed that different growth media could significantly influence the fruit yield per plant. The highest fruit yield per plant was recorded by M_7 (229.78g/plant) and it was on par with M_4 (227.92g/plant).Lowest fruit yield per plant was recorded in M_6 (25.44g/plant).

4.1.2.7 Total fruit yield (t ha^{-1})

The data recorded on total fruit yield (t ha^{-1}) are presented in table 15.

The results showed that different growth media had significant influence on total fruit yield. The highest total fruit yield was recorded with M_7 (12.64) and was on par with all other treatments. The lowest fruit yield was recorded by M_6 (1.4).

4.1.2.8. Number of malformed fruits

The data on average number of malformed fruit given in table 15, revealed that different growth media had no significant influence on the number of malformed fruits.

4.1.3 ROOT STUDY

Data regarding the effect of different growth media on root characters is given in table 16.

4.1.3.1. **Root length (cm)**

The data on different growth media has significant influence on root length given in the table 16. M_4 recorded the highest root length (66.27 cm) and was found to be on par with M_1 (57.40 cm), M_2 (58.27 cm), M_3 (63.27 cm) and M_5 (57.77 cm).The minimum root length was recorded by M_6 (31.30 cm).

4.1.3.2 Root spread (cm)

The different growth media has significant influence on root spread shown in the table 16. M_5 (18.67) recorded the highest root spread and it was found to be on par with M_4 (18.53).The minimum root spread was recorded by M_6 (14.73).

4.1.3.3 Root volume (cm^3)

Table 16. Effect of different growth media on root characters and WUE of the plant

Growth media	Root length (cm)	Root spread (cm)	Root volume (cm³)	WUE (kg/pot/l)
M_1	57.40	15.27	180.00	0.0021
M_2	58.27	15.53	206.00	0.0023
M_3	63.27	16.77	285.33	0.0024
M_4	66.27	18.53	503.33	0.0031
M_5	57.77	18.67	450.33	0.0026
M_6	31.30	14.73	94.33	0.0001
M_7	53.00	15.10	151.00	0.0022
SE	3.75	0.52	6.62	0.0001
CD(0.01)	11.38	1.58	4.29	0.0003

M_1 : Coir pith + FYM 1:1
M_2 : Coir pith + FYM 1:2
M_3 : Coir pith compost + FYM 1:1
M_4 : Coir pith compost + FYM 2:1
M_5 : Coir pith compost alone
M_6 : Compressed coir pith (neopeat)
M_7 : Potting mixture (1:1:1 soil, sand and FYM)

Growth media has significant influence on root volume is given in the table 16. M_4 recorded the highest root volume (503.33) followed by M_5 (450.33). Minimum root volume was recorded by M_6 (94.33).

4.1.4 Water use efficiency (kg/pot/l)

The data on water use efficiency given in table 16 revealed that M_4 recorded the highest WUE (0.0031) and was significantly superior to all other treatments. WUE was minimum in M_6 (0.0001).

4.1.5 MICROBIAL LOAD

4.1.5.1 Bacterial count

The data on average bacterial count is given in the table 17.

Growth media has significant influence on bacterial count. M_7 recorded highest bacterial population 74×10^6, which was significantly superior to all other treatments. The data shows a decreasing trend in bacterial count to 74×10^6 from 145×10^6.

4.1.5.2 Fungal count

The data on average fungal count given in table 17 revealed that number of fungal propagule has shown a decreasing trend in different growth media. Maximum count and reduction of fungal propagule was found in M_7 and the number was reduced to 13.67×10^4 from 20.33×10^4.

4.1.5.3 Actinomycetes count

The data on average actinomycetes count is given in the table 17.

The number of actinomycetes showed a decreasing trend in different growth media. Maximum number of actinomycetes was found in M_7 and the count was increased to 68.67×10^3 from 41.00×10^3.

4.1.6 Chemical analysis of the growth media before and after the experiment

4.1.6.1Organic carbon and available NPK content of potting mixture

Table 17. Effect of different growth media on microbial load in the media

Growth media	bacterial count, 10^6		Fungal count, 10^4		Actinomycetes count, 10^3	
	Initial	Final	Initial	Final	Initial	Final
M_1	125.00	31.33	10.33	7.33	8.33	5.33
M_2	32.00	8.67	4.67	1.67	6.33	4.00
M_3	41.33	9.00	5.33	1.33	4.00	4.33
M_4	32.00	4.67	3.67	1.33	4.00	3.00
M_5	15.67	7.67	8.67	6.00	0.00	0.33
M_6	30.33	8.33	3.33	7.00	12.00	7.67
M_7	145	74.67	20.33	13.67	41.00	68.67
SE	7.22	3.42	1.42	1.46	3.90	2.92
CD(0.01)	7.23	10.36	4.31	4.42	11.82	8.87

M_1 : Coir pith + FYM 1:1
M_2 : Coir pith + FYM 1:2
M_3 : Coir pith compost + FYM 1:1
M_4 : Coir pith compost + FYM 2:1
M_5 : Coir pith compost alone
M_6 : Compressed coir pith (neopeat)
M_7 : Potting mixture (1:1:1 soil, sand and FYM)

Table 18. Chemical properties of the potting mixture after the experiment

Sl no	Properties	Potting mixture
1	Organic carbon (%)	1.16
2	Available Nitrogen (kg/ha)	367.87
3	Available Phosphorus (kg/ha)	62.2
4	Available Potassium (kg/ha)	50.82
5	pH	6.50
6	EC (dS/m)	1.17

A general decrease was noticed in organic carbon and increase was observed in nitrogen, phosphorus, potassium of the potting mixture after the experiment(table 18). Organic carbon was decreased in the potting mixture from 2.17(%) to 1.16(%), available nitrogen was increased in the mixture from 179.797 (kg/ha) to 367.867(kg/ha). Available phosphorus was increased from 52.8 (kg/ha) to 68.2(kg/ha) and available potassium content in media was reduced from 133.1 (kg/ha) to 50.82 (kg/ha).

4.1.6.2 Available NPK content of growth media

4. 1.6.2.1 Nitrogen (%)

The data on total nitrogen was presented in the table 19.

A decrease in nitrogen content was noticed in all the treatments after the experiment. M_3 recorded the highest value (0.57) which was on par with all other treatments. M_1 (0.42), M_2 (0.50), M_4 (0.30), M_5 (0.27), M_6 (0.48)

4.1.6.2.2 **Phosphorus (%)**

The data on total phosphorus content was presented in the table 19.

A decrease in phosphorous content was noticed in all the treatments after the experiment. M_2 recorded the highest value (0.28) and the lowest value was recorded in M_6 (0.06).

4.1.6.2.3 **Potassium**

The data on total potassium content was presented in the table 19.

A decrease in potassium content was noticed in all the treatments after the experiment. M_6 recorded the highest value (0.63) and it was found to be on par with M_4 (0.15).

Table 19. Chemical properties of growth media after the experiment.

Growth media	N (%)	P (%)	K (%)	pH	EC (dS/m)
M_1	0.42	0.18	0.02	5.36	0.65
M_2	0.50	0.28	0.04	5.37	0.32
M_3	0.57	0.06	0.08	5.79	1.20
M_4	0.29	0.14	0.15	5.39	1.05
M_5	0.26	0.14	0.02	5.55	1.39
M_6	0.47	0.06	0.63	5.53	0.57
SE	0.26	0.09	0.16	0.20	13.36
CD	0.79	0.28	0.49	0.62	40.52

M_1 : Coir pith + FYM 1:1
M_2 : Coir pith + FYM 1:2
M_3 : Coir pith compost + FYM 1:1
M_4 : Coir pith compost + FYM 2:1
M_5 : Coir pith compost alone
M_6 : Compressed coir pith (neopeat)
M_7 : Potting mixture (1:1:1 soil, sand and FYM)

4.1.6.2.4 pH

The data on pH was presented in table 19.

A sharp decrease in pH was noticed in all the treatments after the experiment. M_3 recorded the highest value (5.79) which was on par with all other treatments.

4.1.6.2.5 EC (dS/m)

The data on total EC value was presented in table 19.

A sharp decrease in EC was noticed in all the treatments after the experiment. M_5 (1.39) recorded the highest value and was on par with M_3 (1.20) and M_4 (1.05).

4.1.7. Plant analysis

4.1.7.1 Nitrogen uptake (g/plant)

The data on nitrogen uptake presented in table 20.

The result shows that different growth media has significant influence on uptake of nitrogen .The highest nitrogen uptake was recorded in M_4 (4.38) and the lowest was recorded in M_6 (0.88).

4.1.7.2 Phosphorus uptake

The data on phosphorus uptake is given in the table 20.

The result showed that different growth media has significant influence on uptake of phosphorous. The highest P uptake was recorded in M_3 (2.0) and the lowest was recorded in M_6 (0.08).

4.1.7.3 Potassium uptake

The data on potassium uptake is given in the table 20.

Table 20. Effect of different growth media on plant nutrient uptake, g/plant

Growth media	Uptake of Nitrogen	Uptake of Phosphorus	Uptake of Potassium
M_1	2.90	0.47	2.09
M_2	3.26	1.89	2.38
M_3	4.05	2.00	3.46
M_4	4.38	1.98	4.17
M_5	3.67	1.96	2.49
M_6	0.88	0.08	0.03
M_7	3.44	1.22	5.18
SE	0.13	0.13	0.80
CD(0.01)	0.39	0.39	49.28

M_1 : Coir pith + FYM 1:1
M_2 : Coir pith + FYM 1:2
M_3 : Coir pith compost + FYM 1:1
M_4 : Coir pith compost + FYM 2:1
M_5 : Coir pith compost alone
M_6 : Compressed coir pith (neopeat)
M_7 : Potting mixture (1:1:1 soil, sand and FYM)

Table 21. Effect of different growth media on net income and BCR

Growth media	Net income (Rs)	BCR
M_1	0.77	1.15
M_2	1.37	1.47
M_3	1.96	1.67
M_4	3.91	2.34
M_5	1.96	1.67
M_6	-2.15	0.26
M_7	3.97	2.36
SE	0.17	0.07
CD(0.01)	0.53	0.21

M_1 : Coir pith + FYM 1:1
M_2 : Coir pith + FYM 1:2
M_3 : Coir pith compost + FYM 1:1
M_4 : Coir pith compost + FYM 2:1
M_5 : Coir pith compost alone
M_6 : Compressed coir pith (neopeat)
M_7 : Potting mixture (1:1:1 soil, sand and FYM)

The result showed that different growth media has significant influence on uptake of potassium .The highest uptake was recorded in M_7 (5.18) and the lowest was recorded in M_6 (0.03).

4.1.8 Economic analysis

4.1.8.1 Net income

The economic analysis of bhindi is given in table 21.

The result revealed that different growth media significantly influenced the net income of the crop. Highest net income was obtained from M_7 (3.97) and it was found to be on par with M_4 (3.91). M_6 registered a loss of Rs -2.15.

4.1.8.2. BCR

The benefit cost ratio calculated for bhindi is given in table 21

The results showed that different growth media has significant influence on benefit cost ratio of the crop. Highest BCR was obtained in M_7 (2.36) and it was found to be on par with M_4 (2.34). The lowest BCR was recorded in M_6 (0.26).

Part II. Nutrient scheduling for soilless culture

4.2.1 Growth Characters of Bhindi

4.2.1.1 Height of the plants (cm)

The average height of plants recorded at 15, 30, 45,60,75,90 and 105 DAS is presented in table 22. There was a progressive increase in plant height at different stages of crop growth.

