AGRONOMIC PACKAGE FOR CONTAINER GROWN ELEPHANT FOOT YAM

by

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THESIS

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DECLARATION

I, hereby declare that this thesis entitled **"AGRONOMIC PACKAGE FOR CONTAINER GROWN ELEPHANT FOOT YAM"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Vellayani,
Date: 14.07.17

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LIST OF ABBREVIATIONS AND SYMBOLS USED

@	At the rate of
^{0}C	Degree Celsius
%	Per cent
₹	Rupees
µg	Microgram
BCR	Benefit cost ratio
BR	Bulking rate
CD	Critical difference
cm	Centimetre
C:N	Carbon : Nitrogen
CRD	Completely randomized design
CTCRI	Central Tuber Crops Research Institute
EC	Electrical conductivity
et al.	And others
Fig.	Figure
FYM	Farmyard Manure
g	Gram
ha	Hectare
ha^{-1}	Per hectare
ICAR	Indian Council of Agricultural Reasearch
INM	Integrated nutrient management
K	Potassium
KAU	Kerala Agricultural University

kg	Kilogram
kg ha^{-1}	Kilogram per hectare
L	Litre
LAI	Leaf area index
MAI	Month after incubation
MAP	Month after planting
MgM^{-3}	Mega gram per cubic metre
mm	Millimetre
No.	Number
N	Nitrogen
Plant $^{-1}$	Per plant
P	Phosphorus
Sack^{-1}	Per sack
SEm	Standard error of means
t ha^{-1}	Tonnes per hectare
TDMP	Total dry matter production
UI	Utilization index
viz.	Namely

INTRODUCTION

1. INTRODUCTION

Elephant foot yam *(Amorphophallus paeoniifolius* (Dennst.) Nicolson) is a tropical tuber crop belonging to the family Araceae of order Nudiflorae of Monocotyledonae. It is basically a crop of south eastern Asian origin. It is mainly grown and consumed in Africa, South Asia, South East Asia and the tropical Pacific islands. In India, it is cultivated in Andhra Pradesh, Tamil Nadu, Gujarat, Maharashtra, West Bengal, North Eastern states, Kerala, Karnataka, Bihar, Odisha and Uttar Pradesh. It has high production potential and serves as a source of starch as well as protein. It is mainly used as vegetable and possesses good keeping quality. In addition to its high nutritive value and good culinary properties, it has medicinal values also. It is traditionally used for the treatment of various diseases such as piles, abdominal disorders, tumours, enlargement of spleen, asthma and rheumatism (Singh and Wadhwa, 2014).

In Kerala, elephant foot yam is usually cultivated in the coconut garden as a remunerative intercrop. In the present context of shrinking land area available for cultivation especially in urban areas, the container cultivation is becoming popular. The elephant foot yam can be raised in containers in the available space around houses or on house terraces to ensure safe and fresh produce for household consumption in urban areas. Container cultivation also avoids tedious field work and enables efficient utilization of nutrients and moisture by the plant in the container.

An ideal growth medium is necessary for crops grown in containers. Usually soil, sand and FYM are taken in 1:1:1 ratio to prepare the growth medium. Due to non availability of sand and its high cost, the possibility of substituting sand with coir pith is to be explored. Coir pith is abundantly available in Kerala as a byproduct of coir industry. Besides, use of coir pith as a component of growth medium will reduce the weight of the container which is especially advantageous for farming on house terrace. Due to its high C : N ratio, it is necessary to find out the optimum proportion of coir pith in the growth medium for achieving high yield.

Organic farming is the thumb rule for raising crops on house terrace in containers. Elephant foot yam is amenable for organic cultivation. In the present study, the recommended dose of nutrients for elephant foot yam is applied in the growth medium through organic sources like groundnut cake, bone meal and wood ash. For field cultivation, it is recommended to apply nutrients in splits at 1 ½ months after planting (MAP) and 2 ½ MAP for elephant foot yam as per KAU (2011). But more number of split application may be required for the crop grown in containers.

In Kerala, the crop is usually cultivated under rainfed conditions by planting during February-March and harvesting in November – December. Although elephant foot yam tolerates soil water deficit stress, it should be avoided to ensure higher corm yield. Moisture stress should be avoided especially when the crop is grown in containers. Padmanabhan and Swadija (2015) advocated ration irrigation but daily irrigation for vegetables grown in containers on house terraces. However, daily irrigation is not required for a tuber crop like elephant foot yam. Hence, it is necessary to standardize frequency of irrigation for the crop grown in containers.

At present, technology for organic production of elephant foot yam in containers is lacking. Hence there is the necessity to standardize growth medium as well as nutrient and irrigation schedule for container grown elephant foot yam. In this background, the present study is undertaken

- to standardize growth medium and nutrient and irrigation schedule for elephant foot yam grown in containers
- to study tuberisation pattern in elephant foot yam
- to study nutrient release pattern in different growth media

in order to formulate a cost effective agronomic package for elephant foot yam grown in containers.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The present study is undertaken to standardize growth medium and nutrient and irrigation schedule for elephant foot yam grown in containers, to study tuberisation pattern in elephant foot yam and to study nutrient release pattern in different growth media in order to formulate a cost effective agronomic package for elephant foot yam grown in containers. Hence relevant literature on elephant foot yam and related crops are reviewed in this chapter.

2.1 CONTAINER CULTIVATION

Container cultivation is a farming where a family unit or household is producing fruits and vegetables in special containers for achieving food and nutritional security of family members. The advantages of container cultivation includes maximum utilization of space and time, benefit on personal growth and development and availability of fresh pollution free produce (Deveza and Holmer, 2002).

Container cultivation can be advocated on house terraces or in the available area around houses where land is limited especially in urban homesteads (Padmanabhan and Swadija, 2002; 2006; 2007; 2015). According to Padmanabhan and Swadija (2006 and 2015) plastic sacks are found to be better containers than earthen flower pots due to their less weight , low cost and retention of moisture for longer periods. In addition to vegetables, tuber crops like elephant foot yam, colocasia, coleus, sweet potato and cassava can also be cultivated in plastic sacks on house terraces.

According to John *et al.*, (2015), commonly used containers are earthen pots, plastic pots, grow bags and plastic sacks of varying size. Other containers like stone container, metallic container, wooden container, concrete pots and soild waste like plastic bottles, milk jug, PVC pipes etc. can also be used. Plastic sack hold more growing media and are more porous and hence found to be the best container for most vegetables.

The containers filled with growth medium can be placed even in porches where ample sunlight is available, house balcony, indoors, low cost poly houses and rain shelters. John *et al.* (2015) observed that in majority of households surveyed, 50-75 per cent of the terrace area was utilized for cultivation. The major crops cultivated in containers include vegetables like amaranthus, cowpea, chilli, tomato, brinjal and cucurbits. Crops like banana, cassava, elephant foot yam, colocasia, ginger and turmeric are also grown in containers in the homesteads.

2.2 GROWTH MEDIUM FOR CONTAINERS

Growth medium plays an important role in growth and yield of crops. A suitable proportion of various components is essential for production of quality crops. The growing medium should have appropriate aeration, water holding capacity and drainage for efficient functioning of the root system. It should not contain any pathogen or eggs and larvae of any pest in order to avoid pest and disease incidence. Different materials can be used depending on their properties, availability and cost. Soil, sand and FYM are commonly used to prepare the growth medium. Sand is used in the growth medium to facilitate aeration and drainage. Non availability and high cost of sand have led us to think of alternate sources like coir pith.

2.2.1 Farmyard Manure

Farmyard manure is the most readily available and commonly used organic manure. It supplies both major and minor nutrients as well as improves the physical, chemical and biological properties of soil. Hence it is used as an important component of the growth medium.

2.2.1.1 Effect of FYM on Growth Characters

In elephant foot yam, Hore *et al.* (2003) reported that length and girth of pseudostem and crop canopy were the highest in treatments with the highest level of FYM. According to Sahoo *et al.* (2015), application of FYM @ 25 t ha $^{-1}$ resulted in the highest leaf area plant^{-1} and it was on a par with the treatment FYM 10 t ha $^{-1}$ + 100:60:100 kg NPK ha $^{-1}$.

In a study conducted with 3 levels of FYM (0, 12.5 and 25 t ha $^{-1}$) and P (0,30 and 60 kg ha $^{-1}$), the treatment with FYM @ 25 t ha $^{-1}$ resulted in the highest plant biomass (9.54 kg plant^{-1}) and foliage weight (6.24 kg plant^{-1}) in cassava (Sankar *et al.*, 1999). Pamila (2003) reported that among different organic manures, FYM produced significantly higher plant height and higher number of leaves in cassava. Cassava with application of FYM 12.5 t ha^{-1}gave better response in growth characters (KAU, 2007).

Coleus produced higher dry matter production when FYM was applied as the source of organic manure (Archana and Swadija, 2000). Compared to poultry manure and CPC, FYM application recorded maximum vine length in sweet potato (Dhanya, 2011).

2.2.1.2 Effect of FYM on Yield Components and Yield

Patel and Mehta (1987) reported higher corm yield of elephant foot yam with the application of FYM @ 30 t ha^{-1}. Hore *et al.* (2003) observed that the corm diameter and corm weight were the highest with the highest FYM level and there was a yield increase from 28.92 to 32.34 t ha^{-1} by increasing the FYM level from 15 to 20 t ha^{-1}. According to Suja *et al.* (2010), application of FYM @ 36 t ha^{-1} along with green manuring and neem cake resulted in higher corm yield (34.6 t ha^{-1}) and higher income over conventional farming. Sahoo *et al.* (2015) reported that the application of FYM @ 25 t ha^{-1} resulted in 97.1% higher corm yield over control.

Cassava showed an increase in yield of about 17.7 % (Mohankumar *et al.*, 1976) and 11.8 % (Gaur *et al.*, 1984) over control when FYM alone was applied. Guar *et al.* (1984) also reported an increase in yield of about 30.6 % in sweet potato due to application of FYM over control. In sweet potato basal application of FYM @ 5 t ha $^{-1}$ increased the yield (Pillai *et al.*, 1987 and Ravindran and Balanambisan, 1987).

In arrow root, application of even lower dose of FYM (10 t ha^{-1}) produced 46 % higher rhizome yield over control as reported by Swadija *et al.* (2013).

2.2.1.3. Effect of FYM on Quality Characters

Sankar *et al*., (1999) reported that application of FYM @ 25 t ha $^{-1}$ resulted in the highest cooking quality, organoleptic scores and the highest starch content (38 %) in elephant foot yam. Suja *et al*. (2010) reported higher dry matter and Mg contents and significantly lower oxalate content in the corms of elephant foot yam due to application of FYM @ 36 t ha^{-1} along with green manuring and neem cake.

Dhanya (2011) obtained higher starch content in tubers of sweet potato when 100 % of recommended dose of nutrients was substituted with FYM.

In arrow root, quality characters of rhizome such as dry matter, starch, crude protein, and crude fibre were increased with the application of even 10 t ha^{-1} of FYM alone over control (Swadija *et al*., 2013).

2.2.1.4. Effect of FYM on Soil Properties

Incorporation of FYM was shown to decrease bulk density (Khaleel *et al*., 1981), increase infiltration rate (Acharya *et al*., 1988) and improves soil structure and water retention capacity (Bhagat and Verma, 1991). Kumar *et al*. (2015) noticed a decreasing trend of soil bulk density with increasing FYM levels.

Availability of phosphorus (P) from native and applied sources increased with the application of FYM (Krishnaswamy *et al*., 1984). FYM treated soils showed an increase in available P content than inorganically treated soils (Bharadwaj and Omanwar, 1994).

Application of FYM continuously in tropical area improved organic carbon and microbial biomass carbon in soil with balanced fertilization (Goyal *et al*., 1993). Application of FYM increased organic carbon content in soil (Acharya *et al*., 1988 and Benbi *et al*., 1998). Mastol (2006) reported increase in soil organic carbon, microbial biomass and microbial coefficient with the application of FYM.

Patil *et al*. (2003) observed that with each increment in FYM, the soil pH decreased from 7.99 to 7.65 and pH decreased significantly during decomposition due to the production of organic acids. Electrical conductivity of soil was also found to decrease with application of FYM (Rathod *et al*., 2003). Kumar *et al*.

(2015) reported that soil pH, EC and nutrient status increased with increasing levels of FYM application.

2.2.2 Coir Pith

2.2.2.1. Properties of Coir Pith

Coir pith, the mesocarp of the coconut, is a waste product of coir industry. Das (1992) reported that it has 70% of porosity and above 500% water holding capacity. The water holding capacity was reported to be in the range of 400 to 600 % by Savithri and Khan (1994). It has low bulk density and particle density and high K content (Evans *et al.*, 1996). Coir pith has high cation exchange capacity (Mapa and Kumara 1995; Mbah and Pdili, 1998) and can retain large amounts of nutrients, and adsorption complex has high contents of exchangeable K, Na, Ca and Mg (Verhagen and Papadopoulos, 1997). Due to this high nutrient storage capacity, coir pith can prevent the loss of nutrients and due to the presence of nitrification inhibitors, it can prevent the loss of nitrogen (N) by reducing the nitrification (Prabhu and Thomas, 2002).

The organic carbon content of raw coir pith was reported to be around 29 per cent by Ramamoorthy *et al.* (1999 and 2000). Coir pith is reported to be acidic in nature (Mukherjee, 2001; Jeyaseel and Raj, 2010).

2.2.2.2. Effect of Coir Pith on Soil Properties

The continuous application of coir pith for eight years improved the soil organic carbon status (Nambiar *et al.*, 1983). Coir pith also increased the oxygen supply to the rooting medium (Nagarajan *et al.*, 1985).

Bhowmic and Debnath (1985) reported that coir pith application increased the soil water holding capacity. Application of coir pith in soil improves the structure and other chemical and physical properties of the soil (Bopaiah, 1991). Coir pith application in soil increases the fixed and mineral potassium in soil and hence the quantity of potassium fertilizers can be reduced (Savithri *et al.*, 1993). When coir pith is incorporated as an ameliorant, it improves the physical properties such as pore space, bulk density, hydraulic conductivity and infiltration rate of the soil. It helps to retain water and improve aeration in root zone because of its sponge like structure (Savithri and Khan, 1994).

2.2.2.3. Coir Pith as a Component of Growth Medium

Coir pith has beneficial properties such as it can be used in agriculture as a rooting medium, mulching material, and as soil conditioner to improve soil drainage (Hume, 1949). Cresswell (1992) reported the use of coir pith as a growth medium for several ornamental and agronomic crops and recommended it as a substitute for peat in growth media. Coir pith can be used in growth medium as a component alternative to peat due to its favorable physical and chemical properties (Bragg *et al.,* 1993; Savithri and Khan, 1994).

For cassava, there was a significant yield increase when coir waste was incorporated @ 10 t ha^{-1} compared to coir waste @ 5 t ha^{-1} and FYM @ 12.5 t ha^{-1} (Ayyaswami *et al.*, 1996). Mukherjee (2001) observed significant increase in yield of elephant foot yam, taro, and sweet potato grown in soil amended with 50% coir pith over control (100% soil) and supplied with recommended dose of nutrients.

Suharban *et al.*, (2004) observed that the best medium for anthurium cultivation is that the combination of coarse sand, coconut husk and coir pith in the ratio of 1:1:1 or coarse sand, coconut husk, dry cow dung and coir pith in the ratio of 1:1:1:1 among seven different media. Jeyaseel and Raj (2010) found that coir pith can be successfully used as soil less medium for crops like brinjal, bhindi and tomato. Reghuvaran and Ravindranath (2013) reported that coir pith is an ideal medium for plant growth, it helps to keep low soil temperature, being a poor conductor of heat.

Coir pith compost: FYM (2:1) was found to be the best medium for growing vegetables like bindhi in containers (Cuckoorani, 2013). Soumya (2015) reported that coir pith compost: FYM (1:2) was the best medium for tomato grown in containers.

According to John *et al*. (2015), the best yield of brinjal grown in containers was obtained with cow dung + coir pith in 1:1 proportion among different growth media and for bhindi, cow dung + coir pith in 1:1 proportion was on a par with soil+ sand+cow dung in 1:1:1 proportion.

2.3 ORGANIC NUTRITION FOR ELEPHANT FOOT YAM

According to Suja *et al.* (2012), organic nutrition is a viable technology to maximize productivity and quality of elephant foot yam while maintaining soil fertility. Elite and local varieties responded equally well to organic and conventional farming.