Different levels of nutrients had significant influence on plant height during all the stages of crop growth except at 15 DAS. During all the stages N_3 (125 % of

Table22. Effect of nutrient levels and methods of application on plant height (cm)

Growth media	Days After Sowing, DAS						
	15	30	45	60	75	90	105
Nutrient levels							
N_1	16.65	25.59	38.82	45.51	56.22	64.70	67.53
N_2	16.52	25.19	35.06	42.73	49.08	56.18	62.06
N_3	16.38	25.96	40.48	46.51	59.26	66.01	69.63
SE	0.096	0.107	0.555	0.630	0.675	0.849	0.834
CD(0.05)	NS	0.317	1.651	0.891	2.008	2.523	2.480
Methods of application							
T_1	16.45	25.73	38.85	45.34	55.40	62.992	67.14
T_2	16.58	25.43	37.39	44.50	54.30	61.607	65.68
SE	0.079	0.087	0.453	0.514	0.551	0.693	0.681
CD(0.05)	NS	.259	1.348	NS	NS	NS	NS
Interaction							
n_1t_1	16.57	25.86	38.85	45.92	57.24	65.75	67.95
n_1t_2	16.72	25.33	38.80	45.09	55.21	63.65	67.53
n_2t_1	16.50	25.26	37.03	43.52	48.33	57.22	62.70
n_2t_2	16.55	25.13	33.09	41.95	49.82	55.14	61.06
n_3t_1	16.30	26.08	40.67	46.57	60.64	66.00	70.77
n_3t_2	16.47	25.84	40.29	46.46	57.87	66.02	68.50
SE	0.137	0.151	0.786	0.891	0.955	1.200	1.180
CD(0.05)	NS	NS	2.336	NS	NS	NS	NS

N_1-100%POP N_2-75%POP N_3-125%POP T_1-Direct application T_2-Foliar application

POP as organic) recorded significantly superior height compared to other 2 levels of nutrients, but at 90 DAS (66.01cm) and 105 DAS (69.63cm), N_3 was found to be on par with N_1 (64.70 cm and 67.53cm respectively).

Different methods of application was found to have significant effect on plant height at 30 DAS and 45 DAS. T_1 recorded significantly superior plant height compared to T_2

The interaction effect between the different nutrient levels and method of application was found to be significant at 45 DAS only. The highest plant height was recorded by the treatment combination n_3t_1 (40.67 cm) which was on par with n_1t_1 (38.85cm), n_1t_2 (38.80 cm) and n_3t_2 (40.29 cm).

4.2.1.2 Number of branches

The different nutrient levels and method of application and their interaction could not significantly influence the number of branches.

4.2.1.3 Number of leaves

The average number of leaves plants^{-1} recorded at 15, 30, 45, 60, 75, 90 and 105 DAS is presented in table 23.

Different levels of nutrition had significant influence on number of leaves during all the growth stages except at 15 DAS. During all the stages except at 30 DAS and at 105 DAS, N_3 recorded maximum number of leaves. At 30 DAS and 105 DAS, N_1recorded maximum leaf number (7.87 and 12.31 respectively) and at 105 DAS, N_1 was on par with N_3 (12.00).

The different methods of application could show significant effect at 105 DAS only and T_1 recorded maximum number of leaves than T_2 . Interaction effect was also non significant on the number of leaves.

Table 23. Effect of nutrient levels and method of application on number of leaves of the plant

Growth media	Days After Sowing, DAS						
	15	30	45	60	75	90	105
Nutrient levels							
N_1	5.81	7.87	9.75	10.62	11.56	11.81	12.31
N_2	5.25	6.76	8.25	9.00	10.68	10.18	10.31
N_3	5.62	6.76	10.75	12.50	12.87	12.50	12.00
SE	0.217	0.159	0.25	0.291	0.313	0.310	0.274
CD(0.05)	NS	0.474	0.742	0.866	0.930	0.922	0.816
Methods of application							
T_1	5.58	7.08	9.66	10.83	11.70	11.87	12.04
T_2	5.54	7.18	9.5	10.58	11.08	11.12	11.04
SE	0.177	0.130	0.204	0.238	0.255	0.253	0.224
CD(0.05)	NS	NS	NS	NS	NS	NS	0.666
Interaction							
n_1t_1	5.87	7.75	10.00	11.00	11.5	12.00	12.5
n_1t_2	5.75	8.00	9.50	10.25	11.62	11.62	12.12
n_2t_1	5.25	6.75	8.25	9	10.37	10.37	10.62
n_2t_2	5.25	6.77	8.25	9	11.0	10.00	10.00
n_3t_1	5.62	6.75	10.75	12.5	13.25	13.25	13.00
n_3t_2	5.62	6.77	10.75	12.5	12.5	11.75	11.00
SE	0.307	0.225	0.353	0.412	0.442	0.438	0.388
CD(0.05)	NS	NS	NS	NS	NS	NS	NS

N_1-100%POP N_2-75%POP N_3-125%POP T_1-Direct application T_2-Foliar application

Table 24. Effect of nutrient levels and method of application on leaf area index of the plant

Growth media	Days After Sowing, DAS		
	30	60	90
Nutrient levels			
N_1	0.32	0.90	0.87
N_2	0.33	0.92	0.92
N_3	0.34	1.22	1.20
SE	0.019	0.025	0.030
CD(0.05)	NS	0.076	0.091
Methods of application			
T_1	.34	1.00	0.99
T_2	.32	1.03	1.00
SE	0.016	0.020	0.025
CD(0.05)	NS	NS	NS
Interaction			
n_1t_1	0.31	0.88	0.89
n_1t_2	0.33	0.93	0.85
n_2t_1	0.34	0.93	0.89
n_2t_2	0.33	0.91	0.94
n_3t_1	0.36	1.20	1.19
n_3t_2	0.32	1.25	1.22
SE	0.019	0.036	0.043
CD(0.05)	0.009	NS	NS

N_1-100%POP N_2-75%POP N_3-125%POP T_1-Direct application T_2-Foliar application

4.2.1.4 Leaf area index

The data on average leaf area index of the plants calculated at 30, 60 and 90 DAS is presented in table 24.

Different nutrient levels could not significantly influence leaf area index at 30DAS. At 60 and 90 DAS, N_3 recorded maximum LAI (1.23 and 1.21respectively).

The different methods of application could not significantly influence LAI at all growth stages.

Interaction effect was significant at 30 DAS alone and n_3t_1 recorded the highest LAI (0.36).

4.2.1.5 Duration of the crop (Days)

The mean values of crop duration as influenced by treatments are presented in table 25.

Nutrient levels significantly influenced the duration of the crop. N_2 recorded highest duration (108.37 days) and lowest duration was observed on N_3 (98 days).

The method of application and interaction could not significantly influence the duration of the crop.

4.2.1.6 Lodging percentage

In the pot experiment lodging was not observed.

4.2.2 Yield attributes and yield

4.2.2.1 Number of flowers per plant

Data on the number of flowers per plant presented in table 26 revealed that different levels of nutrients significantly influenced the number of flowers per plant. The highest number of flowers per plant was recorded by N_3 (24.75) and the lowest recorded by N_2 (19.75).

The method of application could not significantly influence the number of flowers.

Table 25. Effect of nutrition levels and method of application on duration of the crop, days

Growth media	Duration
Nutrient levels	
N_1	100.25
N_2	108.37
N_3	98.00
SE	1.518
CD(0.05)	4.513
Methods of application	
T_1	102.58
T_2	101.83
SE	1.240
CD(0.05)	NS
Interaction	
n_1t_1	100.50
n_1t_2	100.00
n_2t_1	110.5
n_2t_2	106.25
n_3t_1	96.75
n_3t_2	99.25
SE	2.148
CD(0.05)	NS

N_1-100%POP N_2-75%POP N_3-125%POP T_1-Direct application T_2-Foliar application

The interaction effect of different nutrient levels and method of application was found to be significant. The highest number of flowers per plant was recorded by n_3t_1 (26.50) and was significantly superior to all other treatment combinations.

4.2.2.2 Number of fruits per plant

The number of fruits per plant recorded is presented in table 26

The different levels of nutrients could significantly influence the number of fruits per plant. The highest number of fruits per plant was recorded by N_3 (16.12) and was significantly superior to other two nutrient levels. The lowest number of fruits per plant was recorded by N_2 (11.25).

The method of application and the interaction effect did not show any significant influence on number of fruits per plant.

4.2.2.3 Setting percentage

The data on setting percentage is recorded in the table 26.

Different nutrient levels, methods of application and their interaction could not show any significant influence on setting percentage in bhindi

4.2.2.4 Fruit yield per plant

The data on number of fruits per plant is presented in the table 26.

The different levels of nutrients could significantly influence the fruit yield per plant. N_3 (273.46) recorded the maximum fruit yield per plant.

The method of application also could influence the fruit yield per plant. T_1 (235.41) recorded the maximum fruit yield per plant.

The interaction effect of different nutrient levels and method of application could significantly influence the fruit yield per plant. The maximum yield was recorded by n_3t_1 (283.41).

Table 26. Effect of nutrient levels and method of application on number of flowers, number of fı setting percentage, fruit yield and total fruit yield.

Growth media	Number of flowers	Number of fruits	Setting percentage(%)	Fruit yield(g/plant)	Total fruit yield,t/ha
Nutrient levels					
N_1	20.98	13.12	62.11	233.17	8.61
N_2	19.75	11.25	57.23	168.32	6.21
N_3	24.75	16.12	59.58	273.46	10.11
SE	0.608	0.482	4.095	3.578	0.1327
CD(0.05)	1.807	1.433	NS	10.659	0.394
Methods of application					
T_1	22.40	13.91	58.09	235.41	8.70
T_2	21.25	13.08	61.18	214.46	7.92
SE	0.496	0.393	3.344	2.923	0.108
CD(0.05)	NS	NS	NS	8.70	0.322
Interaction					
n_1t_1	21.97	13.25	60.32	234.77	8.68
n_1t_2	20.00	13.00	63.91	231.56	8.55
n_2t_1	18.75	11.00	58.95	187.86	6.94
n_2t_2	20.75	11.50	55.50	148.77	5.48
n_3t_1	26.50	17.50	55.02	283.41	10.48
n_3t_2	23.00	14.75	64.13	214.56	9.73
SE	0.860	0.682	5.792	5.073	0.187
CD(0.05)	2.556	NS	NS	15.07	0.558

N_1-100%POP N_2-75%POP N_3-125%POP T_1-Direct application T_2-Foliar application

4.2.2.5 Total fruit yield (t/ha)

The data on total fruit yield is recorded in the table 26.

The different levels of nutrients could significantly influence the total fruit yield. N_3 recorded the maximum total fruit yield (10.11) and was significantly superior to N_1 and N_2.

The method of application significantly influenced the total fruit yield. The treatment T_1 recorded the highest total fruit yield (8.70) and was significantly superior to T_2 (7.92).

The interaction effect of different nutrient levels and method of application also significantly influenced the total fruit yield. The maximum yield was recorded by n_3t_1 (10.48).

4.2.2.6 Length of fruit (cm)

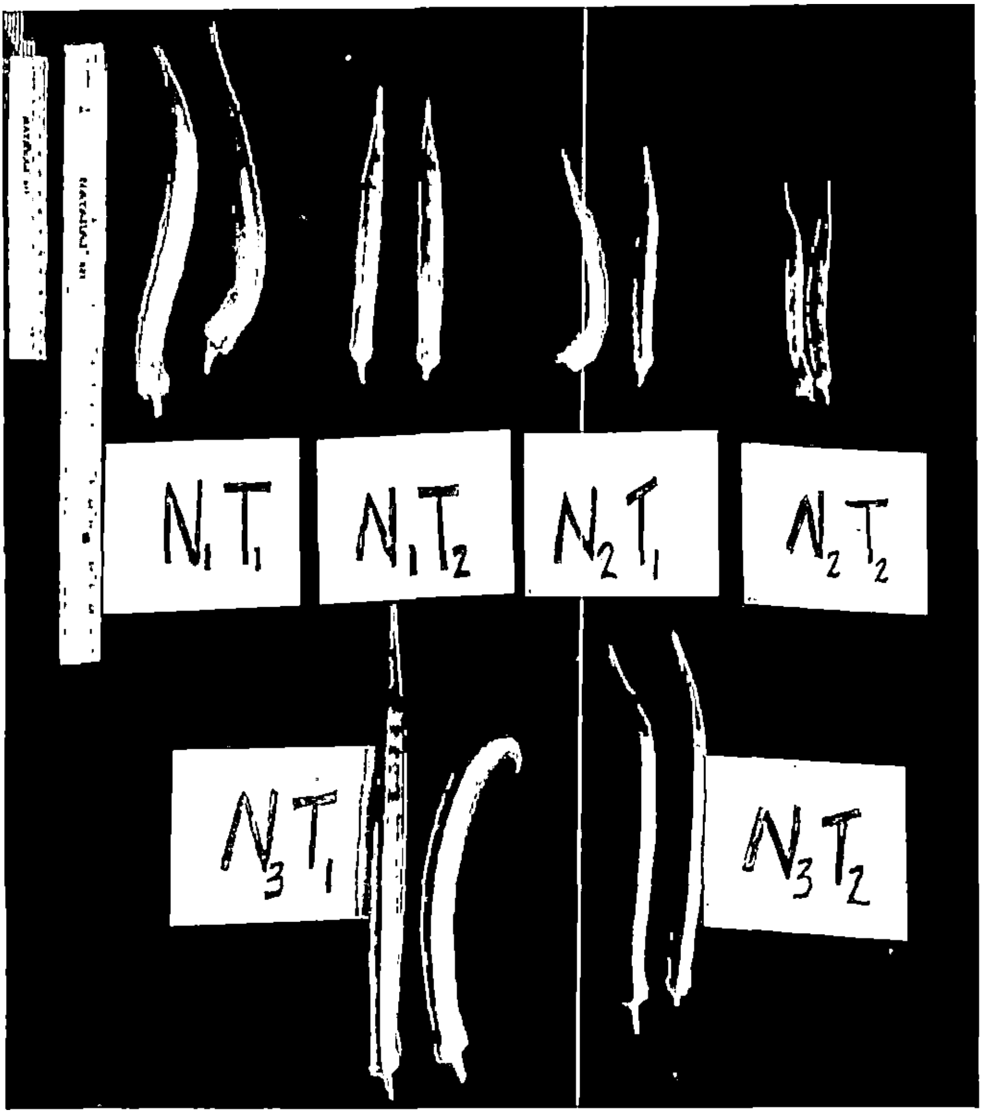
The data on length of fruit (table 27) revealed that the different levels of nutrients could significantly influence the length of the fruit. N_3 (16.05 cm) recorded the highest fruit length and was on par with N_1 (15.12 cm).

Among two methods of application T_1 (15.32 cm) recorded the highest fruit length and was on par with T_2 (14.24 cm).

The interaction effect of different nutrient levels and method of application could not significantly influence the length of fruit.

4.2.2.7 Girth of fruit (cm)

The data on girth of fruit is recorded in the table 27.



Platel. Influence of different nutrient levels and method of application on fruit Characters.

Table 27. Effect of nutrient levels and method of application fruit length, fruit girth, number of harvest and number of malformed fruits.

Growth media	Fruit length (cm)	Fruit girth(cm)	Number of harvest	Number of malformed fruits
Nutrient levels				
N_1	15.12	5.47	12.12	1.62
N_2	13.16	5.20	10.37	1.37
N_3	16.05	5.44	11.00	1.50
SE	0.443	6.295	1.113	0.242
CD(0.05)	1.316	0.187	NS	NS
Methods of application				
T_1	15.32	5.39	11.91	1.58
T_2	14.24	5.35	10.41	1.41
SE	0.361	5.140	0.909	0.198
CD(0.05)	1.075	NS	NS	NS
Interaction				
n_1t_1	15.31	5.42	12.50	1.5
n_1t_2	14.93	5.52	11.75	1.75
n_2t_1	13.75	5.29	9.750	1.75
n_2t_2	12.57	5.12	11.00	1.00
n_3t_1	16.90	5.47	13.50	1.50
n_3t_2	15.21	5.42	8.50	1.50
SE	0.626	0.089	1.574	1.58
CD(0.05)	NS	NS	NS	NS

N_1-100%POP N_2-75%POP N_3-125%POP T_1-Direct application T_2-Foliar application

The different levels of nutrients significantly influenced the girth of fruit. N_1 (5.47 cm) recorded the maximum fruit girth and was found to be on par with N_3 (5.44 cm).

4.2.2.8 Number of harvest

The data on number of harvest is recorded in the table 27.

Nutrient levels, method of application and their interaction could not show any significant influence on number of harvests.

4.2.2.9 Number of malformed fruits

The data on number of malformed fruits is recorded in the table 27.

Different nutrient levels, method of application and their interaction could not show any significant influence on number of malformed fruits.

4.2.3 Root study

Data regarding the influence of different nutrient levels and method of application and their interaction on root characteristics is given in the table 28.

4.2.3.1 Root length (cm)

The data presented in the table 28 revealed that nutrient levels, method of application and their interaction significantly influenced the root length.

Treatment N_3 recorded the highest root length (65.67) and was significantly superior to N_1 and N_2.

Methods of application also significantly influenced the root length. T_1 recorded the highest root length (64.22) and was significantly superior to T_2.

Table 28. Effect of nutrient levels and method of application on root characters and water use efficiency

Growth media	Root length,cm	Root spread, cm	Root Volume, cm^3	WUE (kg/pot/l)
Nutrient levels				
N_1	60.77	20.98	189.97	0.003
N_2	57.17	19.87	156.82	0.002
N_3	65.67	24.25	180.26	0.004
SE	1.200	.876	3.752	0.0002
CD(0.05)	3.565	2.603	11.149	0.0006
Methods of application				
T_1	64.22	21.74	175.80	0.003
T_2	58.19	21.66	175.57	0.003
SE	0.979	0.715	3.063	0.0001
CD(0.05)	2.911	NS	NS	NS
Interaction				
n_1t_1	61.22	21.97	187.2	0.003
n_1t_2	60.32	20.0	192.75	0.002
n_2t_1	59.75	18.75	155.70	0.002
n_2t_2	54.60	21.0	157.95	0.002
n_3t_1	71.70	24.50	184.5	0.004
n_3t_2	59.65	24.0	176.025	0.004
SE	1.697	1.239	5.306	0.0003
CD(0.05)	5.0424	NS	NS	NS

N_1-100%POP N_2-75%POP N_3-125%POP T_1-Direct application T_2-Foliar application

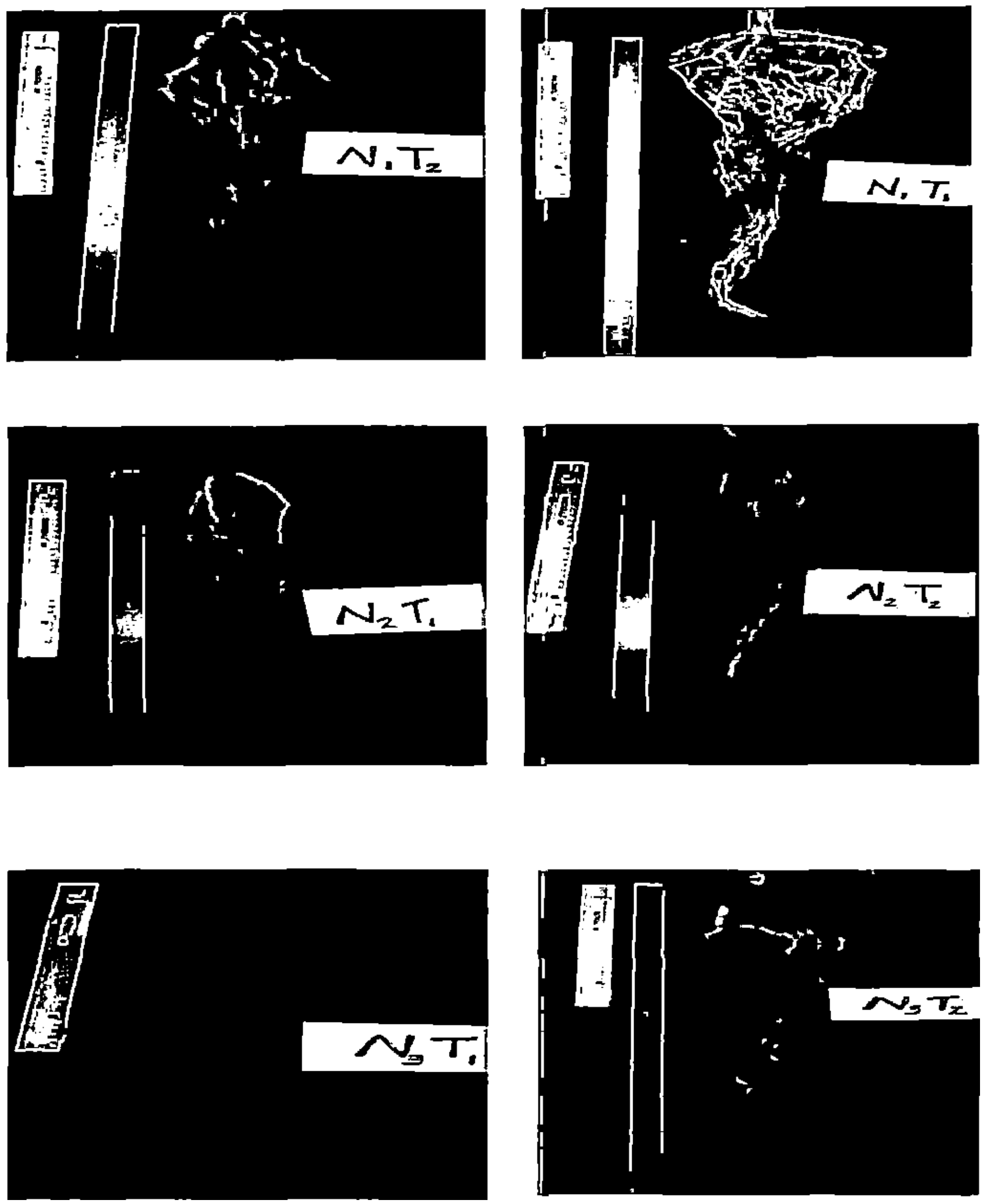


Plate2. Influence of different nutrient levels and method of application on root characters.

Interaction between different nutrient levels and method of application was significant. Treatment combination n_3t_1 recorded the highest root length (71.70) and was significantly superior to all other treatment combinations.

4.2.3.2 Root spread (cm)

The data presented in the table 28 revealed that the different levels of nutrients could significantly influence the root length of the crop. N_3 recorded highest root spread (24.25 cm) and were significantly superior to N_1 and N_2.

Methods of application and the interaction effect between levels of nutrients and the method of application did not show any significant influence on root spread.

4.2.3.3 Root volume (cm^3)

The data on root volume is presented in the table 28.

The different levels of nutrients could significantly influence the root volume of the crop. N_1 (189.97) recorded the maximum root volume and it was found to be on par with N_3 (180.26).

The different methods of application and their interaction did not show any significant influence on root volume.

4.2.4 **Water use efficiency (kg/pot/l)**

The data presented in the table 28 revealed that nutrient levels alone significantly influenced the WUE.

The treatment N_3 recorded the highest WUE (0.004) and was on par with N_1 and N_2.

Methods of application and the interaction effect did not show any significant influence on water use efficiency.

4.2.5 MICROBIAL LOAD

4.2.4.1 Bacteria, fungi and actinomycetes count

The data on average bacteria, fungi and actinomycetes count is given in the table 29.

Nutrient levels, methods of application and their interaction could not show any significant influence on bacterial, fungal and actinomycetes count after the experiment.

4.2.6 Chemical analysis of the growth media after the experiment-Organic carbon, N, P and K

4.2.6.1 Nitrogen (%)

The data on nitrogen content in the media is presented in the table 30.

The different levels of nutrients could significantly influence the nitrogen content in the media. N_3 recorded the highest nitrogen content (1.83) and was significantly superior to the other two nutrient levels N_1 and N_2.

Among the two methods of application, treatments T_1 recorded the highest nitrogen content (1.56) and were significantly superior to T_2.

The interaction between the different levels of nutrients and methods of application also showed significant influence. Treatment combination n_3t_1 recorded the highest nitrogen content (2.00) and was significantly superior to all other treatment combinations.

4.2.6.2 Phosphorus content (%)

The data on phosphorus content in the media is presented in the table 30.

Table 29.Effect of different nutrition levels and method of application on microbial load

Treatment	Bacteria,10	Fungi, 10	Actinomycetes, 10
Nutrient levels			
N_1	12.37	8.75	2.87
N_2	12.00	4.87	1.75
N_3	12.12	8.37	1.75
SE	1.330	1.493	0.633
CD	NS	NS	NS
Methods of application			
T_1	11.91	7.83	3.75
T_2	12.41	6.83	2.00
SE	1.08	1.219	0.517
CD	NS	NS	NS
Interaction			
n_1t_1	13.00	9.75	3.75
n_1t_2	11.75	7.75	2.00
n_2t_1	10.75	5.75	1.25
n_2t_2	13.25	4.00	2.25
n_3t_1	12.00	8.00	1.75
n_3t_2	12.25	8.75	1.75
SE	1.881	2.111	0.895
CD	NS	NS	NS

N_1-100%POP N_2-75%POP N_3-125%POP T_1-Direct application T_2-Foliar application

The different levels of nutrients significantly influenced the phosphorous content of the media. N_3 recorded the highest phosphorus content (0.62) and was significantly superior to other two nutrient levels N_1 and N_2.