2.3.1 Effect of Organic Nutrition on Growth and Yield

Ray *et al*. (2006) obtained the highest yield (45.89 t ha^{-1}) of elephant foot yam with organic manures alone. Organic nutrition package standardized in elephant foot yam comprising FYM, green manuring, neem cake and wood ash profoundly favoured growth and yield of elephant foot yam over conventional (INM) practice (Suja *et al.,* 2010 and 2012). In farmers' field trials, organic farming resulted in higher corm yield (34.6 t ha^{-1}) and additional income of ₹43,651 ha^{-1} (BCR of 1.49) over INM (BCR of 1.4) (Suja *et al.*, 2010). According to Suja *et al.* (2012), organic farming resulted in 20 per cent yield increase in elephant foot yam with an additional income of ₹ 47,716 ha^{-1} over conventional practice but Kolambe *et al.*(2013) reported that the organic treatments were on a par with chemical based farming for the growth parameters like plant height, pseudo stem girth and canopy spread as well as corm yield of elephant foot yam.

2.3.2 Effect of Organic Nutrition on Tuber Quality

Organic farming in elephant foot yam improved tuber quality with significantly higher dry matter and starch contents and lower oxalate content (Suja et al., 2010 and 2012; Suja , 2013) Significantly higher starch and sugar contents and improvement in protein content of corm of elephant foot yam were observed by Kolambe *et al*. (2013) due to organic management.

2.3.3 Effect of Organic Nutrition on Soil Properties.

Organic nutrition plays a major role in maintaining soil fertility status and environmental quality besides improving the yield. Addition of organic manures increased the soil organic carbon and available NPK contents (Srivastava, 1985; More, 1994). Kabeerathumma *et al.* (1993) observed increased levels of Ca and Mg in soil due to the application of wood ash. Soil organic matter, soil pH and available NPK contents in soil were increased in organic farming system (Clark *et al.*, 1998). Gerhardt (1997) observed increased aeration, water holding capacity and porosity of soils under organic management system. Organic farming is a comprehensive management system to improve the soil health and productivity (Palaniyappan and Annadurai, 1999). In situ water holding capacity is the highest in organic management system (Colla *et al.*, 2000).

Suja *et al.* (2010) observed overall improvement in soil physio- chemical properties under organic farming at all farm sites due to the influence of organic manures besides increased yield in elephant foot yam. Suja *et al.* (2012) also observed higher water holding capacity, lower particle density and bulk density and higher porosity in organic plots under elephant foot yam. Post-harvest analysis of organic plot revealed significant improvement in soil pH and soil organic matter and higher N and P status after elephant foot yam.

According to Kolambe *et al.* (2013), continuous application of organic manures from 2005 to 2011 lowered the bulk density of soil. The lowering of bulk density coupled with greater mineralization of organic matter favoured the growth and yield of elephant foot yam. There was overall improvement in soil physico-chemical properties under the influence of continuous application of organic manures for elephant foot yam.

2.3.5 Organic Nutrition for Container Grown Plants

According to Cuckoorani (2013), application of 125 % of the recommended dose of organics through groundnut cake recorded significantly higher plant height, number of leaves, LAI, flowers plant^{-1}, root characters, water use efficiency, nutrient uptake and yield of bhindi grown in containers. Direct application to the growth media was better than foliar application in terms of length, fruit yield, root length and water use efficiency.

Soumya (2015) noticed that application of 125 % of recommended dose of nutrients (KAU, 2011) as groundnut cake incubated with PGPR mix I resulted in the highest net income and BCR for soil less culture of tomato grown in containers.

Swadija and Padmanabhan (2002), Padmanabhan and Swadija (2006) and Padmanabhan (2015) advocate organic farming for cultivating vegetables in containers on house terrace in order to obtain safe and fresh vegetables as well as to ensure safety of the terrace.

2.6 IRRIGATION FOR ELEPHANT FOOT YAM

Changuler and Khot (1963) recommended 9 to 10 irrigations for elephant foot yam during a growing season.

According to George (2000), a well distributed rainfall of 1000 to 1500 mm spread over a period of six to eight months is ideal for elephant foot yam.

According to Misra *et al.* (2001) for the crop planted in March, which gives better yield than June planting, a light irrigation should be given immediately after planting and then depending on soil moisture availability, irrigation should be given at regular intervals upto onset of monsoon.

Santosa *et al.* (2004) conducted an experiment to study the effect of frequency of irrigation on the growth and yield of elephant foot yam grown in plastic bags. About 1 to 1.5 litres of tap water was applied at one, three, five, seven and 15 days interval when the buds became visible. It was observed that number and size of leaves, corm size, cormel number and root growth were affected by irrigation frequency. Frequent irrigation produced larger leaves and extended their lifespan compared to less frequent irrigation. Longer interval between watering restricted the growth and yield and irrigation at one, three or five days interval did not show any abnormalities on the growth of plants. In the case of infrequent irrigation, corms entered into dormancy after leaf senescence and reduced yield.

In Tamil Nadu, elephant foot yam is cultivated by giving weekly irrigations (Srinivas and Ramanathan, 2005).

Ravi *et al.* (2009) reported that about 1000 to1500 mm of rainfall year^{-1} is optimum for the crop. Ravi *et al.* (2011) opined that soil moisture status does not influence sprouting but further development of new shoot depends on adequate soil moisture. When the rainy season is shorter than four months, supplementary irrigation is necessary for high productivity.

According to Sunitha, *et al.* (2013) moisture stress should be avoided to ensure higher corm yield although elephant foot yam tolerates soil water deficit stress.

Irrigation @ 100% CPE with 100 % recommended dose of fertilizers promoted growth and yield parameters across various agro- climatic regions of India (George *et al.*, 2011; Venkatesan *et al.,* 2014).

According to Ravi *et al.* (2015), water deficit stress during four to six month crop growth period significantly affects the growth and yield of elephant foot yam. For achieving higher corm yield, the crop must be irrigated adequately during initial establishment period and growth period between four to six months. Water deficit stress in plant resulted in significant reduction in leaf area, corm dry matter and corm yield plant^{-1}. Reduction in yield of 41.9 % and 78.52 % were observed in plants due to water deficit stress during 4 to 5 MAP and 6 to 7 MAP respectively compared to control plants.

Review of literature indicated the lack of technology for organic production of elephant foot yam in containers. Container cultivation assumes importance where land availability is limited especially in urban homesteads. Technology for container cultivation of elephant foot yam needs to be developed by standardizing growth medium utilizing coir pith, a byproduct of coir industry, to reduce the weight of container especially for farming on house terrace as well as to make it cost effective. It is also necessitated to standardize nutrient as well as irrigation schedule to reap economic yield from containers. Hence the present investigation was undertaken to standardize growth medium, nutrient schedule and irrigation schedule for container grown elephant foot yam.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The experiment entitled "Agronomic package for container grown elephant foot yam" has been carried out at College of Agriculture, Vellayani to standardize growth medium and nutrient and irrigation schedule for elephant foot yam grown in containers, to study tuberisation pattern in elephant foot yam and to study nutrient release pattern in different growth media in order to formulate a cost effective agronomic package for elephant foot yam grown in containers. The investigation comprised of two separate experiments (1) Standardization of growth medium and nutrient and irrigation schedule for container grown elephant foot yam and (2) Incubation study – Nutrient (N P K) release pattern in different growth media.

3.1 MATERIALS

3.1.1 Experimental Site

The experiment I was conducted in the Instructional Farm attached to College of Agriculture, Vellayani, Kerala, which is located at 8.5^0 North latitude, 76.9^0 East longitude and at an altitude of 29 m above mean sea level. The experiment II (incubation study) was carried out in the laboratory of the Department of Agronomy, College of Agriculture, Vellayani.

3.1.2 Weather

Vellayani experiences a tropical humid climate. The data on maximum and minimum temperatures, relative humidity, evaporation and rainfall received during the cropping period were collected from the Agro- Meteorological Observatory at College of Agriculture, Vellayani and is presented in Fig. 1 and Appendix 1.

3.1.3 Season

The experiments were conducted from April to November 2016.

3.1.4 Crop and Variety

Amorphophallus variety "Gajendra" released from Acharya N. G. Ranga Agricultural University, Hyderabad was used for the experiment. The variety has a

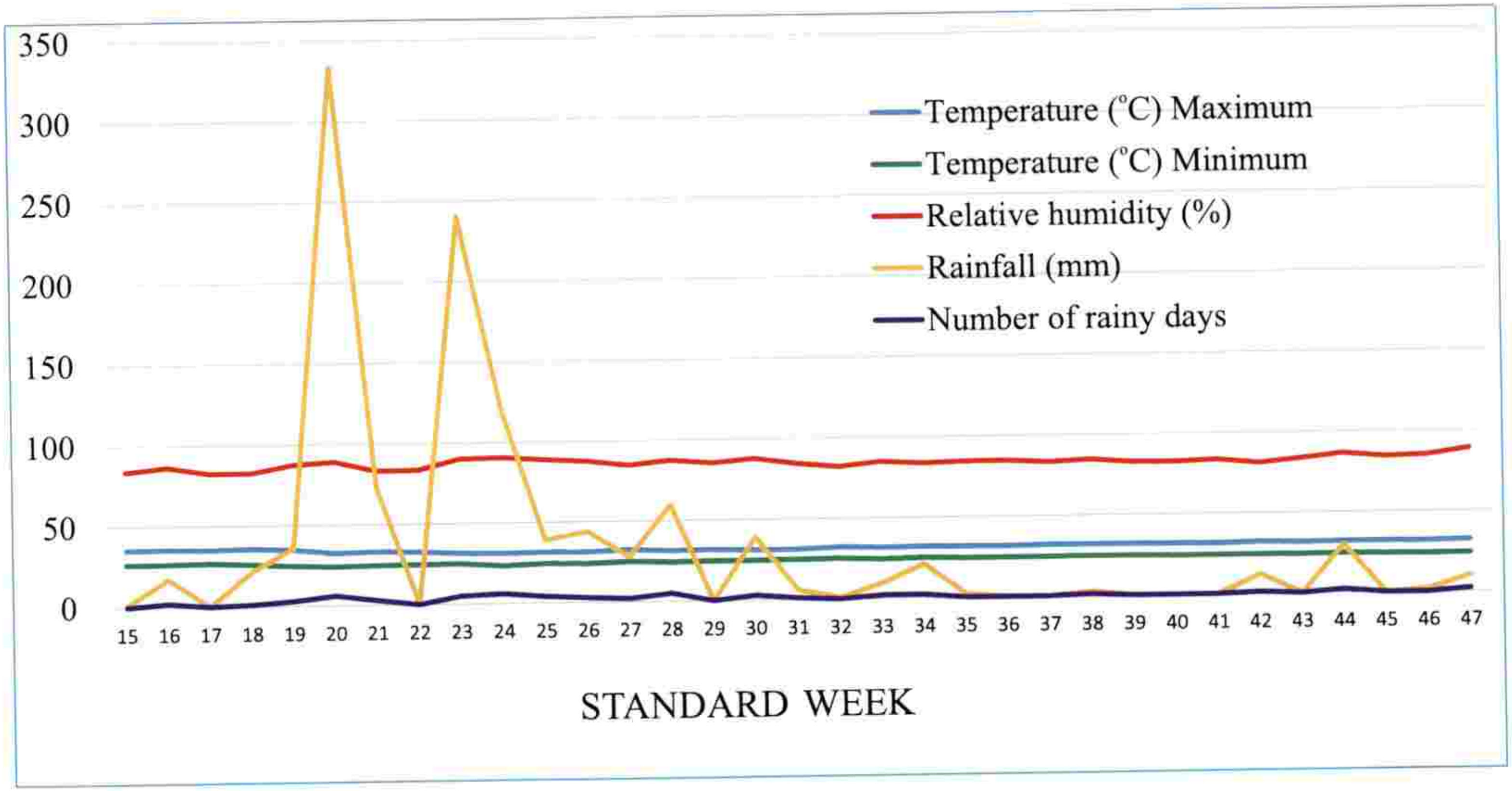

Fig. 1 Weather parameters during the cropping period – 9th April to 25th November 2016

duration of 180 to 210 days and an average yield of 50 t ha^{-1} (Palaniswami and Anil, 2008).The plant is medium tall with medium canopy spread. The corm is globose with mostly no cormels and has brownish black skin colour and yellow with orange tinge flesh colour. It has good culinary quality and low acridity. The corms were procured from Indian Council of Agricultural Research (ICAR) - Central Tuber Crops Research Institute (CTCRI), Sreekariyam, Thiruvananthapuram.

3.1.5 Growth Media

Different growth media used in the experiment were prepared with soil, sand, FYM and coir pith in different proportions by volume as per the technical programme. Plastic cement sacks of uniform size (50 kg capacity) were used as containers for experiment I and small plastic pots of 3 ½ L capacity were used for experiment II (incubation study).

For filling plastic sacks in experiment I, the growth medium M_1 was prepared by mixing 9 kg soil + 8 kg sand + 3 kg FYM, M_2 with 9 kg soil + 3 kg coir pith + 3 kg FYM and M_3 with 7 kg soil + 3.75 kg coir pith + 3 kg FYM.

The quantity of growth media M_1, M_2 and M_3 in two plastic sacks each were uniformly filled in 15 plastic pots for each growth medium in experiment II (incubation study).

3.1.6 Organic Manures

The organic manures used in the experiment were analyzed for pH, EC, organic carbon and total N, P and K contents using the standard procedures given in Table 1. The analytical values are presented in Table 2.

Table 1. Procedures followed in the analysis of organic manures

Sl. No.	Properties	Method	Reference
1	pH	pH meter method	Jackson (1973)
2	EC	Conductivity meter method	Jackson (1973)
3	Organic carbon	Walkley and Black rapid titration method	Jackson (1973)
4	Total N	Digestion with H_2SO_4 and micro kjeldahl method	Jackson (1973)
5	Total P	Digestion with H_2SO_4 and phosphomolybdate yellow colour method	Jackson (1973)
6	Total K	Digestion with H_2SO_4 and flame photometry	Jackson (1973)

Table 2. Physico – chemical properties of organic manures

Organic manures	pH	EC (dSm^{-1})	Organic carbon (%)	N (%)	P (%)	K (%)
FYM	7.44	4.10	10.73	1.52	0.72	0.31
Coir pith	3.10	0.36	7.07	0.70	0.37	0.14
Neem cake	7.54	6.70	3.60	1.54	0.93	1.91
Groundnut cake	6.06	5.40	20.62	6.86	0.69	1.24
Bone meal	6.58	11.60	9.97	3.08	19.85	0.10
Wood ash	12.06	0.04	0.75	0.58	0.37	5.16

3.2 METHODS

3.2.1 Experimental Design and Layout

Experiment I: Standardization of growth medium and nutrient and irrigation schedule for container grown elephant foot yam.

Design : CRD

Replications : 3 + 1 (one for destructive sampling at monthly interval)

Treatments : 12 (3x2x2)

Growth media (M) - 3

M_1 - soil : sand : FYM 1:1:1

M_2 – soil : coir pith : FYM 1:1:1

M_3 - soil : coir pith : FYM 0.75:1.25:1

Nutrient schedule (N) - 2

N_1 – N and K in 3 splits (1, 3 and 5 MAP)

N_2 – N and K in 6 splits (1, 2,3,4,5 and 6 MAP)

Irrigation schedule (I) - 2

I_1 - Irrigation once in 3 days

I_2 -Irrigation once in 6 days

Treatment combinations - 12

T_1 : $m_1n_1i_1$	T_5 : m_2 n_1i_1	T_9 : $m_3n_1i_1$
T_2 : $m_1n_1i_2$	T_6 : m_2 n_1i_2	T_{10} : $m_3n_1i_2$
T_3 : m_1n_2 i_1	T_7 : m_2 n_2 i_1	T_{11} : m_3n_2 i_1
T_4 : m_1n_2 i_2	T_8 : m_2 n_2 i_2	T_{12} : m_3n_2 i_2

Number of sacks per treatment per replication - 3

A general view of the experiment is given in Plate 1.

Experiment II - Incubation Study -Nutrient (NPK) release pattern in different growth media

Design : CRD

Replications : 5

Treatments : 3 - Growth Media (M)

M_1 - soil : sand : FYM 1:1:1

M_2 - soil : coir pith : FYM 1:1:1

M_3 - soil : coir pith : FYM 0.75:1.25:1

Number of plastic pots per treatment per replication - 3

Lime @ 1.33 g and neem cake @ 13.33 g were applied as basal dose uniformly in all the plastic pots. The growth media was uniformly supplied with the recommended NPK dose of 100:50:150 kg ha^{-1} for elephant foot yam as groundnut cake, bone meal and wood ash. Full dose of bone meal (1.33 g pot^{-1}) was given as basal dose. Groundnut cake (6.67 g pot^{-1}) and wood ash (13.33 g pot^{-1}) were applied in three equal splits at bimonthly interval starting from 2 MAP. Moisture content of the growth media was maintained at field capacity.