Methods of application and their interaction did not show any significant influence on phosphorus content.

4.2.6.3 Potassium content (%)

The data on potassium content in the media presented in table 30 showed that levels of nutrients significantly influenced the potassium content in the media. N_3 and N_1 recorded highest potassium content (0.31) and was significantly superior to N_2.

Methods of nutrient application could not significantly influence the potassium content in the media.

The interaction between the different levels of nutrient and methods of application showed significant influence on potassium content. n_1t_2 recorded the highest potassium content (0.38) and was on par with n_3t_1 (0.35) and was significantly superior to all other treatment combinations.

4.2.6.4 pH

The data on pH of the growth media as influenced by treatments is presented in the table 30.

The different levels of nutrients could significantly influence the pH of the media. N_3 (6.0) and N_1 (6.0) recorded the maximum pH and the minimum was recorded by N_2 (5.8).

Methods of application and interaction did not show any significant influence on pH of the growth media.

Table30. Effect of nutrient levels and method of application on NPK content, pH, organic carbon and EC of media after the experiment

Growth media	N(%)	P (%)	K(%)	pH	Organic C (%)	EC (dS/m)
Nutrient						
N_1	1.49	0.46	0.31	6.0	7.61	1.08
N_2	0.89	0.21	0.10	5.8	7.07	1.09
N_3	1.83	0.62	0.31	6.0	7.02	1.00
SE	0.035	0.03	0.013	0.074	0.209	2.1
CD(0.05)	0.104	0.092	0.039	0.222	NS	NS
Methods of application						
T_1	1.56	0.42	0.23	5.9	7.17	1.01
T_2	1.25	0.44	0.25	6.0	7.30	1.01
SE	0.028	0.025	0.01	6.104	0.170	1.7
CD(0.05)	0.085	NS	NS	NS	NS	NS
Interaction						
n_1t_1	1.57	0.45	0.23	6.0	7.43	1.03
n_1t_2	1.41	0.47	0.38	6.0	7.80	1.03
n_2t_1	1.10	0.17	0.11	5.6	7.33	1.09
n_2t_2	0.67	0.24	0.10	5.9	6.81	1.05
n_3t_1	2.00	0.64	0.35	6.1	6.73	1.00
n_3t_2	1.67	0.61	0.27	5.9	7.31	1.04
SE	0.049	0.043	0.018	0.105	0.295	3.0
CD(0.05)	0.147	NS	0.055	NS	NS	NS

N_1-100%POP N_2-75%POP N_3-125%POP T_1-Direct application T_2-Foliar application

4.2.6.5 EC (dS/m)

The data on EC presented in table 30 revealed that nutrient levels, methods of application and their interaction could not show any significant influence on EC content.

4.2.6.6 Organic carbon content (%)

The data on organic carbon content is given in the table 30

Nutrient levels, method of application and their interaction could not show any significant influence on organic carbon content.

4.2.7 Nutrient uptake

4.2.7.1 Nitrogen uptake (g/plant)

The data on nitrogen uptake is recorded in the table 31.

The different levels of nutrients significantly influenced the nitrogen uptake. N_3 recorded the highest nitrogen uptake (4.84g/plant) and was significantly superior to other two nutrient levels N_1 and N_2.

Among the two methods, T_2 recorded the highest nitrogen uptake (3.49 g/plant) and was significantly superior to T_1 (2.85g/plant).

The interaction effect of different nutrient levels and methods of application also significantly influenced the nitrogen uptake. The maximum uptake was recorded by n_3t_1 (5.28) and was significantly superior to all other treatment combinations.

4.2.7.2 Phosphorus uptake (g/plant)

The data on phosphorous uptake is presented in the table 31.

Table 31. Effect of nutrient levels and method of application on plant nutrient uptake, g/plant

Growth media	Nitrogen	Phosphorus	Potassium
Nutrient levels			
N_1	2.90	1.30	2.38
N_2	1.79	0.35	0.81
N_3	4.84	1.98	2.78
SE	0.108	0.0656	0.130
CD(0.05)	0.3232	0.194	0.386
Methods of application			
T_1	2.85	1.53	2.31
T_2	3.49	0.88	1.67
SE	0.088	0.053	0.106
CD(0.05)	0.263	0.159	0.316
Interaction			
n_1t_1	1.38	1.87	2.16
n_1t_2	4.42	0.73	2.61
n_2t_1	1.92	0.43	1.56
n_2t_2	1.65	0.27	0.05
n_3t_1	5.28	2.30	3.22
n_3t_2	4.4	1.66	2.34
SE	0.1538	0.09277	0.184
CD(0.05)	0.457	0.2756	0.546

N_1-100%POP N_2-75%POP N_3-125%POP T_1-Direct application T_2-Foliar application

The different levels of nutrients significantly influenced the phosphorous uptake. Among the three nutrient levels, N_3 recorded highest phosphorus uptake (1.98) and was significantly superior to the other two nutrient levels.

As far as methods of application is concerned T_1 recorded highest phosphorus content (1.53g/plant) and was significantly superior to T_2 (0.88 g/plant).

The interaction effect of different nutrient levels and method of application significantly influenced the phosphorus uptake. The highest uptake was recorded by n_3t_1 (2.30 g/plant) and was significantly superior to all other treatment combinations.

4.2.7.3 Potassium uptake (g/plant)

The data on potassium uptake is given in table 31.

Nutrient levels significantly influenced the potassium uptake. N_3 recorded the highest potassium uptake (2.78g/plant) and was on par with N_1 .

Methods of application also significantly influenced the potassium uptake. T_1 recorded the highest uptake (2.31g/plant) and was significantly superior to T_2 (1.67g/plant).

The interaction effect of different nutrient levels and methods of application also significantly influenced the potassium uptake. The maximum uptake was recorded by n_3t_1 (3.22 g/plant) and was significantly superior to all other treatment combinations.

4.2.8 EONOMIC ANALYSIS

4.2.8.1 Net income

The data on net income per pot as presented in the table 32, revealed that the nutrient levels significantly influenced the net income. N_3 recorded the highest net income (Rs.4.72/pot) and was on par with N_1 .

Methods of application also significantly influenced the net income. T_1 recorded highest net income (Rs. 4.16/pot).The interaction effect of different nutrient levels and method of application could significantly influence the net income. The maximum net income was recorded by n_3t_1 (5.07).

4.2.8.2 Benefit Cost Ratio

The data on benefit cost ratio is presented in the table 32. Nutrient levels significantly influenced the benefit cost ratio, N_1 recorded the highest benefit cost ratio (2.39) and it was on par with N_3 (2.35) and these two were significantly superior to N_2.

The different methods of application also significantly influenced the benefit cost ratio. T_1 (2.39) recorded highest benefit cost ratio and was significantly superior to T2. The interaction effects of different nutrient levels and methods of application did not show significant influence on the benefit cost ratio.

Table 32. Effect of nutrient levels and method of application on net income and BCR

Growth media	Net income, Rs	BCR
Nutrient levels		
N_1	4.07	2.39
N_2	2.72	2.07
N_3	4.72	2.35
SE	0.111	0.063
CD(0.05)	0.330	0.187
Methods of application		
T_1	4.16	2.39
T_2	3.51	2.15
SE	0.09	0.05
CD(0.05)	0.269	0.152
Interaction		
n_1t_1	4.13	2.42
n_1t_2	4.02	2.38
n_2t_1	3.32	2.31
n_2t_2	2.14	1.82
n_3t_1	5.07	2.44
n_3t_2	4.380	2.26
SE	0.16	0.08
CD(0.05)	0.467	NS

N_1-100%POP N_2-75%POP N_3-125%POP T_1-Direct application T_2-Foliar application

Discussion

5. Discussion

An experiment entitled 'Organic nutrient scheduling in soilless vegetable cultivation' was undertaken out to standardize soilless media and nutrient schedule for organic vegetable production (grown in containers) and to work out the economics of different treatments and also to assess the effect of growth media on growth, yield and quality of bhindi. The results obtained are discussed below.

Part 1. Standardization of different growth media for soilless culture

Soilless cultivation is the most intensive production method in today's horticulture industry. The results of the study indicated that there is significant influence of different soilless growth media on the growth characters of bhindi. All the growth and yield characters studied were profoundly influenced by different growth media. For all the growth characters except crop duration, highest values were recorded by coir pith compost along with FYM mixed in 2:1 ratio by weight and potting mixture. Among soilless growth media coir pith compost along with FYM in 2:1 ratio was found to be best. It recorded better growth and yield parameters. This growth media resulted in maximum growth characters like height (15, 30 and 75DAS), number of leaves (60and 90 DAS), LAI (90DAS) and yield characters like fruit yield per plant, significantly superior to other growth media. Among the yield attributes 2:1 ratio of coir pith compost and FYM found to be better than 1:1, this may be due to better nutrient content (1.37%N, 0.46%P_2O_5 and 0.11%K_2O). Coir pith compost was found to be better than coir pith which decomposes slowly because of its low pentosan-lignin ratio (<0.5) and due to the chemical and structural complexity of lignin- cellulose complex. Presence of lignin and hemi-cellulose decreases the microbial activity (Van Sumere,1989). Reduced yield in coir pith based media can be attributed to the nitrogen immobilization by coir micro organisms and high C:N ratio (Arenas *et al*,2002). High concentration of phenolic compounds in undecomposed coir pith is responsible for growth and yield reductions.

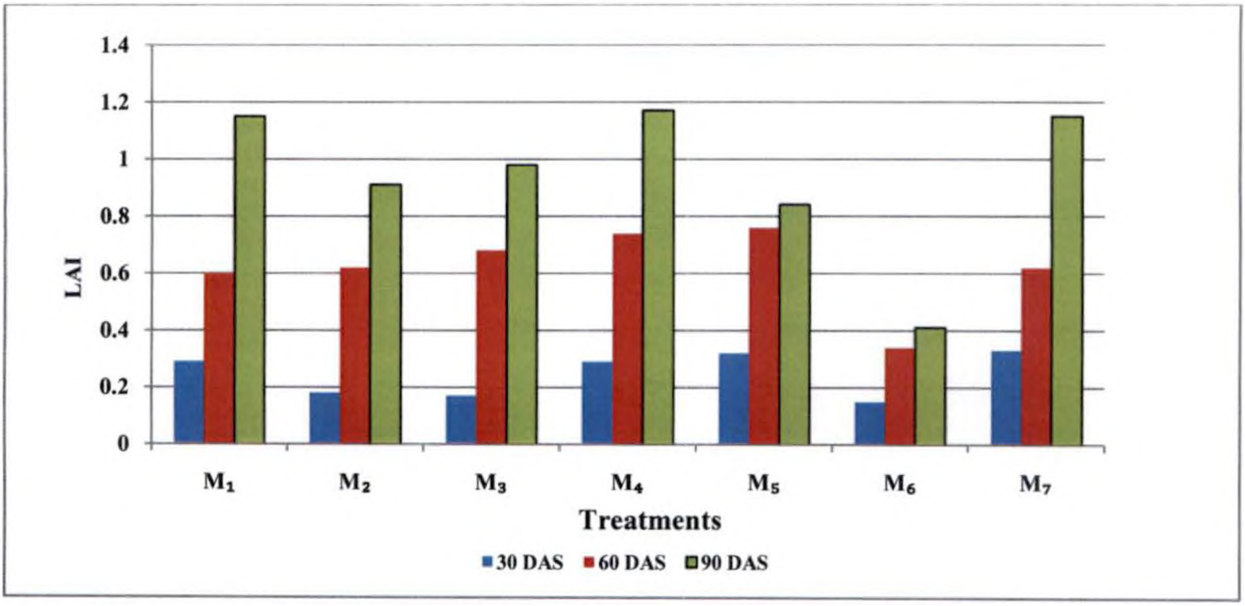


Fig 2 -Effect of different growth media on LAI of bhindi

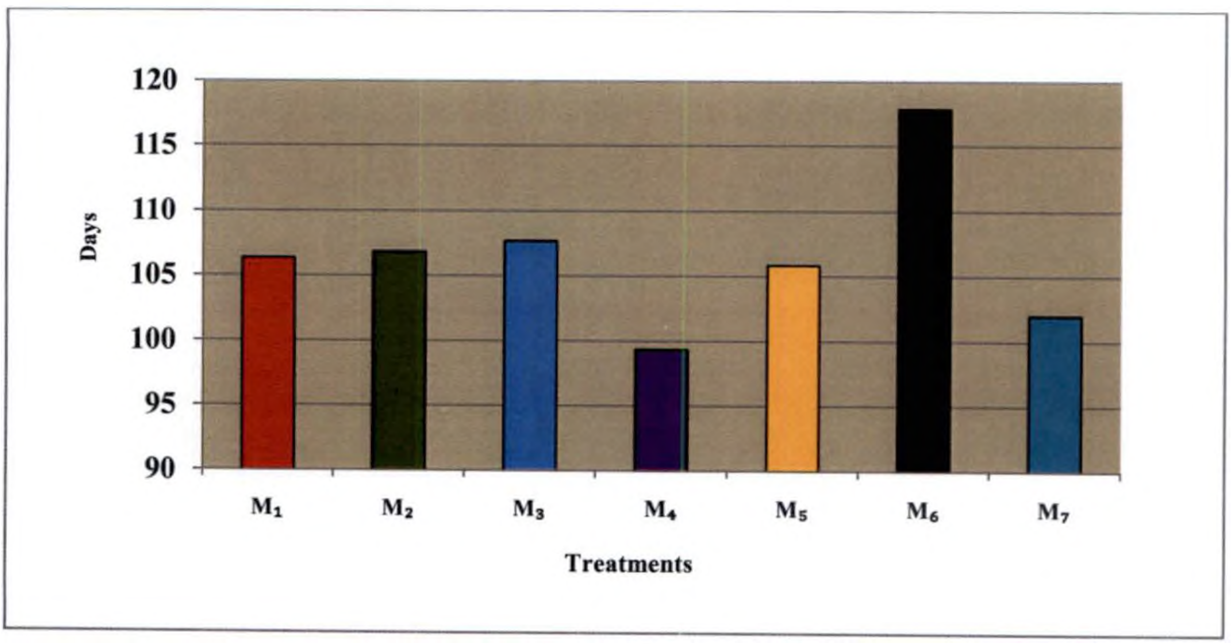


Fig 3 -Effect of different media on duration of bhindi

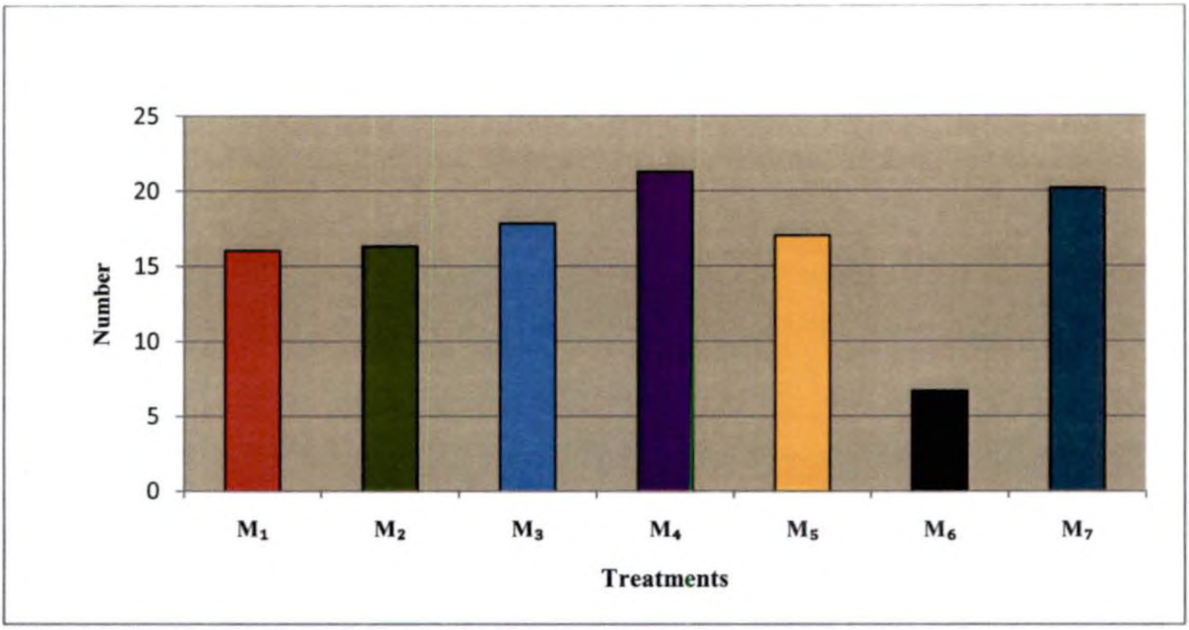


Fig 4-Effect of different media on number of flowers/plant

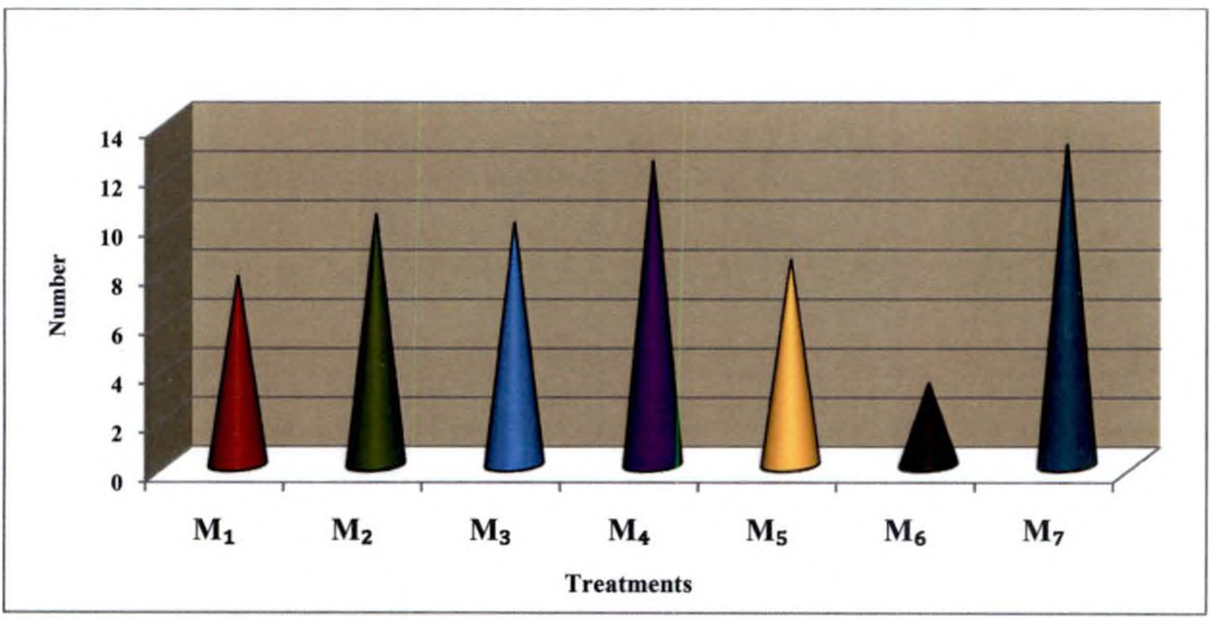


Fig 5 -Effect of different media on number of fruits/plant

Regarding crop duration, duration was extended in treatments, neopeat and coir pith compost alone. Shortest crop duration was recorded in coir pith compost + FYM (2:1). As far as yield characters and yield are concerned coir pith compost + FYM in 2:1ratio and potting mixture were found best. Composted coirpith contain all plant nutrient elements and it can provide a supplemental effect when mixed with FYM.

When root characters were analyzed, highest values were recorded in coir based media than potting mixture. Among the coir based media, coir pith compost + FYM (2:1) was the best in all the root characters. Same trend was reflected in water use efficiency and nutrient uptake. Mixtures of Coirpith compost and FYM have all the required characteristics and make an excellent growing medium. This might be due to the better physical and chemical properties, congenial for proper root growth and enhanced uptake of nutrients.

Most of the growth and yield attributes were found to be superior in growing media comprising coir pith compost + FYM in 2:1ratio. Addition of cattle manure to the media would have improved the physical properties, microbial activity and nutrient availability especially N, P, K since it contains 0.35% N, 0.12% P_2O_5 and 0.17% K_2O (Tandon, 1999).

Composts provide a “warm” growing medium, which promotes root growth. Quicker root growth might have increased the subsequent canopy development and overall crop performance. Better aeration, nutrient availability and vigorous root growth allows better growth and yield attributes which might have resulted in higher yield and net income in coir pith compost +FYM (2:1) media.

The result of the study showed that combination of coir pith compost and FYM in 2:1 ratio by weight *ie.*, 2.75kg coir pith compost along with 1.25kg FYM filled in pots of 7litre volume is the ideal growth medium for soilless bhindi production This result was in agreement with the report of Abesh and Anita, 2010. In their study better production of medicinal plant was obtained when composted coir