A general view of the incubation study is given in Plate 2.

3.3 CROP HUSBANDRY IN EXPERIMENT 1

3.3.1 Arrangement of containers in the field

The experimental area was cleared of weeds and stubbles. The sacks filled with different growth media were arranged at a spacing of 60 x 60 cm.

Plate 1. General view of the experiment I

Plate 2. General view of experiment II - incubation study

3.3.2 Planting

Corm pieces weighing 250 g were treated with *Trichoderma* – cowdung slurry (procured from the Department of Microbiology, College of Agriculture, Vellayani), shade dried and planted in sacks on 11-04-2016.

3.3.3 Mulching

The crop was mulched with dry leaves throughout the growth period.

3.3.4 Application of Manures

Lime @ 10 g and neem cake @ 100 g $sack^{-1}$ were applied initially in all growth media. The calculated quantities of groundnut cake (50 g), bone meal (10 g) and wood ash (100 g) were applied in each sack in order to supply the recommended dose of 100:50:150 kg NPK ha^{-1} (KAU, 2011). Bone meal was applied as a single basal dose in all sacks prior to planting of corm. The groundnut cake and wood ash were given in split doses as per the treatments. The groundnut cake was made into 10 per cent slurry with water, fermented for three days and mixed with wood ash and applied.

3.3.5 Irrigation

Initially, the moisture content of growth media was brought to field capacity. No irrigation was given during rainy days. When irrigation was needed, measured quantity of water, calculated based on evaporation data (Pandian, 2007) taken from the Agro Meteorological Observatory in the College, was applied at different intervals as per the treatments either once in three days or once in six days.

Quantity of water applied = πr^2 x cumulative evaporation x pan coefficient x crop coefficient

where r is radius of the container.

3.3.6 Other Management Practices

Weeding was carried out as and when needed.

3.3.7 Harvest

The crop was harvested seven months after planting on 23-11-2016.

3.4 BIOMETRIC OBSERVATIONS

Three plants in each treatment were tagged as observational plants. Biometric observations were recorded from these plants and average values were worked out.

3.4.1 Growth characters

Growth characters were recorded from the observational plants at bimonthly interval from 2 MAP upto harvest.

3.4.1.1 Height of the Plant

Height of the plant (cm) was measured from the base to the growing tip in their vertical position.

3.4.1.2 Leaf Area Index

Total leaf area (cm^2) of elephant foot yam was determined by using the formula suggested by Ravi *et al.* (2010).

Total leaf area = P (average value of few observations) x 0.65 x total number of leaflets $plant^{-1}$

where P = Product of leaflet length (cm) and breadth (cm).

Leaf area index (LAI) was worked out by the formula given by Watson (1947)

$$\text{LAI} = \frac{\text{Leaf area of the plant (cm}^2\text{)}}{\text{Land area occupied by the plant (cm}^2\text{)}}$$

3.4.1.3 Canopy Spread

Canopy spread in elephant foot yam was measured across the diameter of the leaf (Ravindran, 1997) and expressed in cm.

3.4.2 Yield Attributes and Yield

Yield and yield attributes were recorded at monthly interval and also at harvest. Number of roots per plant, weight of roots plant^{-1} and weight of corm plant^{-1} were recorded monthly by uprooting (destructive sampling) plants from each treatment from the 4th replication.

3.4.2.1 Number of Roots per Plant

Total number of roots in the uprooted sample plants was counted and average was worked out.

3.4.2.2 Weight of Roots per Plant

Weight of roots in the uprooted sample plants were recorded and average was worked out in g plant^{-1}.

3.4.2.3 Time of Corm Initiation

Observation on time of corm initiation was made visually from the uprooted sample plants.

3.4.2.4 Weight of Corm per Plant

Weight of corm in the uprooted sample plants was recorded, mean value was worked out and expressed in g plant^{-1}.

3.4.2.5 Bulking Rate of Corm

This is the rate of increase in tuber weight per unit time and is an important measure of tuber growth. This was calculated from the data on corm weight plant^{-1} at monthly interval. It is expressed as g day^{-1} plant^{-1} on dry weight basis (Kumar, 1986)

$$\text{Bulking rate (BR)} = \frac{w_2 - w_1}{t_2 - t_1}$$

where w_1 – dry weight of tuber at time t_1

w_2 – dry weight of tuber at time t_2

3.4.2.6 Corm Yield per Plant at Harvest

At the time of harvest, weight of corm from the observational plants were recorded and average was calculated in g $plant^{-1}$.

3.4.2.7 Utilization Index

It is the ratio of the tuber yield to top yield on fresh weight basis. This was worked out from the corm weight and top (pseudostem /leaf) weight of the observational plants.

3.4.2.8 Dry Matter Production at Harvest

The sample plants uprooted prior to general harvest were used for computing dry matter production. Fresh weight of each plant part was recorded and samples taken for estimating dry weight. Samples were first shade dried and then dried in an oven at 70 ± 5^0 C to a constant dry weight. The dry weight of each plant part was recorded and total dry matter production (TDMP) at harvest was computed in kg ha^{-1}.

3.4.3 Quality Attributes

3.4.3.1 Starch Content of Corm

Starch content of corm was estimated by potassium ferricyanide method (Ward and Pigman, 1970). The values were expressed as percentage on fresh weight basis.

3.4.3.2 Crude Protein Content

The crude protein content of corm was calculated by multiplying N content of corm with the factor 6.25 (Simpson *et al.*, 1965) and expressed as percentage on fresh weight basis.

3.5 GROWTH MEDIA ANALYSIS

Samples of growth media were taken before planting of the crop and after harvest from experiment I. The samples were collected at monthly interval from experiment II (incubation study) to study the nutrient release pattern from different growth media. The collected samples were air dried, powdered and passed through 2 mm sieve for the analysis of available N, P and K contents and 0.5 mm sieve for organic carbon. The samples were analyzed for pH, EC, organic carbon, available N, available P and available K using standard procedures as presented in Table 3. The dehydrogenase activity of the samples were analyzed by following the procedure outlined by Casida *et al.* (1964). The initial values of parameters of growth media analyzed are presented in Table 4.

Table 3. Procedures followed in the analysis of growth media

Sl. No.	Properties	Method	Reference
1	pH	pH meter method	Jackson (1973)
2	EC	Conductivity meter method	Jackson (1973)
3	Organic carbon	Walkley and Black rapid titration method	Jackson (1973)
4	Available N	Alkaline potassium permanganate method	Subbiah and Asija (1956)
5	Available P	Bray colorimeter method	Jackson (1973)
6	Available K	Neutral normal ammonium acetate method	Jackson (1973)

Table 4. Physico- chemical properties of growth media prior to experiment

Growth media	pH	EC (dSm^{-1})	Dehydrogenase activity (μg TPF $g^{-1} 24h^{-1}$)	Organic carbon (%)	Available N (%)	Available P (%)	Available K (%)
M_1	7.25	0.83	320.15	3.68	0.095	0.034	0.015
M_2	7.12	1.78	263.24	5.65	0.084	0.042	0.017
M_3	6.91	1.78	258.09	5.85	0.077	0.038	0.017

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3.6 PLANT ANALYSIS

From experiment I, samples of plants collected at harvest and dried to compute TDMP were used for the analysis of nutrient contents. Samples were ground to pass through a 0.5 mm sieve and digested for nutrient analysis.

3.6.1 Uptake of Nitrogen

Nitrogen content in each plant part was estimated by the modified microkjeldhal method (Jackson, 1973). The uptake was calculated by multiplying the N content of each plant part with corresponding dry weight and summing up the values.The uptake values were expressed in g plant^{-1}.

3.6.2 Uptake of Phosphorus

Phosphorus content in the plant sample was determined colorimetrically (Piper, 1967). The uptake was calculated by multiplying the P content of each plant part with corresponding dry weight and adding up the values and expressed in g plant^{-1}.

3.6.3 Uptake of Potassium

Potassium content was determined by flame photometry (Jackson, 1973). The uptake was calculated by multiplying the K content of each plant part with corresponding dry weight and summing up the values. The uptake values were expressed in g plant^{-1}.

3.7 PEST AND DISEASE INCIDENCE

Incidence of pest and disease was monitored throughout the crop growth period.

3.8 ECONOMIC ANALYSIS

Economics of cultivation was worked out by taking into account the cost of inputs and market price of elephant foot yam during the cropping period as given in appendix II. Net income and benefit cost ratio (BCR) were calculated as follows.

Net income (₹ $sack^{-1}$) : Gross income – Total expenditure

Benefit: Cost Ratio : $\frac{\text{Gross income}}{\text{Total expenditure}}$

3.9 STATISTICAL ANALYSIS

The data recorded from the experiments were subjected to statistical analysis by applying analysis of variance technique and significance was tested by 'F' test (Cochran and Cox, 1965). Critical difference was calculated in cases where treatments were found to be significant. Suitable correlations were also worked out.

RESULTS

4. RESULTS

The present study was undertaken during April to November 2016 to standardize growth medium and nutrient and irrigation schedule for elephant foot yam grown in containers, to study tuberisation pattern in elephant foot yam and to study nutrient release pattern in different growth media in order to formulate a cost effective agronomic package for elephant foot yam grown in containers. The first experiment was done by raising elephant foot yam in plastic sacks with 12 treatment combinations involving three growth media, two nutrient schedule and two irrigation schedule with four replications in completely randomized design. The second experiment was also conducted during the same period in small plastic pots with three growth media and five replications in CRD to study the nutrient release pattern in different growth media.

4.1. EXPERIMENT I

4.1.1 Growth Characters

4.1.1.1 Height of the Plant

The effect of different growth media, nutrient schedule and irrigation schedule and their interactions on height of the plant at bimonthly interval from 2 MAP are presented in Table 5a, 5b and 5c.

Height of the plant increased upto harvest in all treatments. But the height increased at faster rate upto 6 MAP beyond which the rate of growth was lowered.

Growth medium showed significant effect on plant height at all stages except 2 MAP (Table 5a). Among three growth media, M_2 recorded the tallest plants and was significantly superior to M_1 and M_3. The growth media M_1 and M_3 were on a par in their effects on plant height.

Nutrient schedule did not significantly influence plant height during the initial stages upto 4 MAP but had significant influence at 6 MAP and harvest. At 6 MAP and harvest, N_2 (N and K in six splits) produced significantly taller plants than N_1 (three splits).

Table 5a. Effect of growth medium, nutrient schedule and irrigation schedule on height of the plant, cm.

Treatments	Plant height			
	2MAP	4MAP	6MAP	Harvest
Growth medium (M)				
M_1 - soil : sand : FYM 1:1:1	42.17	46.83	55.92	57.58
M_2 - soil : coir pith : FYM 1:1:1	45.42	52.33	66.25	68.67
M_3- soil : coir pith : FYM 0.75:1.25:1	42.42	47.25	55.58	57.17
SEm±	1.235	1.210	1.288	1.530
CD(0.05)	-	3.350	3.760	4.465
Nutrient schedule (N)				
N_1 - N&K in 3 splits	43.33	48.00	56.78	58.5
N_2 - N&K in 6 splits	43.33	49.61	61.72	63.78
SEm±	1.008	0.988	1.052	1.249
CD(0.05)	-	-	3.070	3.640
Irrigation schedule (I)				
I_1 - Irrigation once in 3 days	42.95	48.66	58.00	60.11
I_2 - Irrigation once in 6 days	43.72	48.94	60.50	62.17
SEm±	1.008	0.988	1.052	1.249
CD(0.05)	-	-	-	-

Table 5b. Interaction effect of growth medium, nutrient schedule and irrigation schedule on plant height, cm

Treatments	Plant height			
	2MAP	4MAP	6MAP	Harvest
M x N interaction				
m_1n_1	41.00	45.5	49.83	52.33
m_1n_2	43.33	48.17	62.00	62.33
m_2n_1	46.17	52.17	67.00	68.33
m_2n_2	44.67	52.50	65.50	69.00
m_3n_1	42.83	46.33	53.50	54.33
m_3n_2	42.00	48.17	57.67	60.00
SEm±	1.747	1.711	1.822	2.163
CD(0.05)	-	-	5.310	-
M x I interaction				
m_1i_1	41.17	46.17	56.50	57.67
m_1i_2	43.17	47.50	55.33	57.50
m_2i_1	43.83	57.17	64.50	67.67
m_2i_2	47.00	53.50	68.00	69.67
m_3i_1	43.83	48.67	53.00	55.00
m_3i_2	41.00	45.83	58.17	59.33
SEm±	1.747	1.711	1.822	2.163
CD(0.05)	-	-	-	-
N x I interaction				
n_1i_1	42.56	47.56	55.89	57.78
n_1i_2	44.11	48.44	57.67	59.22
n_2i_1	43.33	49.77	60.11	62.44
n_2i_2	43.33	49.44	63.33	65.11
SEm±	1.426	1.397	1.488	1.766
CD(0.05)	-	-	-	-

Table 5c. Effect of M x N x I interaction on plant height, cm

Treatments	Plant height			
	2MAP	4MAP	6MAP	Harvest
$m_1n_1i_1$	39.33	44.67	50.00	53.00
$m_1n_1i_2$	42.67	46.33	49.67	52.67
$m_1n_2i_1$	43.00	47.67	63.00	62.33
$m_1n_2i_2$	43.67	48.67	61.00	62.33
$m_2n_1i_1$	44.33	50.67	65.67	67.33
$m_2n_1i_2$	48.00	53.67	68.33	69.33
$m_2n_2i_1$	43.33	51.67	63.33	68.00
$m_2n_2i_2$	46.00	53.33	67.67	70.00
$m_3n_1i_1$	44.00	47.33	52.00	53.00
$m_3n_1i_2$	41.67	45.33	55.00	55.67
$m_3n_2i_1$	43.67	50.00	54.00	57.00
$m_3n_2i_2$	40.33	46.33	61.33	63.00
SEm±	2.470	2.419	2.577	3.060
CD(0.05)	-	-	-	-

Irrigation schedule could not exert any significant influence on plant height at any growth stage of the crop. But the plants were taller at all stages with I_2 (irrigation once in six days) than with I_1 (irrigation once in three days).

Regarding the interaction effects, only MxN interaction showed significant response at 6 MAP (Table 5b). At 6 MAP, the treatment combination m_2n_1 recorded the tallest plants which was on a par with m_2n_2 and m_1n_2.

No significant effect on plant height was observed due to MxNxI interaction (Table 5c).

4.1.1.2 Canopy spread

The data on the effect of growth medium, nutrient schedule and irrigation schedule on canopy spread of the plant at bimonthly interval are given in Table 6a, 6b and 6c.

As in the case of plant height, canopy spread showed an increasing trend with increase in the age of the crop irrespective of treatments. But the rate of increase was maximum during the period from 2 MAP to 4 MAP with lower rate of increase from 4 MAP to 6 MAP and slight increase from 6 MAP upto harvest.

Different growth media had significant effect on canopy spread at all stages (Table 6a). The growth medium M_2 recorded the highest value at all stages. The growth media M_1 and M_3 were on a par in their effects at all growth stages.

Nutrient schedule and irrigation schedule did not show any significant influence on canopy spread at any stage of the crop.

The second order and third order interactions failed to show any significant effect on canopy spread at any growth stage (Table 6b and 6c).

4.1.1.3 Leaf Area Index

The average values of LAI at bimonthly interval as influenced by growth medium, nutrient schedule and irrigation schedule and their interactions are presented in Table 7a, 7b and 7c.

Table 6a. Effect of growth medium , nutrient schedule and irrigation schedule on canopy spread, cm.

Treatments	Canopy spread			
	2MAP	4MAP	5MAP	Harvest
Growth medium (M)				
M_1 - soil : sand : FYM 1:1:1	66.42	83.42	86.58	88.33
M_2 - soil : coir pith : FYM 1:1:1	75.25	94.00	100.08	103.42
M_3- soil : coir pith : FYM 0.75:1.25:1	65.17	83.50	88.00	88.83
SEm±	2.594	2.461	2.921	2.814
CD(0.05)	7.570	7.180	8.520	8.210
Nutrient schedule (N)				
N_1 - N&K in 3 splits	67.67	87.00	91.33	93.22
N_2 - N&K in 6 splits	70.22	86.94	91.78	93.83
SEm±	2.118	2.009	2.385	2.298
CD(0.05)	-	-	-	-
Irrigation schedule (I)				
I_1 - Irrigation once in 3 days	66.56	85.28	91.11	91.83
I_2 - Irrigation once in 6 days	71.33	88.67	92.00	95.22
SEm±	2.118	2.009	2.385	2.298
CD(0.05)	-	-	-	-

Table 6b. Interaction effect of growth medium, nutrient schedule and irrigation schedule on canopy spread, cm

Treatments	Canopy spread			
	2MAP	4MAP	6MAP	Harvest
M x N interaction				
m_1n_1	62.33	81.17	84.00	85.17
m_1n_2	70.50	85.67	89.17	91.50
m_2n_1	76.00	98.17	103.67	107.83
m_2n_2	74.50	89.83	96.50	99.00
m_3n_1	64.67	81.67	86.33	86.67
m_3n_2	65.67	85.33	89.67	91.00
SEm±	3.668	3.480	4.131	3.980
CD(0.05)	-	-	-	-
M x I interaction				
	63.50	81.17	84.17	85.33
m_1i_2	69.33	85.67	89.00	91.33
m_2i_1	73.17	90.67	99.50	100.17
m_2i_2	77.33	97.33	100.67	106.67
m_3i_1	63.00	84.00	89.67	90.00
m_3i_2	67.33	83.00	86.33	87.67
SEm±	3.668	3.480	4.131	3.980
CD(0.05)	-	-	-	-
N x I interaction				
n_1i_1	62.56	83.89	89.33	89.33
n_1i_2	72.78	90.11	93.33	97.11
n_2i_1	70.56	86.67	92.89	94.33
n_2i_2	65.67	87.22	90.67	93.33
SEm±	2.995	2.841	3.375	3.249
CD(0.05)	-	-	-	-

Table 6c. Effect of M x N x I interaction on canopy spread, cm

Treatments	Canopy spread			
	2MAP	4MAP	6MAP	Harvest
$m_1n_1i_1$	56.33	75.67	78.00	79.00
$m_1n_1i_2$	68.33	86.67	90.00	91.33
$m_1n_2i_1$	70.67	86.67	90.33	91.67
$m_1n_2i_2$	70.33	84.67	88.00	91.33
$m_2n_1i_1$	73.33	92.67	100.67	101.00
$m_2n_1i_2$	78.67	103.67	106.67	114.67
$m_2n_2i_1$	73.00	88.67	98.33	99.33
$m_2n_2i_2$	76.00	91.00	94.67	98.67
$m_3n_1i_1$	58.00	83.33	89.33	88.00
$m_3n_1i_2$	71.33	80.00	83.33	85.33
$m_3n_2i_1$	68.00	84.67	90.00	92.00
$m_3n_2i_2$	63.33	86.00	89.33	90.00
SEm±	5.187	4.922	5.842	5.628
CD(0.05)	-	-	-	-

In general, LAI increased upto 4 MAP, retained the values at 6 MAP which decreased afterwards registering lower values at harvest stage of the crop.

The growth media exerted significant influence on LAI at all growth stages (Table 7a). The growth medium M_2 recorded the highest value for LAI at all stages (1.45, 2.53, 2.55 and 2.34 at 2 MAP, 4 MAP, 6 MAP and at harvest respectively). The effects of M_1 and M_3 were on a par at 2 MAP while $M_1$was superior to M_3 at all other stages.

The effect of nutrient schedule on LAI was significant at all stages except 2 MAP and the treatment N_2 was superior to N_1 at those stages.

Irrigation schedule showed significant effect on LAI only at 6 MAP and harvest when the treatment I_1 was superior to I_2.

Regarding the second order interactions (Table 7b), MxI interaction showed significant effect on LAI at harvest stage of the crop. The treatment combination m_2i_1 recorded the highest value, which was on a par with m_2i_2.

MxNxI interaction failed to produce any significant effect on LAI at any stage of the crop (Table 7c).

4.1.2 Tuberisation Pattern

Sample plants were uprooted at monthly interval from all treatments in the fourth replication in order to study the tuberisation pattern in elephant foot yam as influenced by growth medium, nutrient schedule and irrigation schedule.

4.1.2.1 Number of Roots Plant^{-1} at Monthly Interval

Average number of roots produced plant^{-1} at monthly interval upto 6 MAP as influenced by growth medium, nutrient schedule and irrigation schedule is presented in Table 8. The data was observed from sample plants uprooted from fourth replication. The replicated data on root number plant^{-1} recorded at harvest from observational plants was statistically analyzed and given in Table 10a, 10b and 10c.

Table 7a. Effect of growth medium, nutrient schedule and irrigation schedule on leaf area index

Treatments	Leaf area index			
	2MAP	4MAP	6MAP	Harvest
Growth medium (M)				
M_1 - soil : sand : FYM 1:1:1	1.32	2.20	2.16	1.94
M_2 - soil : coir pith : FYM 1:1:1	1.45	2.53	2.55	2.34
M_3- soil : coir pith : FYM 0.75:1.25:1	1.28	1.80	1.81	1.59
SEm±	0.025	0.044	0.048	0.036
CD(0.05)	0.073	0.128	0.141	0.105
Nutrient schedule (N)				
N_1 - N&K in 3 splits	1.36	2.08	2.06	1.83
N_2 - N&K in 6 splits	1.35	2.28	2.29	2.08
SEm±	0.021	0.036	0.040	0.029
CD(0.05)	-	0.104	0.115	0.085
Irrigation schedule (I)				
I_1 - Irrigation once in 3 days	1.38	2.22	2.30	2.05
I_2 - Irrigation once in 6 days	1.33	2.13	2.04	1.86
SEm±	0.021	0.036	0.040	0.029
CD(0.05)	-	-	0.115	0.085

Table 7b. Interaction effect of growth medium, nutrient schedule and irrigation schedule on leaf area index

Treatments	Leaf area index			
	2MAP	4MAP	6MAP	Harvest
M x N interaction				
m_1n_1	1.33	2.14	2.12	1.86
m_1n_2	1.32	2.26	2.20	2.01
m_2n_1	1.45	2.38	2.39	2.18
m_2n_2	1.46	2.69	2.71	2.51
m_3n_1	1.30	1.71	1.66	1.44
m_3n_2	1.27	1.90	1.96	1.74
SEm±	0.036	0.062	0.068	0.051
CD(0.05)	-	-	-	-
M x I interaction				
m_1i_1	1.33	2.20	2.28	1.95
m_1i_2	1.31	2.20	2.03	1.92
m_2i_1	1.50	2.56	2.67	2.41
m_2i_2	1.41	2.51	2.43	2.27
m_3i_1	1.30	1.91	1.95	1.80
m_3i_2	1.26	1.69	1.68	1.38
SEm±	0.036	0.062	0.068	0.051
CD(0.05)	-	-	-	0.148
N x I interaction				
n_1i_1	1.37	2.10	2.16	1.92
n_1i_2	1.34	2.06	1.95	1.73
n_2i_1	1.38	2.35	2.44	2.19
n_2i_2	1.31	2.21	2.14	1.98
SEm±	0.029	0.051	0.056	0.042
CD(0.05)	-	-	-	-

Table 7c. Effect of M x N x I interaction on leaf area index

Treatments	Leaf area index			
	2MAP	4MAP	6MAP	Harvest
$m_1n_1i_1$	1.32	2.15	2.27	1.91
$m_1n_1i_2$	1.32	2.13	1.97	1.81
$m_1n_2i_1$	1.33	2.45	2.30	1.99
$m_1n_2i_2$	1.30	2.27	2.10	2.03
$m_2n_1i_1$	1.48	2.37	2.47	2.25
$m_2n_1i_2$	1.42	2.38	2.31	2.10
$m_2n_2i_1$	1.52	2.74	2.88	2.57
$m_2n_2i_2$	1.39	2.63	2.55	2.44
$m_3n_1i_1$	1.30	1.77	1.74	1.60
$m_3n_1i_2$	1.29	1.65	1.58	1.29
$m_3n_2i_1$	1.30	2.05	2.15	2.00
$m_3n_2i_2$	1.24	1.74	1.77	1.47
SEm±	0.051	0.088	0.097	0.072
CD(0.05)	-	-	-	-

It can be seen that number of roots produced plant^{-1}showed an increasing trend from 1 MAP upto 5 MAP and started declining afterwards.

Root number was the highest in the growth medium m_2 at all stages of observation (Table 8). At 1 MAP and 2 MAP, M_1 produced lesser number of roots than M_2 and M_3. From 3 MAP onwards, M_3 produced lesser number roots than M_1 and M_2. At harvest, the highest root number of 282.5 (Table 10a) could be produced in the growth medium M_2 but was found to be on a par with M_1. The growth medium M_3 recorded the lowest root number plant^{-1} (216.83).

No marked difference in root number plant^{-1} was observed due to nutrient schedule upto 4 MAP (Table 8). Application of N and K in six splits (N_2) produced more number of roots than three splits (N_1) at all stages of observation except at 1 MAP. But marked variation was noted from 5 MAP onwards. At harvest, application of N and K in six splits (N_2) resulted in significantly higher number (266.94) of roots plant^{-1} (Table 10a).

During the initial stages, no marked variation was observed in root number due to irrigation schedule. From 4 MAP upto 6 MAP (Table 8), higher number of roots were produced due to irrigation once in three days (I_1) than once in six days (I_2). At harvest, no significant variation in the number of roots produced plant^{-1} was observed due to irrigation schedule (Table 10a) although irrigation once in three days produced higher number than once in six days.

Among second order interactions (Table 10b), NxI interaction had significant effect on root number plant^{-1} at harvest. The treatment combination n_2i_1 recorded the highest number of roots plant^{-1} which was significantly superior to other treatment combinations which were all on a par in their effects.

MxNxI interaction (Table 10c) did not have significant effect on root number plant^{-1} at harvest but the treatment combination $m_2n_2i_1$ produced the highest number (360) of roots plant^{-1} at harvest.

Table 8. Effect of growth medium, nutrient schedule and irrigation schedule on number of roots plant^{-1} at monthly interval*

Treatments	1 MAP	2 MAP	3 MAP	4 MAP	5 MAP	6 MAP
$m_1n_1i_1$	29	97	270	299	355	259
$m_1n_1i_2$	27	100	280	309	350	248
$m_1n_2i_1$	32	87	262	321	365	327
$m_1n_2i_2$	28	103	298	294	300	276
$m_2n_1i_1$	37	113	295	326	358	328
$m_2n_1i_2$	33	108	281	297	329	282
$m_2n_2i_1$	28	120	292	368	411	389
$m_2n_2i_2$	34	120	283	320	392	296
$m_3n_1i_1$	30	115	242	269	341	282
$m_3n_1i_2$	32	106	230	255	323	270
$m_3n_2i_1$	35	114	247	230	371	292
$m_3n_2i_2$	25	120	223	228	273	238
m_1	29.00	96.75	277.50	305.75	342.50	277.50
m_2	33.00	115.75	287.75	327.75	372.50	323.75
m_3	30.50	113.25	235.50	245.50	318.00	270.50
n_1	31.33	106.5	265.00	292.50	342.66	278.16
n_2	30.33	110.67	267.50	294.33	352.00	303.00
i_1	31.83	107.67	268.00	302.17	366.83	312.83
i_2	29.83	109.50	268.50	282.17	327.83	268.33

(*Unreplicated data)

4.1.2.2 Weight of Roots Plant^{-1} at Monthly Interval

The data on fresh weight of roots plant^{-1} at monthly interval upto 6 MAP as influenced by the treatments are given in Table 9. The replicated data at harvest was statistically analyzed and presented in Table 10a, 10b and 10c.

An increasing trend in the fresh weight of roots plant^{-1} was registered in all the treatments upto 5MAP which further decreased towards harvest.

At all stages of observation, higher values of fresh weight of roots were observed in the growth medium M_2 followed by M_1 (Table 9). At harvest (Table 10a), the growth medium M_2 recorded significantly higher value followed by M_1. The growth medium M_3 registered the lowest value.

Upto 4 MAP, slightly higher values of fresh weight of roots were observed when N and K were applied in three splits (N_1) than six splits (N_2). From 5 MAP to 6 MAP, the root weight was higher when N and K were applied in six splits (Table 9). At harvest also (Table 10a), application of N and K in six splits registered significantly higher value of root weight plant^{-1}.

Marked variation in root fresh weight due to irrigation schedule was observed from 4 MAP onwards (Table 9) when irrigation once in three days (I_1) registered higher values than once in six days (I_2). At harvest (Table 10a), fresh weight of roots plant $^{-1}$ was not significantly influenced by the irrigation schedule.

The interaction effects shown in Table 10b and 10c revealed the significant effect of only NxI interaction. The treatment combination n_2i_1 registered the highest value superior to all others followed by n_1i_2.

Though not significant, the treatment combination $m_2n_2i_1$ registered the highest value (150 g) of fresh weight of roots plant^{-1}.

Table 9. Effect of growth medium, nutrient schedule and irrigation schedule on fresh weight of roots plant^{-1} at monthly interval, g *

Treatments	1 MAP	2 MAP	3 MAP	4 MAP	5 MAP	6 MAP
$m_1n_1i_1$	9	31.5	62	94	139	124
$m_1n_1i_2$	8	33	64	92	129	120
$m_1n_2i_1$	12	28	60	84	147	139
$m_1n_2i_2$	9	29	66	82	119	109
$m_2n_1i_1$	23	34	69	96	146	134
$m_2n_1i_2$	26	35	70	94	132	128
$m_2n_2i_1$	22	32	68	103	169	152
$m_2n_2i_2$	24	30	62	91	124	121
$m_3n_1i_1$	7	26	53	89	109	93
$m_3n_1i_2$	8	28	55	82	97	90
$m_3n_2i_1$	10	24	52	90	114	104
$m_3n_2i_2$	7	26	51	86	93	84
m_1	9.50	30.37	63.00	88.00	131.75	123.00
m_2	23.75	32.75	67.25	96.00	142.75	133.75
m_3	8.00	26.22	52.75	86.75	103.25	92.75
n_1	13.50	31.40	62.16	91.17	124.16	114.83
n_2	14.00	28.17	59.83	89.33	127.67	118.17
i_1	13.83	29.40	60.66	92.66	136.16	124.30
i_2	13.66	30.16	61.33	87.83	115.66	108.67

(*Unreplicated data)

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Table 10a. Effect of growth medium, nutrient schedule and irrigation schedule on root number and root weight $plant^{-1}$ at harvest

Treatments	Root number $plant^{-1}$	Root fresh weight (g $plant^{-1}$)
Growth medium (M)		
M_1 - soil : sand : FYM 1:1:1	254.17	110.42
M_2 - soil : coir pith : FYM 1:1:1	282.50	120.00
M_3- soil : coir pith : FYM 0.75:1.25:1	216.83	83.75
SEm±	11.585	3.164
CD(0.05)	33.810	9.230
Nutrient schedule (N)		
N_1 - N&K in 3 splits	235.39	98.61
N_2 - N&K in 6 splits	266.94	110.83
SEm±	9.459	2.583
CD(0.05)	27.60	7.54
Irrigation schedule (I)		
I_1 - Irrigation once in 3 days	264.61	107.78
I_2 - Irrigation once in 6 days	237.72	101.67
SEm±	9.459	2.583
CD(0.05)	-	-

Table 10b. Interaction effect of growth medium, nutrient schedule and irrigation schedule on root number and root weight plant^{-1} at harvest

Treatments	Root number plant $^{-1}$	Root fresh weight (g plant^{-1})
M x N interaction		
m_1n_1	237.50	106.67
m_1n_2	270.83	114.17
m_2n_1	255.50	113.33
m_2n_2	309.50	126.67
m_3n_1	213.17	75.83
m_3n_2	220.50	91.67
SEm±	16.383	4.475
CD(0.05)	-	-
M x I interaction		
m_1i_1	261.67	115.00
m_1i_2	246.67	105.83
m_2i_1	307.50	125.00
m_2i_2	257.50	115.00
m_3i_1	224.67	83.33
m_3i_2	209.00	84.17
SEm±	16.383	4.475
CD(0.05)	-	-
N x I interaction		
n_1i_1	223.89	85.56
n_1i_2	246.89	111.67
n_2i_1	305.33	130.00
n_2i_2	228.56	91.67
SEm±	13.377	3.654
CD(0.05)	39.04	10.66

Table 10c. Effect of M x N x I interaction on root number and root weight plant^{-1} at harvest

Treatments	Root number plant $^{-1}$	Root fresh weight (g plant^{-1})
$m_1n_1i_1$	211.67	93.33
$m_1n_1i_2$	263.33	120.00
$m_1n_2i_1$	311.67	136.67
$m_1n_2i_2$	230.00	91.67
$m_2n_1i_1$	255.00	100.00
$m_2n_1i_2$	256.00	126.67
$m_2n_2i_1$	360.00	150.00
$m_2n_2i_2$	259.00	103.33
$m_3n_1i_1$	205.00	63.33
$m_3n_1i_2$	221.33	88.33
$m_3n_2i_1$	244.33	103.33
$m_3n_2i_2$	196.67	80.00
SEm±	23.170	6.328
CD(0.05)	-	-

4.1.2.3 Time of Corm Initiation

When samples plants were uprooted from all the treatments at 1 MAP, no corm initiation was observed. But at 2 MAP, corm development was observed in all the treatments. Hence corm initiation might have occurred between 1 MAP and 2 MAP.