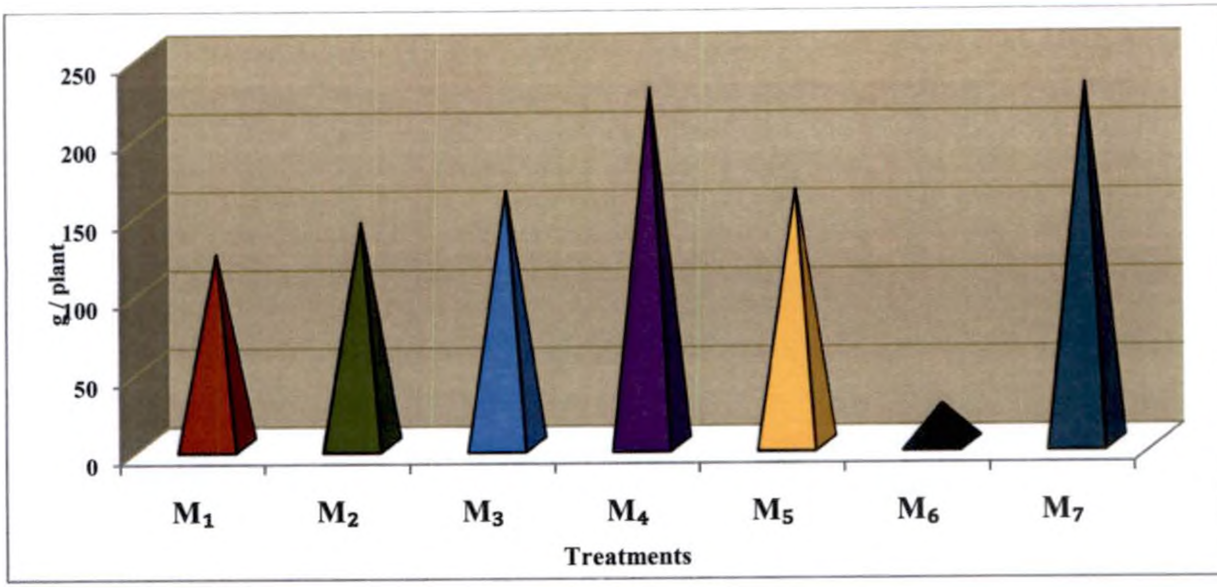


Fig 6- Effect of different media on fruit yield/plant

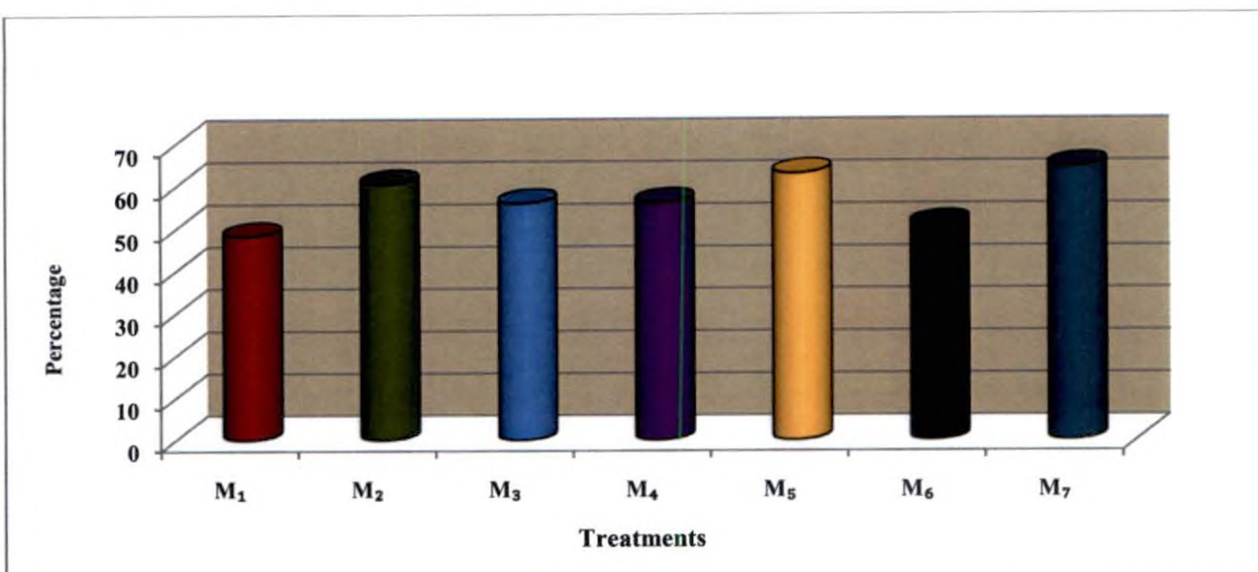


Fig 7- Effect of different media on setting percentage of bhindi

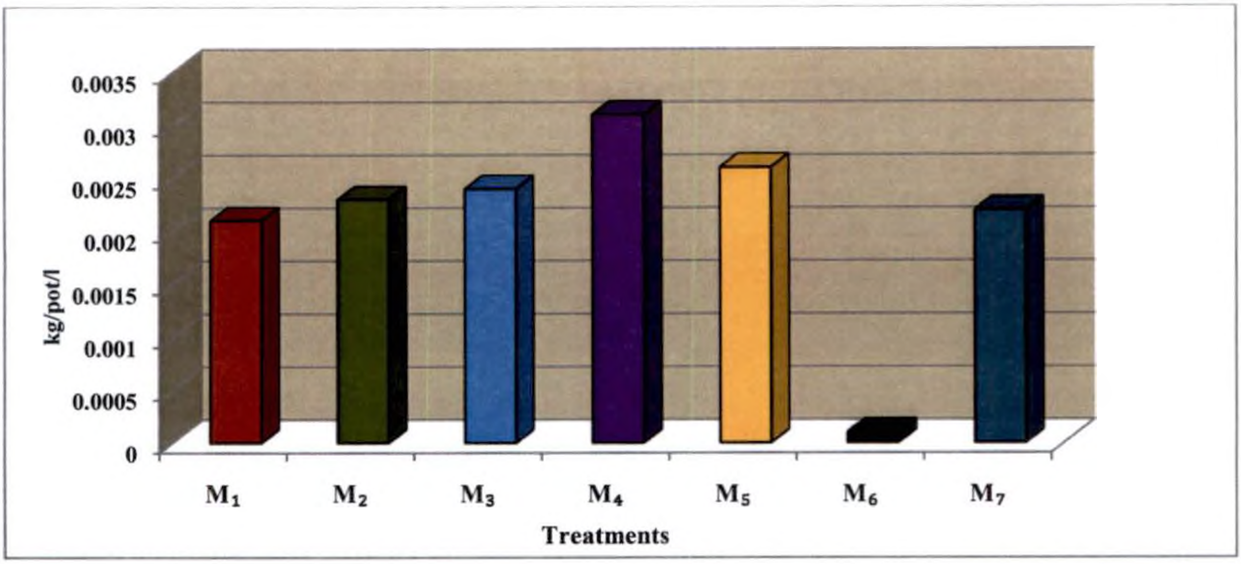


Fig 8- Effect of different media on water use efficiency of bhindi

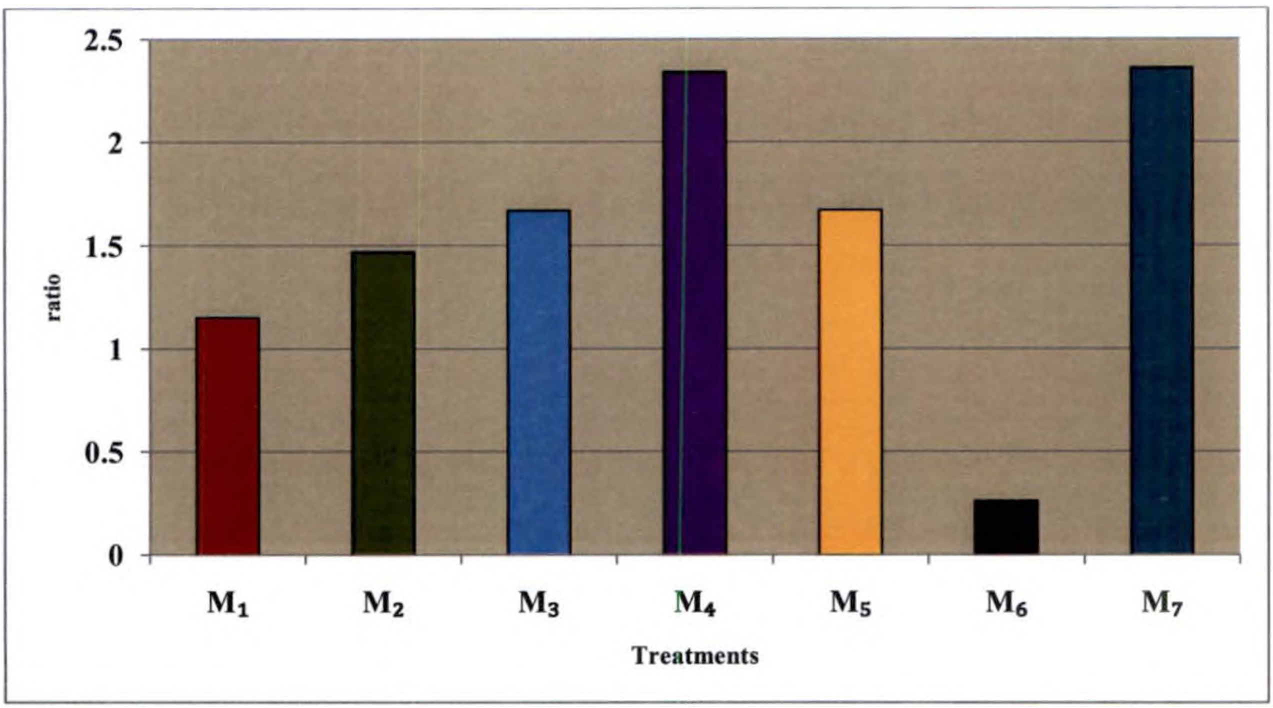


Fig 9. Effect of different media on BCR of bhindi

pith based potting medium was used as growth media. Highest net income and BCR was also recorded in coir pith compost + FYM in 2:1 ratio and potting mixture because of the better yield and their by higher returns obtained in these growth media.

PART II. Nutrient scheduling for soil less culture

5.2.1 Effect of nutrient levels and method of application on growth characters of bhindi

The results of the study indicated that nutrient levels had significant influence on crop growth parameters such as plant height, number of leaves, leaf area index and crop duration.

Among the different nutrient levels, N_3 recorded significantly taller plants at 90 and 105 DAS and was on par with N_1.

Influence of nitrogen on vegetative growth of plants is a universally accepted fact. As the level of nitrogen application increased, the growth characters were found to be responding positively. An adequate supply of nitrogen is associated with high photosynthetic activity and vigorous plant growth. As the level of nitrogen supply increased, the uptake of nitrogen might have contributed to rapid meristematic activity (Crowther, 1935), higher rate of metabolic activity coupled with rapid cell division brought about by phosphorous (Bear, 1965) and increased growth of meristematic tissue (Tisdale and Nelson, 1985). Similar increase in plant height due to vermicompost application in bhindi was reported by Govindan *et al.* (1995), Ushakumari *et al.* (1999) and Shanthi and Vijayakumari (2002). Method of application and interaction had significant influence only on plant height during some crop stages only.

A perusal of the data shown in table 23, revealed that among the various nutrient levels, N_3 recorded significantly more number of leaves during all growth stages except at 15 DAS. Regarding LAI, at 60 and 90 DAS, N_3 recorded the maximum LAI. As the level of nitrogen supply increases, the entire protein produced allows the leaves to grow larger and the amount of leaf area available for photosynthesis is roughly proportional to the amount of nitrogen applied (Russel, 1973). Higher uptake of nutrients would have increased the number of leaves and LAI. Similar results of enhancement in growth characters of bhindi due to increased nutrient levels have been reported by Karthikeyan (2010).

It can be noted from the table 25 that nutrient levels had significant influence on duration of crop. N_2 recorded maximum duration (108.37 days) and lowest duration was observed on N_3 (98 days). Results shows that increased nutrient level decreased the crop duration.

5.2.2 Effect of nutrient levels and method of application on yield characters and yield of bhindi

A perusal of the data shown in table 26 and 27 revealed that nutrient levels showed positive increase in yield attributes of bhindi like number of fruits per plant, number of flowers per plant, fruit yield per plant, length of fruit, girth of fruit and total fruit yield.

Among the nutrient levels, N_3 recorded highest values for all the yield attributes and yield. Method of application showed significant influence on fruit length, and fruit yield. Highest fruit length and fruit yield was recorded by T_1- direct application to growth media.

It is evident from table 26, that the highest dose of nutrient level, N_3 (125% of POP as organic), recorded the highest number of flowers and fruits per plant (24.75 and 16.12). The higher availability and uptake of nutrients might have enabled the plant to produce more number of flower buds which in turn increased the number of fruits. Increased fruit yield per plant may be due to improved vegetative growth, better availability of nutrients, greater synthesis of carbohydrates and their proper translocation (Dar *et al.*, 2009). It is well known that photosynthetic activity of the plant is modified by the nutritional status of the plant, since the nitrogen content in the plants increased with increasing levels of nutrients in the media. More over application of nutrients in organic form reduces the loss of nutrients from the media.

Better nutrient availability and uptake during the vegetative and fruiting phase might have increased the production, translocation and assimilation of photosynthates to growing points and stimulated the plants to produce more number of fruits and better fruit characters.

The normal yield of bhindi is about 500 g per plant. In this study productivity realized was only 50 % of the normal yield. The meteorological observations recorded during the crop growing period (Appendix II) shows that the crop was subjected to high temperature. All the growth parameters recorded were also less compared to normal situations. This cannot be taken as a treatment effect because comparable yield was obtained in the control treatment (potting mixture).

5.2.3 Effect of nutrient levels and method of application on root characters and water use efficiency of bhindi

A scanning of the data presented in table 28 showed that all the root characters were favourably influenced by nutrient levels and method of application. Significantly higher values for root length, root spread, root volume and WUE were recorded by N_3. Media application of nutrients was found to be superior in terms of its effect on root length. Since the study was conducted in summer, daily water requirement of the crop was high due to high temperature during the period of conduct of the experiment.

Higher availability of nutrients in N_3 treated media by direct application would have helped in the development of healthy root system, growth and yield attributes which in turn reflected in higher yield and WUE.

5.2.4 Effect of nutrient levels and method of application on chemical properties of the media after the experiment

Different methods of application had significant influence on NPK content of the media after the experiment. N_3 recorded the highest NPK content of media

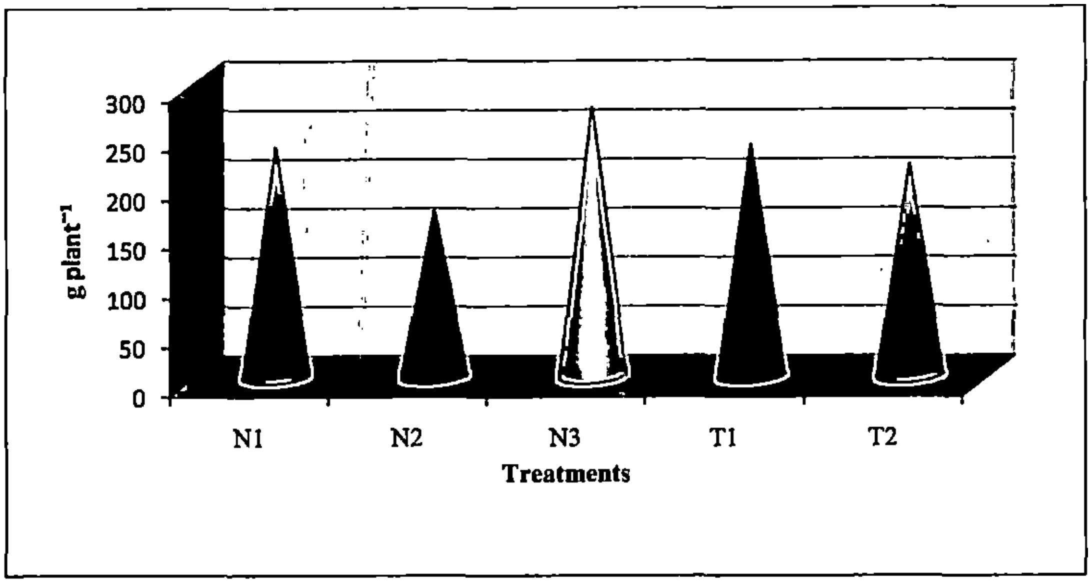


Fig 10. Effect of nutrient levels and methods of application on fruit yield (g plant^{-1})

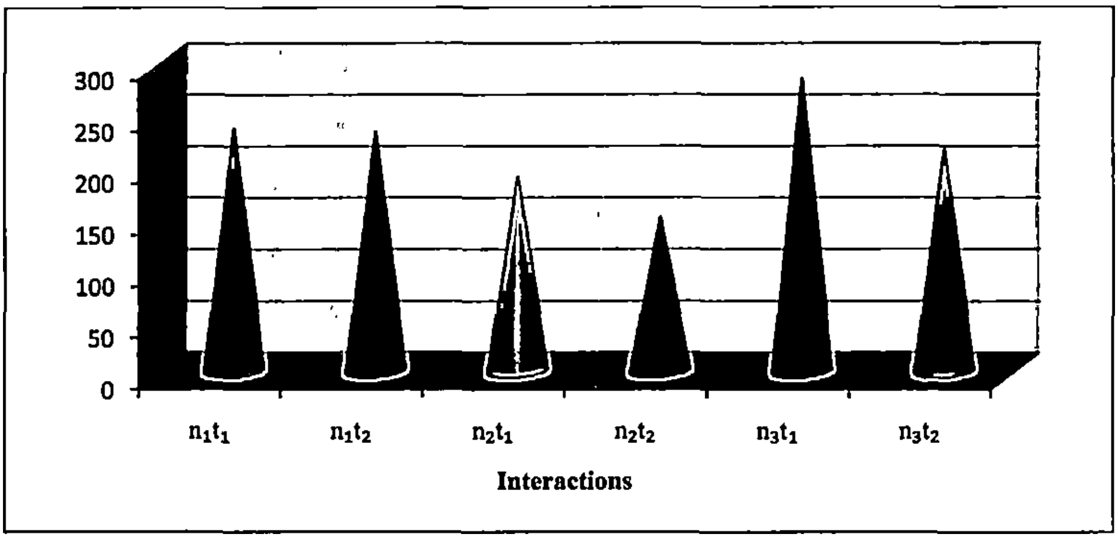


Fig21. Interaction effect of nutrient levels and methods of application on fruit yield (g plant^{-1})

.Among the methods of application, T_1 recorded highest N content in the media after the experiment. The higher value of available nutrients in N_3 might be due to the higher level given to the crop. It can also be due to the higher degree of decomposition and mineralization of the coir pith compost in the media.

5.2.5 Effect of nutrient levels and method of application on nutrient uptake

Increased uptake of nitrogen due to higher rate of nutrient application is a proven fact. Highest N and P uptake were recorded at highest level of nutrient application *ie*; N_3. A stimulated growth under higher levels of nutrient application might have resulted in better proliferation of root system and increased intake efficiency of plants. Higher rate of nitrogen increased protein biosynthesis leading to new tissue formation. Protein synthesis involves ADP and ATP, which are high energy compounds. Hence for the operation of the pathway, phosphorus is utilized in greater amounts at higher rates of nitrogen (Tisdale *et al.*, 1995). Krishnaswamy *et al.* (1984) observed that application of FYM had a significant effect on increasing the available phosphorus from the native and applied sources.

N_3 (0.31) and N_1 (0.31) recorded the maximum potassium uptake and the minimum was recorded by N_2 (0.21). Better vegetative growth resulting from higher level of nitrogen might have resulted in higher potassium uptake. The enhanced proliferation of roots also might have helped in the increased uptake of potassium. The positive effect of coir pith compost and FYM in moisture retention in the media would have accelerated K^+ diffusion to roots.

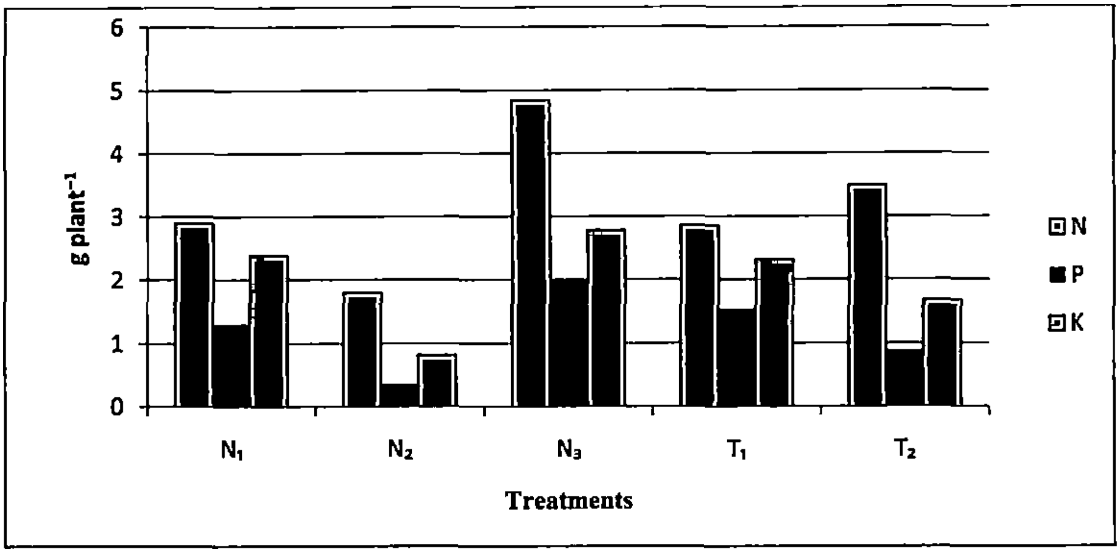


Fig 12. Effect of nutrient levels and methods of application on plant nutrient uptake, g/plant

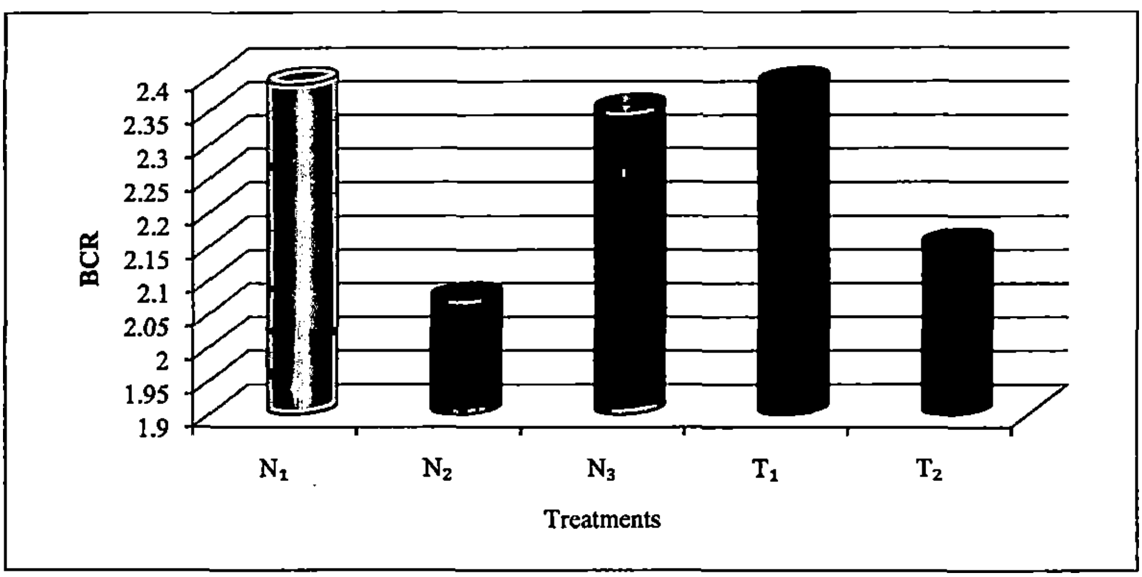


Fig13. Effect of nutrient levels and methods of application on BCR

5.2.6 Effect of nutrient levels and method of application on economic analysis

The economics of cultivation was worked out as BCR and net income. It can be noted from the table 32 that the different levels of nutrients could significantly influence the net income and BCR.

Among the nutrient levels N_3 recorded the maximum net income (4.72). Highest BCR was recorded in N_1 and it was found to be on par with N3. Direct application of nutrients to the growth media (T_1) recorded highest BCR and net income. This is might be to the highest yield obtained when 125 % of POP recommendation was directly applied to the media.

Summary

6. SUMMARY

An investigation titled "Organic nutrient scheduling in soilless vegetable cultivation" has been carried out at College of Agriculture, Vellayani during the year 2012-13. The main objectives of the study were to standardize soilless media and nutrient schedule for vegetable production in soilless culture (grown in containers) and to work out the economics of different treatments, and also to assess the effect of growth media on growth, yield and quality of Bhindi. The investigation comprises of two parts (1) Standardization of different growth media for soilless culture and (2) Nutrient scheduling for soilless culture.

The first experiment was conducted in CRD with seven treatments and three replications. The treatments included combinations of coir pith and coir pith compost with FYM in various ratios of 1:1, 1:2, and 2:1 (by weight), coir pith compost alone, neopeat and ordinary potting mixture.

The salient findings of this investigation are summerised below.

Part 1.Standardization of different growth media for soilless culture

1. The effect of different growth media on growth, yield and WUE of bhindi was significant. Plant height differed significantly with various treatments at all stages of growth. Plant height was highest for the medium coirpith compost and FYM in 2:1 proportion by weight. But at 45, 60, 90 and 105 DAS ordinary potting mixture recorded the highest plant height.

2. Number of leaves per plant differed significantly with different growth media at all stages of growth. Number of leaves per plant was highest in coirpith compost and FYM in 2:1 proportion by weight at 60 and 90 DAS.

3. Growth media does not have any significant influence on the number of branches per plant.

4. Duration of the crop was influenced significantly. Coir pith compost and FYM in 2:1 ratio resulted in shortest duration compared to other treatments.

5. Flowers per plant, number of fruits per plant, setting percentage and fruit yield per plant were significantly influenced by different growth media. Ordinary potting mixture was found to be the best in all yield and yield attributing characters and it was on par with coirpith compost and FYM in 2:1ratio.

6. Fruit characters like length and girth varied significantly with various treatments. Ordinary potting mixture, M_7 recorded significantly highest fruit length compared to all other growth media whereas the girth of fruit was highest for coir pith compost and FYM in 2:1ratio.

7. Root characters like root length, spread and volume varied significantly with various growth media. Coir pith compost and FYM in 2:1 ratio, recorded the highest root length and was on par with all treatments except neopeat and ordinary potting mixture.

8. Influence of different growth media on water use efficiency was significant. Coir pith compost and FYM in 2:1ratio recorded the highest WUE.

9. Ordinary potting mixture recorded highest microbial count and was significantly superior to all other growth media.

10. Chemical properties of media also showed significant variation. Coir pith compost and FYM in 1:1 ratio, recorded the highest nitrogen and pH compared to other growth media. Phosphorous content was highest in coir pith and FYM mixed in 1:2 ratio. Potassium content was highest in neopeat.

11. Nutrient uptake differed significantly with treatments. Highest uptake of nitrogen and phosphorous was recorded in the treatment coir pith compost and FYM in 2:1 ratio. Potassium content was highest for ordinary potting mixture.