4.1.2.4 Weight of Corm Plant^{-1} at Monthly Interval

Weight of corm plant^{-1} at monthly interval as influenced by the treatments are presented in Table 11.

At 2 MAP, the corm weight was the highest in growth medium M_1 and the lowest in M_3. At all other stages of observation, corm weight plant^{-1} was the highest in M_2 and the lowest in M_3.

Higher variation in corm weight plant^{-1} due to nutrient schedule was observed from 5 MAP onwards and N and K application in six splits (N_2) recorded the highest value at each stage.

Higher values of corm weight was observed from 3MAP upto 7 MAP due to irrigation once in three days (I_1) than once in six days (I_2).

4.1.2.5 Bulking Rate of Corm

The calculated values of BR of corm as influenced by the treatments are shown in Table 12.

An increasing trend in BR of corm was noticed in all the treatments upto 5 MAP beyond which the rate was lowered towards harvest. The peak values were observed between 4 MAP and 5 MAP in all the treatments.

The growth medium m_2 registered the highest BR at all stages of observation.

Application of N and K in six splits registered higher values than three splits (N_1)

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Table 11. Effect of growth medium, nutrient schedule and irrigation schedule on weight of corm plant^{-1} at monthly interval, g *

Treatments	2 MAP	3MAP	4 MAP	5 MAP	6 MAP	7 MAP
$m_1n_1i_1$	96	298	517	967	1357	1639
$m_1n_1i_2$	101	280	496	907	1226	1457
$m_1n_2i_1$	98	300	521	980	1384	1699
$m_1n_2i_2$	94	290	502	917	1259	1467
$m_2n_1i_1$	70	361	690	1159	1554	1881
$m_2n_1i_2$	68	356	702	1139	1483	1720
$m_2n_2i_1$	68	350	688	1199	1617	1963
$m_2n_2i_2$	75	359	661	1088	1443	1667
$m_3n_1i_1$	54	275	513	913	1217	1408
$m_3n_1i_2$	48	262	495	882	1151	1319
$m_3n_2i_1$	46	272	512	948	1299	1516
$m_3n_2i_2$	52	283	530	926	1166	1317
m_1	97.25	292.00	509.00	942.75	1305.30	1565.50
m_2	70.25	356.50	685.25	1146.25	1524.25	1807.75
m_3	50.00	273.00	512.50	917.25	1208.85	1390.00
n_1	72.83	305.33	568.83	994.50	1330.33	1570.67
n_2	72.16	309.00	569.00	1009.67	1361.33	1604.83
i_1	72.00	309.33	573.50	1027.67	1404.00	1684.33
i_2	73.00	305.00	564.33	976.50	1288.00	1491.87

(*Unreplicated data)

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Table 12. Effect of growth medium, nutrient schedule and irrigation schedule on bulking rate of corm at monthly interval , g plant^{-1} day^{-1}*

Treatments	2-3 MAP	3-4 MAP	4-5 MAP	5-6 MAP	6-7 MAP
$m_1n_1i_1$	1.14	1.24	2.55	2.19	1.62
$m_1n_1i_2$	1.01	1.22	2.33	1.81	1.31
$m_1n_2i_1$	1.14	1.25	2.60	2.29	1.79
$m_1n_2i_2$	1.11	1.20	2.35	1.94	1.18
$m_2n_1i_1$	1.65	1.86	2.66	2.24	1.85
$m_2n_1i_2$	1.63	1.96	2.48	1.95	1.34
$m_2n_2i_1$	1.60	1.91	2.90	2.37	1.96
$m_2n_2i_2$	1.61	1.71	2.42	2.01	1.27
$m_3n_1i_1$	1.25	1.35	2.27	1.72	1.08
$m_3n_1i_2$	1.21	1.32	2.20	1.52	0.95
$m_3n_2i_1$	1.28	1.36	2.47	1.99	1.23
$m_3n_2i_2$	1.31	1.40	2.24	1.36	0.86
m_1	1.10	1.23	2.46	2.06	1.48
m_2	1.64	1.95	2.62	2.14	1.61
m_3	1.26	1.36	2.30	1.65	1.03
n_1	1.32	1.49	2.42	1.91	1.36
n_2	1.34	1.47	2.50	1.99	1.38
i_1	1.34	1.50	2.58	2.13	1.58
i_2	1.31	1.47	2.34	1.77	1.15

(*Unreplicated data)

Irrigation once in three days (I_1) recorded higher BR than irrigation once in six days (I_2)

4.1.3 Yield Attributes and Yield

4.1.3.1 Corm Yield Plant^{-1} at Harvest

The data on the effects of growth medium, nutrient schedule and irrigation schedule and their interactions on corm yield plant^{-1} at harvest are presented in Table 13a, 13b, and 13c.

The data in Table 13a revealed that corm yield plant^{-1} at harvest was significantly influenced by the growth medium, nutrient schedule and irrigation schedule. Among the growth media, M_2 produced the highest corm yield (1760.42 g) plant^{-1} and it was significantly superior to M_1 and M_3. The growth medium M_3 recorded the lowest yield plant^{-1} (1383.33 g).

Application of N and K in six splits (N_2) recorded the highest corm yield of 1650 g plant^{-1} and was superior to N_1 (three splits).

Significantly higher corm yield of 1773.61 g plant^{-1} could be produced with irrigation once in three days (I_1) compared to I_2 (irrigation once in six days).

The corm yield per plant^{-1} was not significantly influenced by the second order interactions MxN, MxI and NxI (Table 13b). But the data showed that the corm yield plant^{-1} was higher when M_1 or M_2 or M_3 was combined with N_2 than N_1 and when combined with I_1 than I_2. Similarly, higher corm yield was noticed when N_1 or N_2 was combined with I_1 than I_2.

The third order interaction MxNxI (Table 13c) failed to produce any significant effect on corm yield plant^{-1}. But the treatment combination $m_2n_2i_1$ recorded the highest yield of 2041.67 g plant^{-1}.

4.1.3.2 Top Yield Plant^{-1} at Harvest

The top yield plant^{-1} at harvest as influenced by growth medium, nutrient schedule and irrigation schedule and their interactions are given in Table 13a, 13b and 13c.

The growth media did not produce any significant influence on top yield plant^{-1} at harvest (Table 13a). However, the treatment M_2 recorded the highest value of 474.17g plant^{-1} at harvest.

The highest top yield at harvest was produced by the application of N and K in six splits (N_2) than N_1 (3 splits).

The top yield plant $^{-1}$ at harvest was not significantly influenced by the irrigation schedule.

None of the interactions were significant with respect to top yield plant $^{-1}$ at harvest (Table 13c).

4.1.3.3 Utilization Index

The data pertaining to utilization index are furnished in Table 13a, 13b and 13c.

It is observed from Table 13a that the highest UI of 4.01was obtained with the growth medium M_2 which was significantly superior to M_1 and M_3. The next best UI was recorded by M_1 and was found superior to M_3.

Application of N and K in three or six splits (N_1 or N_2) failed to produce any significant effect on UI.

Irrigation once in three days (I_1) significantly increased UI (3.88) than once in six days (I_2).

With regard to interaction effects, only NxI interaction had significant effect on UI and the treatment combination n_2i_1 (4.06) produced the highest UI which was on a par with n_1i_2 (Table 13b).

Table 13a. Effect of growth medium, nutrient schedule and irrigation schedule on yield and utilization index

Treatments	Corm yield (g plant^{-1})	Top yield (g plant^{-1})	Utilization index
Growth medium (M)			
M_1 - soil : sand : FYM 1:1:1	1629.17	474.17	3.45
M_2 - soil : coir pith : FYM 1:1:1	1760.42	440.83	4.01
M_3- soil : coir pith : FYM 0.75:1.25:1	1383.33	434.58	3.2
SEm±	34.882	13.362	0.085
CD(0.05)	101.810	-	0.247
Nutrient schedule (N)			
N_1 - N&K in 3 splits	1531.94	433.89	3.54
N_2 - N&K in 6 splits	1650.00	465.83	3.56
SEm±	28.481	10.910	0.069
CD(0.05)	83.130	31.840	-
Irrigation schedule (I)			
I_1 - Irrigation once in 3 days	1773.61	461.39	3.88
I_2 - Irrigation once in 6 days	1408.33	438.33	3.23
SEm±	28.481	10.910	0.069
CD(0.05)	83.130	-	0.202

Table 13b. Interaction effect of growth medium, nutrient schedule and irrigation schedule on yield and utilization index

Treatments	Corm yield (g plant^{-1})	Top yield (g plant^{-1})	Utilization index
M x N interaction			
m_1n_1	1604.17	457.50	3.52
m_1n_2	1654.17	490.83	3.37
m_2n_1	1712.50	440.00	3.89
m_2n_2	1808.33	441.67	4.12
m_3n_1	1279.17	404.17	3.20
m_3n_2	1487.50	465.00	3.19
SEm±	49.330	18.896	0.120
CD(0.05)	-	-	-
M x I interaction			
m_1i_1	1787.50	478.33	3.76
m_1i_2	1470.33	470.00	3.13
m_2i_1	1945.83	438.33	4.45
m_2i_2	1575.00	443.33	3.57
m_3i_1	1587.50	467.50	3.42
m_3i_2	1179.17	401.67	2.97
SEm±	49.330	18.896	0.120
CD(0.05)	-	-	-
N x I interaction			
n_1i_1	1683.33	460.00	3.69
n_1i_2	1380.56	407.78	3.93
n_2i_1	1863.89	462.78	4.06
n_2i_2	1436.11	468.89	3.06
SEm±	40.278	15.429	0.098
CD(0.05)	-	-	0.285

Table 13c. Effect of M x N x I interaction on yield and utilization index

Treatments	Corm yield (g plant^{-1})	Top yield (g plant^{-1})	Utilization index
$m_1n_1i_1$	1725.00	465.00	3.74
$m_1n_1i_2$	1483.33	450.00	3.30
$m_1n_2i_1$	1850.00	491.67	3.78
$m_1n_2i_2$	1458.33	490.00	2.98
$m_2n_1i_1$	1850.00	460.00	4.03
$m_2n_1i_2$	1575.00	420.00	3.76
$m_2n_2i_1$	2041.67	416.67	4.87
$m_2n_2i_2$	1575.00	466.67	3.38
$m_3n_1i_1$	1475.00	455.00	3.28
$m_3n_1i_2$	1083.33	353.33	3.12
$m_3n_2i_1$	1700.00	480.00	3.55
$m_3n_2i_2$	1275.00	450.00	2.83
SEm±	69.763	26.723	0.170
CD(0.05)	-	-	-

The interaction MxNxI did not have any significant influence on UI (Table 13c).

4.1.3.4 Dry Matter Production at Harvest

The main effects and interaction effects of treatments on TDMP $plant^{-1}$ at harvest are presented in Table 14a, 14b and 14c.

Total dry matter production $plant^{-1}$ at harvest was significantly influenced by the growth medium, nutrient schedule and irrigation schedule (Table 14a). With regard to growth medium, the highest value of 321.31 g $plant^{-1}$ could be produced by M_2 and was superior to M_1 and M_3. The growth medium m_3 registered the lowest value (256.89 g $plant^{-1}$).

Application of N and K in six splits (N_2) recorded significantly higher dry matter production $plant^{-1}$ (303.79 g) than three splits (N_1).

Significantly higher dry matter production (324.86 g $plant^{-1}$) could be observed with irrigation once in three days (I_1) than than once in six days (I_2).

The second order interactions MxN, MxI and NxI (Table 14b) could not exert any significant influence on dry matter production $plant^{-1}$. But the main effects of treatments were reflected in their interaction effects.

MxNxI interaction also failed to produce significant influence on TDMP. However, the highest dry matter of 367.92 g $plant^{-1}$ was produced by the treatment combination $m_2n_2i_1$.

4.1.4 Quality Attributes of Corm

The starch and crude protein contents of the corm on fresh weight basis as influenced by the treatments are given in Table 15a, 15b and 15c.

Table 14a. Effect of growth medium, nutrient schedule and irrigation schedule on dry matter production , g plant^{-1}

Treatments	Total dry matter production
Growth medium (M)	
M_1 - soil : sand : FYM 1:1:1	301.08
M_2 - soil : coir pith : FYM 1:1:1	321.31
M_3- soil : coir pith : FYM 0.75:1.25:1	256.89
SEm±	6.353
CD(0.05)	18.69
Nutrient schedule (N)	
N_1 - N&K in 3 splits	282.40
N_2 - N&K in 6 splits	303.79
SEm±	5.180
CD(0.05)	15.260
Irrigation schedule (I)	
I_1 - Irrigation once in 3 days	324.86
I_2 - Irrigation once in 6 days	261.33
SEm±	5.188
CD(0.05)	15.260

Table 14b. Interaction effect of growth medium, nutrient schedule and irrigation schedule on dry matter production, g plant^{-1}

Treatments	Total dry matter production
M x N interaction	
m_1n_1	296.42
m_1n_2	305.75
m_2n_1	313.12
m_2n_2	329.50
m_3n_1	237.67
m_3n_2	276.13
SEm±	8.985
CD(0.05)	-
M x I interaction	
m_1i_1	328.63
m_1i_2	273.54
m_2i_1	352.71
m_2i_2	289.92
m_3i_1	293.25
m_3i_2	220.54
SEm±	8.985
CD(0.05)	-
N x I interaction	
n_1i_1	309.72
n_1i_2	255.08
n_2i_1	340.00
n_2i_2	267.58
SEm±	7.336
CD(0.05)	-

Table 14c. Effect of M x N x I interaction on dry matter production, g plant^{-1}

Treatments	Total dry matter production
$m_1n_1i_1$	318.17
$m_1n_1i_2$	274.67
$m_1n_2i_1$	339.08
$m_1n_2i_2$	272.42
$m_2n_1i_1$	337.50
$m_2n_1i_2$	288.75
$m_2n_2i_1$	367.92
$m_2n_2i_2$	291.08
$m_3n_1i_1$	273.50
$m_3n_1i_2$	201.83
$m_3n_2i_1$	313.00
$m_3n_2i_2$	239.25
SEm±	12.707
CD(0.05)	-

4.1.4.1 Starch Content

No significant variation in starch content of corm was observed neither due to growth medium nor due to nutrient schedule as observed from Table 15 a. But irrigation schedule significantly influenced the starch content. Irrigation once in three days (I_1) produced higher starch content than once in six days (I_2).

The second order (MxN, MxI and NxI) as well as third order (MxNxI) interactions did not produce any significant variation in the starch content (Table 15b and 15c).

4.1.4.2 Crude Protein Content

Neither the main effects nor the interactions effects of growth medium, nutrient schedule and irrigation schedule did not exert any significant influence on the crude protein content of the corm (Table 15a, 15b and 15c).

4.1.5 Nutrient Uptake

The data on uptake of N, P and K as influenced by the treatments are presented in Table 16a, 16b and 16c.

4.1.5.1 N Uptake

It is seen from Table 16a that uptake of N is significantly influenced by the growth medium. The growth medium M_2 recorded the highest uptake of N (6.98 g $plant^{-1}$) which was on a par with M_1 and significantly superior to M_3.

Application of N and K in six splits (N_2) recorded significantly higher uptake of N (6.67 g $plant^{-1}$) than application in three splits (N_1).

Significantly higher uptake of N (7.14 g $plant^{-1}$) was observed when irrigated once in three days (I_1) than once in six days (I_2).

The interactions MxN, MxI and NxI did not produce any significant effect on N uptake (Table 16b).

Table 15a. Effect of growth medium, nutrient schedule and irrigation schedule on quality attributes, % on fresh weight basis

Treatments	Starch	Protein
Growth medium (M)		
M_1 - soil : sand : FYM 1:1:1	15.03	2.68
M_2 - soil : coir pith : FYM 1:1:1	15.03	2.68
M_3- soil : coir pith : FYM 0.75:1.25:1	15.13	2.65
SEm±	0.027	0.048
CD(0.05)	-	-
Nutrient schedule (N)		
N_1 - N&K in 3 splits	15.56	2.65
N_2 - N&K in 6 splits	14.93	2.69
SEm±	0.228	0.040
CD(0.05)	-	-
Irrigation schedule (I)		
I_1 - Irrigation once in 3 days	15.75	2.71
I_2 - Irrigation once in 6 days	14.75	2.63
SEm±	0.228	0.040
CD(0.05)	0.680	-

Table 15b. Interaction effect of growth medium, nutrient schedule and irrigation schedule on quality attributes, % on fresh weight basis

Treatments	Starch	Protein
M x N interaction		
m_1n_1	15.35	2.65
m_1n_2	14.71	2.71
m_2n_1	15.73	2.62
m_2n_2	15.45	2.75
m_3n_1	15.63	2.68
m_3n_2	14.63	2.63
SEm±	0.395	0.069
CD(0.05)	-	-
M x I interaction		
m_1i_1	15.77	2.68
m_1i_2	14.30	2.68
m_2i_1	15.72	2.71
m_2i_2	15.46	2.66
m_3i_1	15.78	2.74
m_3i_2	14.49	2.56
SEm±	0.395	0.069
CD(0.05)	-	-
N x I interaction		
n_1i_1	16.05	2.65
n_1i_2	15.09	2.65
n_2i_1	15.46	2.78
n_2i_2	14.40	2.61
SEm±	0.322	0.097
CD(0.05)	-	-

Table 15c. Effect of M x N x I interaction on quality attributes,

% on fresh weight basis

Treatments	Starch	Protein
$m_1n_1i_1$	15.72	2.65
$m_1n_1i_2$	14.99	2.65
$m_1n_2i_1$	15.82	2.72
$m_1n_2i_2$	13.60	2.70
$m_2n_1i_1$	16.21	2.58
$m_2n_1i_2$	15.26	2.65
$m_2n_2i_1$	15.23	2.84
$m_2n_2i_2$	15.67	2.66
$m_3n_1i_1$	16.25	2.71
$m_3n_1i_2$	15.02	2.65
$m_3n_2i_1$	15.31	2.77
$m_3n_2i_2$	13.95	2.48
SEm±	0.559	0.097
CD(0.05)	-	-

MxNxI interaction failed to express significant variation in N uptake (Table 16c). But it is observed that in any growth medium the treatment combination $n_2 i_1$ registered higher N uptake than other combinations of N and I

4.1.5.2 P Uptake

As shown in Table 16a, uptake of P was significantly influenced by growth medium. The highest uptake of P (0.78 g plant^{-1}) was observed in the growth medium M_2 which was significantly superior to M_1 and M_3. The effects of M_1 and m_3 were on a par.

No significant variation in P uptake was observed due to nutrient schedule.

Irrigation once in three days (I_1) recorded significantly higher uptake of P than I_2 (once in six days).

No marked variation in P uptake was observed due to any interaction effects (Table 16b and 16c).

4.1.5.3 K Uptake

It is observed from Table 16a that the growth medium had no profound influence on K uptake.

Application of N and K in six splits (N_2) resulted in significantly higher uptake of K (9.2 g plant^{-1}) than three splits (N_1).

Irrigation once in three days (I_1) recorded significantly higher uptake of K (9.87 g plant^{-1}) than once in six days (I_2).

None of the interaction effects (Table 16b and 16c) were significant with respect to K uptake. But with any growth medium, N_2 recorded higher K uptake than $N_1$and I_1 recorded higher K uptake than I_2 treatment.

4.1.6 Pest and Disease Incidence

Incidence of pest and disease was monitored throughout the cropping period. When yellowing of leaves was observed in one or two plants, it was

Table 16a. Effect of growth medium, nutrient schedule and irrigation schedule on nutrient uptake, g plant^{-1}

Treatments	N uptake	P uptake	K uptake
Growth medium (M)			
M_1 - soil : sand : FYM 1:1:1	6.56	0.64	8.82
M_2 - soil : coir pith : FYM 1:1:1	6.98	0.78	8.77
M_3- soil : coir pith : FYM 0.75:1.25:1	5.56	0.59	8.14
SEm±	0.179	0.046	0.408
CD(0.05)	0.522	0.133	-
Nutrient schedule (N)			
N_1 - N&K in 3 splits	6.06	0.72	7.94
N_2 - N&K in 6 splits	6.67	0.62	9.20
SEm±	0.146	0.037	0.333
CD(0.05)	0.426	-	0.97
Irrigation schedule (I)			
I_1 - Irrigation once in 3 days	7.14	0.78	9.87
I_2 - Irrigation once in 6 days	5.59	0.56	7.27
SEm±	0.146	0.037	0.333
CD(0.05)	0.426	0.109	0.97

Table 16b. Interaction effect of growth medium, nutrient schedule and irrigation schedule on nutrient uptake, g plant^{-1}

Treatments	N uptake	P uptake	K uptake
M x N interaction			
m_1n_1	6.39	0.66	8.29
m_1n_2	6.73	0.62	9.34
m_2n_1	6.64	0.84	8.15
m_2n_2	7.31	0.73	9.38
m_3n_1	5.16	0.66	7.38
m_3n_2	5.95	0.52	8.90
SEm±	0.253	0.065	0.576
CD(0.05)	-	-	-
M x I interaction			
m_1i_1	7.12	0.72	10.27
m_1i_2	6.00	0.56	7.37
m_2i_1	7.77	0.91	9.76
m_2i_2	6.19	0.66	7.77
m_3i_1	6.54	0.70	9.59
m_3i_2	4.57	0.47	6.69
SEm±	0.253	0.065	0.576
CD(0.05)	-	-	-
N x I interaction			
n_1i_1	6.63	0.85	8.78
n_1i_2	5.50	0.59	7.11
n_2i_1	7.66	0.70	10.97
n_2i_2	5.68	0.54	7.43
SEm±	0.207	0.053	0.471
CD(0.05)	-	-	-

Table 16c. Effect of M x N x I interaction on nutrient uptake, g plant^{-1}

Treatments	N uptake	P uptake	K uptake
$m_1n_1i_1$	6.79	0.80	8.93
$m_1n_1i_2$	5.99	0.52	7.66
$m_1n_2i_1$	7.45	0.63	11.61
$m_1n_2i_2$	6.01	0.60	7.07
$m_2n_1i_1$	7.12	0.92	8.77
$m_2n_1i_2$	6.16	0.76	7.54
$m_2n_2i_1$	8.41	0.90	10.75
$m_2n_2i_2$	6.22	0.56	8.00
$m_3n_1i_1$	5.98	0.83	8.62
$m_3n_1i_2$	4.34	0.48	6.14
$m_3n_2i_1$	7.11	0.57	10.57
$m_3n_2i_2$	4.79	0.46	7.24
SEm±	0.358	0.091	0.815
CD(0.05)	-	-	-

confirmed as symptom of collar rot. Hence foliar spray of two percent *Pseudomonas* and drenching of two percent *Pseudomonas* were done twice at 4 MAP and 5 MAP when the disease could be brought under control.

4.1.7 Growth Media Analysis after the Experiment

4.1.7.1 pH

The data on pH of the growth medium as influenced by the treatments is given in Table 17a, 17b and 17c.

A slight increase in pH of growth media was observed after the experiment than the initial values (Table 4 and Table 17a). However, no significant variation in pH between different growth media after the experiment was observed.

Application of N and K in six splits (N_2) significantly increased the pH of the growth media than three splits (N_1).

Irrigation once in three days (I_1) or six days (i_2) did not register marked variation in the pH of the growth medium.

No significant variation in pH between different growth media was observed due to interaction effects (Table 17b and 17c). But, with any treatment combination, the pH value increased over the initial values.

4.1.7.2 EC

The average EC values of the growth media as influenced by the treatments are given in Table 17a, 17b and 17c.

The EC values of the growth media increased after the experiment (Table 4 and 17a). Among the growth media, M_1 recorded lower EC value than M_2 and M_3 which were on a par.

Application of N and K in six splits (N_2) significantly increased EC than three splits (N_1).

Table 17a. Effect of growth medium, nutrient schedule and irrigation schedule on physio – chemical properties of growth media after the experiment

Treatments	pH	EC (dSm^{-1})
Growth medium (M)		
M_1 - soil : sand : FYM 1:1:1	7.39	1.46
M_2 - soil : coir pith : FYM 1:1:1	7.45	1.85
M_3- soil : coir pith : FYM 0.75:1.25:1	7.40	2.02
SEm±	0.110	0.103
CD(0.05)	-	0.300
Nutrient schedule (N)		
N_1 - N&K in 3 splits	7.29	1.56
N_2 - N&K in 6 splits	7.56	2.00
SEm±	0.090	0.084
CD(0.05)	0.261	0.245
Irrigation schedule (I)		
I_1 - Irrigation once in 3 days	7.44	1.72
I_2 - Irrigation once in 6 days	7.41	1.86
SEm±	0.090	0.084
CD(0.05)	-	-

Table 17b. Interaction effect of growth medium, nutrient schedule and irrigation schedule on physio – chemical properties of growth media after the experiment

Treatments	pH	EC (dSm^{-1})
M x N interaction		
m_1n_1	7.30	1.33
m_1n_2	7.47	1.62
m_2n_1	7.27	1.51
m_2n_2	7.69	2.20
m_3n_1	7.30	1.85
m_3n_2	7.52	2.20
SEm±	0.155	0.145
CD(0.05)	-	-
M x I interaction		
m_1i_1	7.51	1.38
m_1i_2	7.26	1.57
m_2i_1	7.42	1.82
m_2i_2	7.54	1.90
m_3i_1	7.39	1.95
m_3i_2	7.42	2.10
SEm±	0.155	0.145
CD(0.05)	-	-
N x I interaction		
n_1i_1	7.33	1.43
n_1i_2	7.26	1.70
n_2i_1	7.56	2.00
n_2i_2	7.56	2.01
SEm±	0.127	0.119
CD(0.05)	-	-

Table 17c. Effect of M x N x I interaction on physio – chemical properties of growth media after the experiment

Treatments	pH	EC (dSm^{-1})
$m_1n_1i_1$	7.39	1.13
$m_1n_1i_2$	7.22	1.53
$m_1n_2i_1$	7.63	1.63
$m_1n_2i_2$	7.31	1.60
$m_2n_1i_1$	7.23	1.57
$m_2n_1i_2$	7.31	1.47
$m_2n_2i_1$	7.62	2.06
$m_2n_2i_2$	7.78	2.33
$m_3n_1i_1$	7.36	1.60
$m_3n_1i_2$	7.24	2.10
$m_3n_2i_1$	7.43	2.30
$m_3n_2i_2$	7.60	2.10
SEm±	0.220	0.206
CD(0.05)	-	-

Irrigation schedule did not produce any marked variation in EC of the growth media after the experiment.

None of the interaction effects were found significant (Table 17b and 17c).

4.1.7.3 Dehydrogenase Activity

Initially, the growth medium M_1 had higher activity of dehydrogenase than M_2 and M_3 (Table 4). After the experiment, dehydrogenase activity was significantly higher in the growth media M_2 and M_3 than M_1 (Table 18a).

Dehydrogenase activity did not vary significantly with nutrient schedule.

When irrigation interval was changed from three days (I_1) to six days (I_2), significant reduction in dehydrogenase activity was observed.

The interaction MxN (Table 18b) had significant effect on dehydrogenase activity. The treatment combination m_3n_1 and m_2n_2, which were on a par, recorded higher dehydrogenase activity than other combinations. The interactions MxI and NxI failed to produce any significant effect on dehydrogenase activity.

No significant variation in dehydrogenase activity was observed due to MxNxI interaction (Table 18c).

4.1.7.4 Organic Carbon

After the experiment, no significant variation in organic carbon content of different growth media was noticed (Table 18a).

Neither the nutrient schedule nor the irrigation schedule significantly altered the status of organic carbon in different growth media after the experiment.

The second order (Table 18b) and third order (Table 18c) interactions could not produce any marked variation in the content of organic carbon in different growth media.

Table 18a. Effect of growth medium, nutrient schedule and irrigation schedule organic carbon content and dehydrogenase activity of growth media after the experiment

Treatments	Organic carbon (%)	Dehydrogenase activity (μg TPF $24h^{-1}$ g^{-1})
Growth medium (M)		
M_1 - soil : sand : FYM 1:1:1	5.64	222.33
M_2 - soil : coir pith : FYM 1:1:1	6.02	282.67
M_3- soil : coir pith : FYM 0.75:1.25:1	6.10	287.83
SEm±	0.216	5.409
CD(0.05)	-	15.793
Nutrient schedule (N)		
N_1 - N&K in 3 splits	5.94	261.33
N_2 - N&K in 6 splits	5.89	267.22
SEm±	0.176	4.417
CD(0.05)	-	-
Irrigation schedule (I)		
I_1 - Irrigation once in 3 days	5.85	300.45
I_2 - Irrigation once in 6 days	5.98	228.11
SEm±	0.176	4.417
CD(0.05)	-	12.895

Table 18b. Interaction effect of growth medium, nutrient schedule and irrigation schedule on organic carbon and dehydrogenase activity of growth media after the experiment

Treatments	Organic carbon (%)	Dehydrogenase activity (µg TPF $24h^{-1}$ g^{-1})
M x N interaction		
m_1n_1	5.42	207.00
m_1n_2	5.86	237.67
m_2n_1	6.36	274.16
m_2n_2	5.68	291.17
m_3n_1	6.06	302.83
m_3n_2	6.15	272.83
SEm±	0.305	7.650
CD(0.05)	-	22.335
M x I interaction		
m_1i_1	5.31	262.67
m_1i_2	5.96	182.00
m_2i_1	5.89	313.33
m_2i_2	6.15	252.00
m_3i_1	6.36	325.33
m_3i_2	5.84	250.33
SEm±	0.305	7.650
CD(0.05)	-	-
N x I interaction		
n_1i_1	5.83	295.67
n_1i_2	6.06	227.00
n_2i_1	5.87	305.22
n_2i_2	5.91	229.22
SEm±	0.249	6.246
CD(0.05)	-	-

Table 18c. Effect of M x N x I interaction on organic carbon content and dehydrogenase activity of growth media after the experiment

Treatments	Organic carbon (%)	Dehydrogenase activity (μg TPF $24h^{-1}$ g^{-1})
$m_1n_1i_1$	5.27	245.00
$m_1n_1i_2$	5.55	169.00
$m_1n_2i_1$	5.35	280.33
$m_1n_2i_2$	6.37	195.00
$m_2n_1i_1$	6.01	277.33
$m_2n_1i_2$	6.71	271.00
$m_2n_2i_1$	5.76	349.33
$m_2n_2i_2$	5.59	233.00
$m_3n_1i_1$	6.21	364.67
$m_3n_1i_2$	5.90	241.00
$m_3n_2i_1$	6.51	286.00
$m_3n_2i_2$	5.78	259.67
SEm±	0.432	10.819
CD(0.05)	-	-

4.1.7.5 Available N content

Compared to the initial values (Table 4), available N content in different growth media after the experiment increased due to treatments (Table 19a) and the status of available N was higher in M_2 and M_3 than in M_1.

Neither the main effects nor the interaction effects of the treatments were significant in this respect (Table 19b and 19c).

4.1.7.6 Available P content

The content of P in the growth media showed a decreasing trend after the experiment (Table 19a) when compared to the initial values (Table 4).

No significant variation in available P content was observed due to treatments (Table 19a, 19b and 19c).

4.1.7.7 Available K content

After the experiment, a marked increase in K content in different growth media was observed (Table 19a, 19b and 19c) compared to the initial status (Table 4). Available K content was higher in the growth media M_2 and M_3 than in M_1 before and after the experiment.

The K content did not vary significantly between growth media (Table 19a).

Application of N and K in six splits (N_2) markedly increased the K content than three splits (N_1).

Available K content in the growth media did not vary significantly with irrigation schedule.

None of the interactions (Table 19b and 19c) were significant with respect to available K content in the growth media.