12. Net income and benefit cost ratio were highest in potting mixture and was on par with coir pith compost and FYM mixed in 2:1ratio.

When bhindi was cultivated in different soilless media in pots of 7 litre volume capacity, it was found that coirpith compost and FYM mixed in 2:1 proportion by weight is the ideal growth medium. This media recorded the highest fruit yield per plant of 227.92 g and WUE (0.0031 kg/pot/l). Highest B: C ratio and net income were recorded with ordinary potting mixture, which was on par with coir pith compost and FYM mixed in 2:1ratio.

Part II. Nutrient scheduling for soil less culture

The experiment was conducted to assess the effect of different nutrient levels and method of application for bhindi grown in soilless culture. The experiment was laid out in CRD with 6 treatments and four replications. The treatments included three levels of nutrients and two methods of application. The growth media used for the experiment was coir pith compost and FYM in 2:1 proportion which was found best from the previous experiment.

The salient findings of this investigation are summarized below.

1. Plant height, leaves per plant and LAI were highest at 125 % of POP by organic at all growth stages.

2. Level of nutrients and method of application did not show any significant influence on number of branches.

3. Highest level of nutrient, 125 % of POP,as organic directly applied to growth media recorded highest number of flowers and fruits.

4. Fruit yield per plant (273.46 g) and total fruit yield per ha (8.61 t) were highest with the highest level of nutrient (125 % of POP) as organic applied directly to the growth media.

5. Available nitrogen, phosphorous and potassium were highest at 125 % of POP as organic. The highest nutrient level (125% POP) applied directly to the growth media recorded highest N, P and K uptake of bhindi.

6. Organic nutrient combination of 125 % of POP (N_3) and direct application to growth media, (T_1) recorded the highest WUE.

7. Among all the different nutrient levels and method of application, the highest net income per pot was recorded by the highest level of nutrient (125 % of POP as organic) applied directly to the growth media. 100% of POP recommendation, along with direct application to growth media resulted in the highest BCR.

When bhindi was cultivated in soilless media of coirpith compost and FYM in 2:1 proportion in pots of 7 litre volume , the treatment 125% POP as organic as direct application to the growth media recorded the highest fruit yield per plant (273.46 g) and total fruit yield per ha (8.61 t). The highest B: C ratio was recorded by the highest dose of nutrient application and POP as direct application to growth media resulted in the highest net income of Rs. 4.72.

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ORGANIC NUTRIENT SCHEDULING IN SOILLESS VEGETABLE CULTIVATION

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Abstract of the

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ABSTRACT

An investigation entitled 'Organic nutrient scheduling in soil less vegetable cultivation' has been carried out at College of Agriculture, Vellayani during October 2012- June 2013. The main objectives of the study were to standardize soil less media and nutrient schedule for vegetable production (grown in containers) and to work out the economics of different treatments. The crop selected for the study was bhindi *var-* Varsha Uphar and the study comprised of two pot culture experiments.

First experiment was to standardize growth media for soil less culture. The experiment was laid out in Completely Randomized Block Design with seven treatments and three replications. Treatments consists of seven media: - coir pith + FYM (1:1), coir pith + FYM (1:2), coir pith compost + FYM (1:1), coir pith compost + FYM (2:1), coir pith compost alone, compressed coir pith (neo peat) and potting mixture (1:1:1 soil, sand and FYM).The best media from this study was selected for Part II study.

The results of the study showed that different growth media had significant influence on growth and yield characters of bhindi. Coir pith compost + FYM (2:1) recorded maximum yield and B:C ratio. The effect of this media was on par with potting mixture. Hence Coir pith compost + FYM (2:1) was selected for the part II study.

Second experiment was to standardize nutrient schedule for soil less bhindi .The design was Completely Randomized Block Design with six treatment combinations and four replications. Treatments comprised of three nutrient levels - package of practices recommendations (POP) as organic, 75 % of POP as organic and 125 % of POP as organic and two methods of application for top dressing- direct application to growth media and foliar application.

125 % of POP as organic recorded significantly higher plant height, number of leaves, LAI, flowers/ plant, root characters, water use efficiency, nutrient uptake and yield (283.412 g /pot). Direct application to growth media was better than foliar application in terms of fruit length, fruit yield, root length and WUE.

Direct application of 100 % of POP as organic in the growth media is the most economic treatment (B: C ratio-3.12).

സംഗ്രഹം

മണ്ണില്ലാകൃഷിയിൽ ജൈവിക വളപ്രയോഗം എന്നതിനെ കുറിച്ച് ഒരു പഠനം 2012–2013 കാലയളവിൽ കാർഷികകോളേജ്, വെള്ളായണി ,തിരുവനന്തപുരത്ത് നടത്തുകയുണ്ടായി.

രണ്ടുഭാഗങ്ങളായി നടത്തിയ ഈ പഠനത്തിന്റെ പ്രധാനലക്ഷ്യങ്ങൾ മണ്ണില്ലാ കൃഷിയ്ക്ക് അനുയോജ്യമായ വളർച്ചാമാധ്യമം ഉരുത്തിരിച്ചെടുക്കുക, ജൈവികരീതിയിലുള്ള വളപ്രയോഗം ചിട്ടപ്പെടുത്തുക എന്നിവയായിരുന്നു.

പ്രസ്തുത പരീക്ഷണത്തിന് 'കംപ്ലീറ്റിലി റാംഡമൈസ്ഡ് ബ്ലോക്ക് ഡിസൈൻ' എന്ന പരീക്ഷണ രീതിയാണ് അവലംബിച്ചത്. ഏഴ് മിശ്രിതങ്ങളാണ് പരീക്ഷണ വിധേയമാക്കിയത്. മൂന്നു തവണ ആവർത്തിക്കപ്പെട്ടു. ചകിരിച്ചോറ് + ചാണകം (1:1), ചകിരിച്ചോറ് + ചാണകം (1:2), ചകിരിച്ചോറ് കമ്പോസ്റ്റ് + ചാണകം (1:1), ചകിരിച്ചോറ് കമ്പോസ്റ്റ് + ചാണകം (2:1), ചകിരിച്ചോറ് കമ്പോസ്റ്റ് മാത്രം, കംപ്രസ്ഡ് ചകിരിച്ചോറ് (നിയോപീറ്റ്), നടീൽമിശ്രിതം എന്നിവയാണ് പരീക്ഷിച്ചത്.

പരീക്ഷണഫലം കാണിക്കുന്നത് വളർച്ചാമാധ്യമങ്ങൾ വെണ്ടച്ചെടിയുടെ വളർച്ചയെയും വിളവിനെയും സാരമായി ബാധിക്കുന്നു എന്നതാണ്. അതിൽ ചകിരിച്ചോറ് കമ്പോസ്റ്റ് + ചാണകം (2:1) എന്ന മിശ്രിതം നടീൽ മിശ്രിതം പോലെ തന്നെ മെച്ചമാണെന്ന് കണ്ടു. ആയതിനാൽ ചകിരിച്ചോറ് കമ്പോസ്റ്റ് + ചാണകം (2.1) എന്ന മിശ്രിതം രണ്ടാമത്തെ പരീക്ഷണത്തിനായി ഉപയോഗിച്ചു.

രണ്ടാമത്തെ പരീക്ഷണം ജൈവിക രീതിയിലൂടെയുള്ള വളപ്രയോഗം ചിട്ടപ്പെടുത്തുന്നതിനായിരുന്നു. ഇതിൽ 'കംപ്ലീറ്റിലി റാംഡമൈസ്ഡ് ബ്ലോക്ക് ഡിസൈൻ' എന്ന പരീക്ഷണ രീതിയിൽ വളങ്ങളുടെ 3 തോതും 2 പ്രയോഗങ്ങളും പരീക്ഷണ വിധേയമാക്കി. പരീക്ഷിച്ച വളങ്ങളുടെ തോത്- ശുപാർശ ചെയ്ത വളപ്രയോഗം, ശുപാർശയുടെ 75 ശതമാനം, ശുപാർശയുടെ 125 ശതമാനം. ഈ മൂന്നു തോതിലുള്ള വളങ്ങൾ പരീക്ഷിച്ച രീതി- മുഴുവൻ വളങ്ങളും നേരിട്ട് വളർച്ചാമാധ്യമത്തിൽ നൽകുന്ന രീതിയും പത്രപോഷണം വഴി നൽകുന്ന രീതിയും.

വെണ്ടച്ചെടിയുടെ വളർച്ചാ മാനദണ്ഡങ്ങളായ ചെടിയുടെ പൊക്കം, ഇലകളുടെ എണ്ണം, ജലവിനിയോഗശേഷി, പൂക്കളുടെ എണ്ണം, വേര് പടലത്തിന്റെ പ്രത്യേകതകൾ, മൂലകങ്ങളുടെ ഉപയോഗം, അറ്റാദായം തുടങ്ങിയവ ഏറ്റവും കൂടുതൽ ലഭിച്ചത് ശുപാർശയുടെ 125 ശതമാനം പോഷകങ്ങൾ നൽകിയപ്പോഴാണ്. കായ്കളുടെ നീളം, അറ്റാദായം, വേരുകളുടെ നീളം, ജലവിനിയോഗശേഷി എന്നിവ നോക്കിയപ്പോൾ നേരിട്ട് മാധ്യമത്തിലുള്ള വളപ്രയോഗം ഇലകളിലൂടെയുള്ള വളപ്രയോഗത്തെക്കാൾ നല്ലതാണെന്ന് കണ്ടെത്തി.

മണ്ണില്ലാകൃഷിയ്ക്ക് ഏറ്റവും അനുയോജ്യമായ വളർച്ചാമാധ്യമം ചകിരിച്ചോറ് കമ്പോസ്റ്റ് + ചാണകം (2:1) എന്ന തോതിൽ ചേർത്ത് തയ്യാറാക്കുന്ന മാധ്യമമാണ്. ശുപാർശ ചെയ്തിട്ടുള്ള വളപ്രയോഗത്തിന്റെ 125 ശതമാനം ജൈവികരീതിയിൽ വളർച്ചാമാധ്യമത്തിൽ നേരിട്ട് നൽകുന്നതാണ് ഏറ്റവും മികച്ച അറ്റാദായം നൽകുന്ന വളപ്രയോഗം എന്നും ഈ പഠനത്തിൽ നിന്നു ബോധ്യപ്പെട്ടു.

Appendices

Appendix 1

Weather data for the cropping period

(15th Nov 2012– 1st March, 2013) – Weekly averages

STANDARD WEEK	TEMPERATURE (°C)		Relative humidity (%)	Rain fall (mm)
	Max temp	Min temp		
46	30.55	23.20	79.12	3.00
47	30.50	23.10	85.45	1.00
48	30.60	22.70	83.35	0.00
49	30.50	22.60	82.65	0.50
50	30.60	22.10	80.70	0.00
51	31.10	22.80	75.85	0.00
52	30.50	23.50	85.45	13.30
1	30.60	23.40	83.70	8.80
2	30.00	22.60	85.50	24.0
3	30.10	20.80	85.55	0.00
4	30.50	21.30	84.85	0.00
5	30.50	20.80	84.85	0.00
6	31.20	22.90	83.80	2.50
7	32.00	23.00	84.05	11.00
8	31.40	21.80	82.40	0.00
9	31.80	20.90	77.00	0.00

Appendix II

Weather data for the cropping period

(8th Mar 2013– 13th Jul, 2013) – Weekly averages

STANDARD WEEK	TEMPERATURE (^{0}C)		Relative humidity (%)	Rain fall (mm)
	Max temp	Min temp		
12	32.30	23.70	83.40	0.00
13	32.60	25.30	84.45	31.00
14	32.90	26.00	80.85	0.00
15	32.80	25.60	80.65	1.50
16	33.20	25.10	80.40	0.00
17	33.30	25.00	79.85	20.30
18	32.70	25.80	86.15	3.60
19	32.00	26.10	85.80	11.50
20	32.40	25.70	83.50	5.20
21	32.10	24.20	88.15	7.20
22	30.10	22.30	91.35	33.20
23	29.20	22.80	88.45	15.00
24	29.10	23.20	92.20	20.20
25	28.30	22.50	90.75	23.60
26	29.90	23.30	88.54	8.60
27	29.30	22.40	89.50	6.70