Table 19a. Effect of growth medium, nutrient schedule and irrigation schedule on available N P K content of growth media after the experiment, %

Treatments	Available N	Available P	Available K
Growth medium (M)			
M_1 - soil : sand : FYM 1:1:1	0.089	0.021	0.061
M_2 - soil : coir pith : FYM 1:1:1	0.098	0.028	0.075
M_3- soil : coir pith : FYM 0.75:1.25:1	0.096	0.026	0.070
SEm±	0.0048	0.0044	0.042
CD(0.05)	-	-	-
Nutrient schedule (N)			
N_1 - N&K in 3 splits	0.093	0.024	0.062
N_2 - N&K in 6 splits	0.096	0.026	0.075
SEm±	0.0039	0.0036	0.034
CD(0.05)	-	-	0.0099
Irrigation schedule (I)			
I_1 - Irrigation once in 3 days	0.094	0.026	0.069
I_2 - Irrigation once in 6 days	0.094	0.024	0.068
SEm±	0.0039	0.0036	0.0034
CD(0.05)	-	-	-

Table 19b. Interaction effect of growth medium, nutrient schedule and irrigation schedule on nutrient status of growth media after the experiment ,%

Treatments	Available N	Available P	Available K
M x N interaction			
m_1n_1	0.080	0.021	0.061
m_1n_2	0.098	0.021	0.061
m_2n_1	0.100	0.026	0.062
m_2n_2	0.097	0.030	0.089
m_3n_1	0.099	0.026	0.065
m_3n_2	0.093	0.027	0.076
SEm±	0.0067	0.0062	0.0059
CD(0.05)	-	-	-
M x I interaction			
m_1i_1	0.087	0.023	0.062
m_1i_2	0.090	0.019	0.060
m_2i_1	0.097	0.029	0.073
m_2i_2	0.103	0.028	0.077
m_3i_1	0.099	0.025	0.072
m_3i_2	0.093	0.027	0.068
SEm±	0.0067	0.0062	0.0059
CD(0.05)	-	-	-
N x I interaction			
n_1i_1	0.096	0.025	0.065
n_1i_2	0.090	0.023	0.060
n_2i_1	0.092	0.026	0.073
n_2i_2	0.099	0.026	0.077
SEm±	0.0055	0.0050	0.0048
CD(0.05)	-	-	-

Table 19c. Effect of M x N x I interaction on nutrient status of growth media after the experiment , %

Treatments	Available N	Available P	Available K
$m_1n_1i_1$	0.082	0.025	0.061
$m_1n_1i_2$	0.078	0.016	0.061
$m_1n_2i_1$	0.093	0.022	0.063
$m_1n_2i_2$	0.102	0.021	0.059
$m_2n_1i_1$	0.098	0.026	0.065
$m_2n_1i_2$	0.102	0.027	0.059
$m_2n_2i_1$	0.096	0.032	0.082
$m_2n_2i_2$	0.098	0.029	0.096
$m_3n_1i_1$	0.110	0.025	0.069
$m_3n_1i_2$	0.088	0.027	0.060
$m_3n_2i_1$	0.088	0.025	0.075
$m_3n_2i_2$	0.098	0.027	0.076
SEm±	0.0095	0.0087	0.0084
CD(0.05)	-	-	-

4.1.8 Economics of Cultivation

The economics of container cultivation of elephant foot yam in terms of net income and BCR is presented in Table 20a, 20b, 20c.

4.1.8.1 Net Income

The data furnished in Table 20a revealed the significant effects of treatments on net income $sack^{-1}$. Net income was the highest (₹ 27.2 $sack^{-1}$) when M_2 was used as the growth medium which was significantly superior to M_1 and M_3. The effects of M_1 and M_3 were on a par.

Application of N and K in six splits (N_2) recorded significantly higher net income (₹17.05 $sack^{-1}$) than three splits (N_1).

Significantly higher net income (₹21.99 $sack^{-1}$) was obtained when irrigated once in three days (I_1) than once in six days (I_2).

The interaction effects did not exert any significant effect on net income (Table 20b and 20c). However, the interaction effects followed the same trend of main effects. The highest net income of ₹38.47 $sack^{-1}$ was obtained with the treatment combination $m_2n_2i_1$.

4.1.8.2 Benefit Cost Ratio

Benefit cost ratio also exhibited the same trend of treatment effects as that of net income (Table 20a).

The growth medium M_2 recorded significantly higher BCR of 1.63 followed by M_3 which was significantly superior to M_1.

The treatment N_2 recorded (N and K in six splits) recorded significantly higher BCR (1.37) than N_1 (three splits).

More frequent irrigation (I_1-once in three days) resulted in significantly higher BCR of 1.48.

Table 20a. Effect of growth medium, nutrient schedule and irrigation schedule on economics of cultivation.

Treatments	Net income (₹ $sack^{-1}$)	BCR
Growth medium (M)		
M_1 - soil : sand : FYM 1:1:1	6.97	1.12
M_2 - soil : coir pith : FYM 1:1:1	27.22	1.63
M_3- soil : coir pith : FYM 0.75:1.25:1	9.88	1.22
SEm±	1.395	0.030
CD(0.05)	4.074	0.088
Nutrient schedule (N)		
N_1 - N&K in 3 splits	12.33	1.27
N_2 - N&K in 6 splits	17.05	1.37
SEm±	1.139	0.025
CD(0.05)	3.326	0.072
Irrigation schedule (I)		
I_1 - Irrigation once in 3 days	21.99	1.47
I_2 - Irrigation once in 6 days	7.38	1.17
SEm±	1.139	0.025
CD(0.05)	3.326	0.072

Table 20b. Interaction effect of growth medium, nutrient schedule and irrigation schedule on net income and BCR

Treatments	Net income (₹sack^{-1})	BCR
M x N interaction		
m_1n_1	5.97	1.10
m_1n_2	7.97	1.14
m_2n_1	25.30	1.59
m_2n_2	29.13	1.67
m_3n_1	5.71	1.13
m_3n_2	14.05	1.31
SEm±	1.973	0.043
CD(0.05)	-	-
M x I interaction		
m_1i_1	13.30	1.23
m_1i_2	0.63	1.01
m_2i_1	34.63	1.80
m_2i_2	19.80	1.46
m_3i_1	18.05	1.40
m_3i_2	1.71	1.04
SEm±	1.973	0.043
CD(0.05)	-	-
N x I interaction		
n_1i_1	18.38	1.40
n_1i_2	6.27	1.14
n_2i_1	25.60	1.55
n_2i_2	8.49	1.19
SEm±	1.611	0.035
CD(0.05)	-	-

Table 20c. Effect of M x N x I interaction on net income and BCR

Treatments	Net income (₹sack^{-1})	BCR
$m_1n_1i_1$	10.80	1.19
$m_1n_1i_2$	1.13	1.02
$m_1n_2i_1$	15.80	1.27
$m_1n_2i_2$	0.13	1.00
$m_2n_1i_1$	30.80	1.71
$m_2n_1i_2$	19.80	1.46
$m_2n_2i_1$	38.47	1.89
$m_2n_2i_2$	19.80	1.46
$m_3n_1i_1$	13.55	1.30
$m_3n_1i_2$	-2.11	0.95
$m_3n_2i_1$	22.55	1.50
$m_3n_2i_2$	5.55	1.12
SEm±	2.791	0.060
CD(0.05)	-	-

As in the case of net income, the interaction effects did not have any marked influence on BCR (Table 20b and 20c). But the same trend of main effects was reflected in the interaction effects. The highest BCR of 1.89 was recorded by the treatment combination $m_2n_2i_1$.

4.1.9 Correlation Study

Correlation analysis of corm yield and TDMP versus LAI at 4 MAP and 6 MAP and nutrient uptake plant^{-1}was done and the correlation coefficients are furnished in Table 21.

The correlation coefficients presented in Table 21 revealed that corm yield and total TDMP plant^{-1} were significantly and positively correlated with LAI at 4 MAP and 6 MAP, N uptake plant^{-1}, P uptake plant^{-1} and K uptake plant^{-1}.

4.2 EXPERIMENT II – INCUBATION STUDY

The three different growth media, supplied with the recommended dose of N, P and K for elephant foot yam through organic manures, were incubated for a period of seven months. The physico – chemical properties of the incubated growth media were analysed at monthly interval and the results of analysis are presented in Table 22, 23 and 24.

4.2.1. pH

When growth media were incubated, the pH value decreased in all the growth media upto 3 MAI (Table 22). The pH values showed an increase in all the growth media upto 5 MAI. After five months, the pH decreased in all the growth media.

Significantly higher pH was observed in the growth medium M_1 at all stages except 5 MAI when it was on a par with M_2. At all stages, pH of M_2 was on a par with M_3 except at 1 MAI, 2 MAI and 7 MAI.

Table 21. Correlation analysis of corm yield and TDMP versus LAI and nutrient uptake

Variables correlated	Correlation coefficients
Corm yield x LAI at 4 MAP	0.783**
Corm yield x LAI at 6 MAP	0.870**
Corm yield x N uptake	0.986**
Corm yield x P uptake	0.700*
Corm yield x K uptake	0.841**
TDMP x LAI at 4 MAP	0.779**
TDMP x LAI at 6 MAP	0.864**
TDMP x N uptake	0.985**
TDMP x P uptake	0.691*
TDMP x K uptake	0.844**

** Significant at 1% level

*Significant at 5 % level

4.2.2 EC

Upto 2 MAI, EC was lowered in all the growth media. Afterwards an increasing trend in EC was observed in all the growth media upto 6 MAI beyond which it showed a slight decrease (Table 22). At the end of seven months of incubation, EC in all the growth media showed values much higher than the initial values.

Significant difference in EC was observed in different growth media upto 2 MAI when the highest value was observed in M_3 followed by M_2. At the end of three months of incubation, EC values were almost equal in all the growth media. Afterwards, with increasing period of incubation, significantly higher EC values were observed in M_2 and M_3 than M_1, which were on a par.

4.2.3 Dehydrogenase Activity

The dehydrogenase activity increased at 1MAI but it showed a decreasing trend afterwards upto 4 MAI (Table 23). An increase in dehydrogenase activity was observed from 4 MAI to 5 MAI which further showed a decreasing trend upto 7 MAI.

The growth media were significantly different with respect to dehydrogenase activity from 2 MAI. The highest activity of dehydrogenase was observed in the growth medium M_1 upto 5 MAI which was on a par with M_2 at 2 MAI and 5 MAI. The growth media M_2 and M_3 were on a par with respect to dehydrogenase activity at 1 MAI, 3 MAI, and 4 MAI but M_2 was superior to M_3 at 5 MAI and 6 MAI. At 6 MAI, significantly higher activity of dehydrogenase was observed in the growth medium M_2 followed by M_1 which were on a par and superior to M_3. At 7 MAI M_2 registered higher activity of dehydrogenase but superior to M_1 and on a par with M_3 while M_1 and M_3 were on a par.

4.2.3 Organic Carbon Content

In general, an increasing trend in organic carbon content was observed in the growth medium M1 upto 5 MAI (Table 23). But, a decreasing trend in organic

Table 22. Physio – chemical properties of incubated growth media

Growth media	Months after incubation (MAI)						
	1MAI	2MAI	3MAI	4MAI	5MAI	6MAI	7MAI
pH							
M_1 - soil : sand : FYM 1:1:1	7.07	6.98	6.83	6.81	7.39	7.19	7.18
M_2 - soil : coir pith : FYM 1:1:1	6.98	6.74	6.26	6.55	7.23	6.82	6.95
M_3- soil : coir pith : FYM 0.75:1.25:1	6.83	6.55	6.04	6.53	6.99	6.66	6.76
SEm±	0.053	0.145	0.116	0.063	0.105	0.129	0.317
CD(0.05)	0.089	0.053	0.256	0.181	0.239	0.294	0.025
EC (dSm^{-1})							
M_1 - soil : sand : FYM 1:1:1	0.71	0.62	1.30	1.44	1.48	2.16	1.50
M_2 - soil : coir pith : FYM 1:1:1	1.36	1.13	1.31	1.82	1.86	2.60	2.32
M_3- soil : coir pith : FYM 0.75:1.25:1	1.64	1.45	1.33	2.02	2.04	2.84	2.52
SEm±	0.089	0.077	0.056	0.114	0.195	0.135	0.320
CD(0.05)	0.198	0.187	-	0.262	0.436	0.300	0.702

Table 23. Dehydrogenase activity and organic carbon content in incubated growth media

Growth media	Months after incubation (MAI)						
	1MAI	2MAI	3MAI	4MAI	5MAI	6MAI	7MAI
Dehydrogenase activity (µg TPF $24h^{-1}$ g^{-1})							
M_1 - soil : sand : FYM 1:1:1	323.20	284.00	264.40	237.00	281.96	203.60	154.00
M_2 - soil : coir pith : FYM 1:1:1	300.20	255.20	176.00	126.40	249.28	245.84	191.00
M_3- soil : coir pith : FYM 0.75:1.25:1	260.40	184.00	140.00	104.40	150.20	160.40	181.40
SEm±	24.57	26.73	18.63	14.69	16.70	17.73	13.20
CD(0.05)	-	58.23	40.57	32.03	36.40	38.63	28.77
Organic carbon (%)							
M_1 - soil : sand : FYM 1:1:1	3.47	4.23	4.34	4.32	4.98	3.37	3.08
M_2 - soil : coir pith : FYM 1:1:1	5.26	5.18	5.19	5.07	5.87	4.54	4.49
M_3- soil : coir pith : FYM 0.75:1.25:1	5.79	5.27	5.16	5.11	5.95	5.29	4.37
SEm±	0.350	0.381	0.309	0.227	0.219	0.252	0.235
CD(0.05)	0.762	0.831	0.687	0.498	0.483	0.542	0.510

carbon content was observed upto 4 MAI in the growth media M_2 and M_3 which showed increased values at 5 MAI. At 6 MAI and 7 MAI, the content of organic carbon decreased in all the growth media.

At all stages of observation, growth media differed significantly in their organic carbon contents. Significantly higher contents of organic carbon were observed in the growth media M_2 and M_3 which were on a par but superior to M_1 at all stages except 6 MAI. At 6 MAI, the growth medium m_2 was superior followed by M_3 and M_1 in that order.

4.2.5 Available N Status

When incubated, available N status showed an increasing trend upto 5 MAI which decreased afterwards (Table 24).

No significant difference in the status of available N was observed in the growth media at any stage except 5 MAI. At 5 MAI, the growth medium M_2 registered higher content of available N but was on a par with M_3 and superior to M_1. The growth media M_1 and M_3 were on a par in the content of available N at 5 MAI.

4.2.6 Available P Status

Available P content in the growth media showed an increasing trend upto 2 MAI or 3 MAI and then showed a decreasing trend upto 7 MAI (Table 24).

Significant difference in available P status between growth media was observed only at 1 MAI and 2 MAI. At 1 MAI, significantly higher P content was obtained in M_3 and the lowest in M_1. At 2 MAI, M_2 and M_3 were on a par but M_2 was on a par with M_1.

4.2.7 Available K Status

Available K content showed an increasing trend from 1 MAI upto 7 MAI (Table 24).

At all stages of incubation, significant difference in K status was observed between growth media except at 1 MAI. The growth medium M_3 recorded the highest K content at all stages. But it was found on a par with M_2 at all stages except at 1 MAI and 6 MAI. At all stages, M_1 recorded the lowest K content.

Table 24. Nutrient status of incubated growth media, %

Growth media	Months after incubation (MAI)						
	1MAI	2MAI	3MAI	4MAI	5MAI	6MAI	7MAI
Available N							
M_1 - soil : sand : FYM 1:1:1	0.076	0.078	0.090	0.137	0.146	0.120	0.089
M_2 - soil : coir pith : FYM 1:1:1	0.078	0.081	0.095	0.140	0.162	0.132	0.095
M_3- soil : coir pith : FYM 0.75:1.25:1	0.076	0.078	0.081	0.134	0.148	0.123	0.092
SEm±	0.0052	0.0040	0.0121	0.0080	0.0063	0.0100	0.0089
CD(0.05)	-	-	-	-	0.0138	-	-
Available P							
M_1 - soil : sand : FYM 1:1:1	0.039	0.048	0.058	0.035	0.019	0.015	0.016
M_2 - soil : coir pith : FYM 1:1:1	0.052	0.071	0.076	0.041	0.024	0.023	0.021
M_3- soil : coir pith : FYM 0.75:1.25:1	0.069	0.076	0.062	0.036	0.026	0.022	0.023
SEm±	0.0034	0.0044	0.0074	0.0052	0.0060	0.0066	0.0034
CD(0.05)	0.0104	0.0116	-	-	-	-	-
Available K							
M_1 - soil : sand : FYM 1:1:1	0.016	0.018	0.021	0.019	0.039	0.040	0.048
M_2 - soil : coir pith : FYM 1:1:1	0.018	0.020	0.026	0.026	0.057	0.070	0.062
M_3- soil : coir pith : FYM 0.75:1.25:1	0.021	0.021	0.027	0.027	0.062	0.094	0.064
SEm±	0.0063	0.0028	0.006	0.0048	0.0056	0.004	0.0056
CD(0.05)	-	0.0027	0.0046	0.0057	0.0104	0.0123	0.0129

DISCUSSION

5. DISCUSSION

The results of the experiments conducted to standardize growth medium as well as nutrient and irrigation schedule for container cultivation of elephant foot yam are discussed in this chapter.

5.1 EXPERIMENT I – AGRONOMIC PACKAGE FOR CONTAINER GROWN ELEPHANT FOOT YAM

5.1.1 Growth Characters

The growth characters of elephant foot yam like plant height (height of the pseudostem), canopy spread and LAI were recorded at bimonthly interval from 2 MAP upto harvest. Irrespective of treatments, plant height and canopy spread increased with the age of the crop (Table 5a, 5b, 5c, 6a, 6b and 6c). But a faster rate of increase in plant height was registered upto 6 MAP and canopy spread upto 4 MAP. Leaf area index increased from 2 MAP upto 4 MAP, retained values at 6 MAP and thereafter declined towards harvest (Table 7a, 7b and 7c) which indicated that maximum LAI might have occurred between 4 MAP and 6 MAP. This is in conformity with the findings of Das *et al.* (1997) who observed maximum LAI between 4 MAP and 5 MAP by using corm pieces weighing 250 g as planting material as in the present study. Considering all growth characters, it can be assumed that maximum vegetative growth might have occurred between 4 MAP and 6 MAP.

Growth medium had significant influence on all growth characters at all growth stages except on plant height at 2 MAP. At all stages, taller plants and higher canopy spread and LAI were produced in the growth medium M_2 (Table 5a, 6a and 7a). The growth medium M_2 (soil: coir pith: FYM in 1:1:1 proportion) was similar in composition to the conventional growth medium M_1 (soil: sand: FYM in 1:1:1 proportion) except that the sand was replaced with coir pith. The results indicated that vegetative growth characters of elephant foot yam in terms of plant height, canopy spread and LAI were not affected by including coir pith as a component upto a certain proportion in the growth media. Although the growth medium M_3

performed equally well as M_1 in producing taller plants and higher canopy spread (Table 5a and 6a), M_3 was inferior to M_1 in the development of leaf area and higher LAI at all growth stages (Table 7a).

Nutrient schedule markedly influenced plant height and LAI especially during later stages of crop growth. Application of N and K in six splits resulted in taller plants from 6 MAP and higher LAI from 4 MAP onwards (Table 5a and 7a) compared to application in three splits. It can be presumed that application of nutrients in more splits ensured continued availability of N and K throughout the crop growth stage and is advantageous for container cultivation.

Padmanabhan and Swadija (2015) advocated ration irrigation but daily irrigation for vegetables grown in containers on house terraces. However, daily irrigation is not required for a tuber crop like elephant foot yam. Hence, in the present study, two irrigation schedule (once in three days and once in six days) were experimented for container grown elephant foot yam. No marked variation in plant height and canopy spread was recorded due to irrigation schedule either once in three or six days (Table 5a and 6a). This is an agreement with the findings of Santosa *et al.* (2004) when elephant foot yam was grown in plastic bags. But irrigation once in three days produced markedly higher LAI than once in six days during later stages of the crop *viz.* at 6 MAP and harvest (Table 7a). Santosa *et al.* (2004) also reported that frequent irrigation produced larger leaves and extended the life span compared to less frequent irrigation for elephant foot yam. In the present study, the crop received sufficient rainfall during initial stages upto 4 MAP (Fig. 1) when only few irrigation were given during non-rainy periods. This might have led to significant influence of irrigation schedule on LAI during later stages when majority of irrigations were given.

Among the second order interactions, only MxN interaction could markedly influence plant height at 6 MAP and MxI interaction influenced LAI at harvest. Irrespective of nutrient and irrigation schedule, taller plants and higher LAI were recorded in the growth medium M_2. Although MxNxI interaction failed to express significant influence on growth characters, the highest LAI at each growth stage was registered by the treatment combination $m_2n_2i_1$ reflecting the trend of the main effects.

5.1.2 Tuberisation Pattern

At monthly interval, sample plants were uprooted from twelve treatment combinations in the fourth replication to study the influence of treatments on the tuberisation pattern in elephant foot yam grown in containers. When sample plants were observed at 1 MAP, no corm initiation was noticed in any treatment. Sprouting had occurred in all the treatments (Plate 3). At 2 MAP, corm development was observed in all the treatments (Plate 4). Thus it could be inferred that corm initiation might have occurred between 1 MAP and 2 MAP irrespective of treatments. The sample plants were also observed for number and fresh weight of roots produced plant^{-1} and weight of corm plant^{-1} at monthly interval. Number and weight of roots produced plant^{-1} showed an increasing trend upto 5 MAP and started declining afterwards in all the treatments (Fig 2a, 2b, 2c, 3a, 3b and 3c). The root number showed more than three fold increase from 1 MAP to 2 MAP and more than two fold increase from 2 MAP to 3 MAP with corresponding effect on root weight also.

At all stages of observation, root number plant^{-1} was the highest in the growth medium M_2 (Table 8). At 1 MAP and 2 MAP, both M_2 and M_3 produced more roots than M_1 and from 3 MAP onwards, the root number was the lowest in M_3. The fresh weight of roots plant^{-1} was the highest at each stage in the growth medium M_2 followed by M_1 (Table 9). At harvest, significantly higher root number and root weight plant^{-1} were noticed in the growth medium M_2 which was on a par with M_1 in the case of root number and was superior to M_1 with respect to root weight plant^{-1} (Table 10a). The lowest root number and weight were recorded in M_3. Use of coir pith as a component of growth medium in a suitable proportion as in M_2 favoured the root growth and activity.

Initially, the weight of corm plant^{-1} was the highest in the growth medium M_1 followed by M_2. From 3 MAP onwards, corm weight plant^{-1} was the highest in M_2 followed by M_1. (Fig 2a). The results clearly revealed that sprouting, root

Plate 3. Sprouting observed in different growth media one month after planting elephant foot yam

Plate 4. Corm development observed in different growth media two month after planting elephant foot yam

formation, corn initiation and corm development in elephant foot yam were not affected when coir pith was used as a component of the growth medium.

Nutrient schedule could produce marked variation in root number and weight as well as corm weight plant^{-1} only from 5 MAP onwards when application of N and K in six splits registered higher values of these parameters (Table 8, 9 and 10a and Fig. 2b). Although there was not much variation in root number and weight and corm weight plant^{-1} due to irrigation schedule during initial stages, irrigation once in three days recorded higher values of these parameters from 4 MAP onwards (Table 8, 9 and 10a and Fig. 2c). Steady availability of nutrients due to more split application coupled with irrigation might have favoured root growth and uptake of nutrients during later stages resulting in higher corm development.

Among the interaction effects at harvest (Table 10b), the nutrient schedule and irrigation schedule could influence root number as well as root weight plant^{-1}. Application of N and K in six splits combined with irrigation once in six days produced superior values of root number and weight plant^{-1}. Although not significant, the treatment combination $m_2n_2i_1$ recorded the highest number (360) of roots and weight (150 g) of roots plant^{-1}.

The calculated values of BR of corm indicated an increasing trend upto 5 MAP beyond which it declined towards harvest irrespective of treatments (Table 12). The peak values were observed between 4 MAP and 5 MAP. Mukhopadhayay and Sen (1986) and Nair *et al.* (1991) have also reported steady increase in BR upto 5 to 6 MAP and maximum BR during fifth or sixth MAP. In the present study, maximum BR was observed slightly earlier (4 to 5 MAP) which might be due to early maturing (7 months) character of the var.Gajendra.

The highest BR of corm was recorded in the growth medium M_2 (Fig 3a). Application of N and K in six splits than three splits as well as irrigation once in three days than six days recorded higher BR at all stages of observation (Fig 3b and 3c).

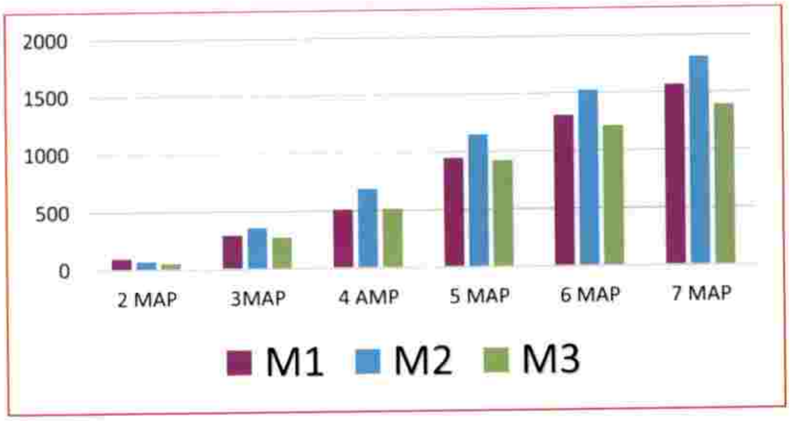

Fig. 2a Effect of growth medium on weight of corm plant^{-1} at monthly interval, g

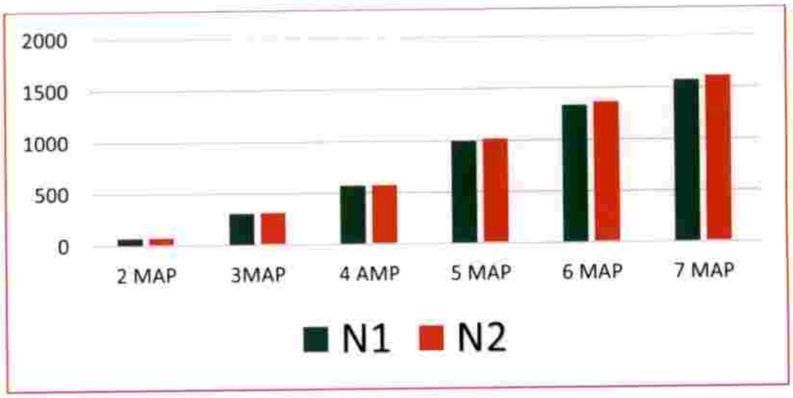

Fig. 2b Effect of nutrient schedule on weight of corm plant^{-1} at monthly interval, g

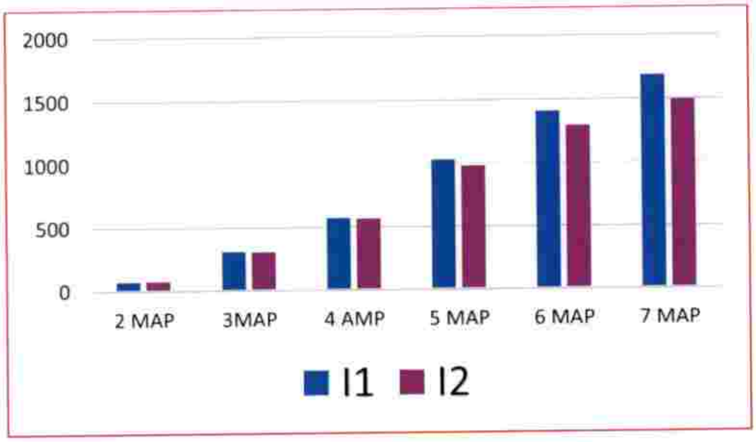

Fig. 2c Effect of irrigation schedule on weight of corm plant^{-1} at monthly interval,

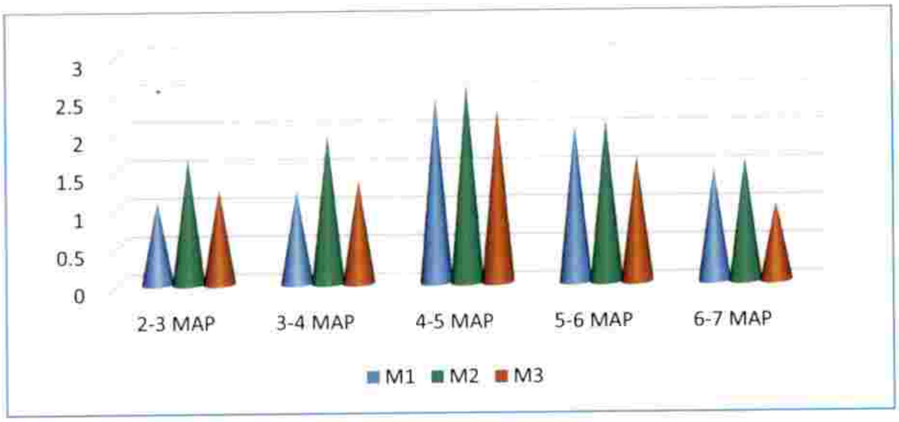

Fig. 3a Effect of growth medium on bulking rate of corm, g plant^{-1} day^{-1}

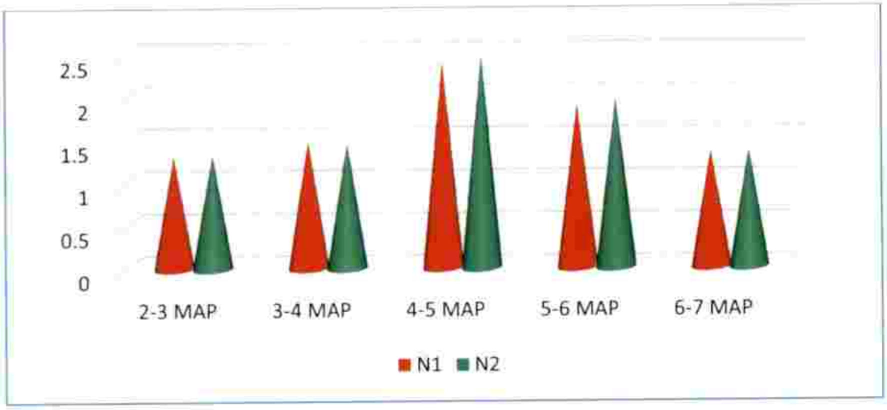

Fig. 3b Effect of nutrient schedule on bulking rate of corm, g plant^{-1} day^{-1}

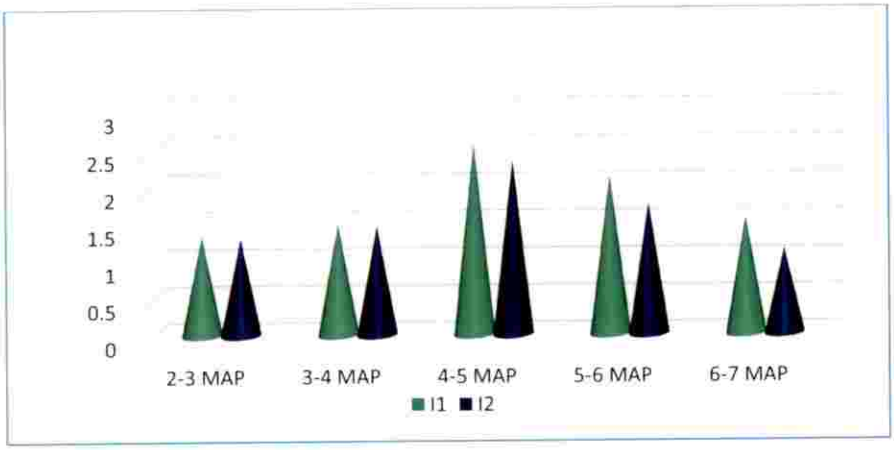

Fig. 3c Effect of irrigation schedule on bulking rate of corm, g plant^{-1} day^{-1}

Among the twelve treatment combinations, $m_2n_2i_1$ registered higher root number plant^{-1} from 3 MAP onwards, higher root weight from 4 MAP onwards, higher corm weight from 5 MAP onwards and higher BR from 4 to 5 MAP onwards as depicted in Table 8,9, 10c,11 and 12. The data clearly revealed the dominance of the treatment combination $m_2n_2i_1$ which could be a reflection of main effects.

5.1.3. Yield Attributes and Yield

Corm yield plant^{-1} was profoundly influenced by growth medium, nutrient schedule and irrigation schedule (Table 13a). The highest yield of 1760.42 g plant^{-1} was obtained in the growth medium M_2 (Fig. 4) followed by M_1 (1629.17 g plant^{-1}). The superiority of growth medium M_2 in the expression of vegetative characters especially higher LAI might have led to higher production of photosynthates and subsequent translocation to corm as evident from higher corm weight plant^{-1} from 1 MAP upto 7 MAP (Table 11). The highest uptake of nutrients like N and P was also observed in the growth medium M_2. These favourable attributes might have resulted in the highest corm yield plant^{-1} at harvest in M_2. Corm yield was found to be significantly and positively correlated with LAI at 4 MAP and 6 MAP as well as N, P and K uptake (Table 21). John *et al.* (2015) also obtained the best yield of container grown brinjal with cow dung + coir pith in 1:1 ratio.

The results indicated that sand in the ordinary growth medium can be suitably substituted with coir pith so that the composition of the best growth medium for elephant foot yam is soil: coir pith : FYM in 1:1:1 ratio (M_2). The corm yield was reduced to 1383.33 g plant^{-1} in M_3 when quantity of soil was reduced and that of coir pith was increased (soil: coir pith: FYM in 0.75: 1.25:1 ratio). Mukherjee (2011) reported higher yield of elephant foot yam from soil amended with 50 % coir pith than from 100 % soil. But the results of the present study revealed that only about 33 % by volume of the growth medium can be constituted by coir pith (M_2) which might have provided ideal soil compaction for higher tuber development. This is clearly evident from Table 25 which depicts the total weight of growth media sack^{-1} and average bulk density values before and after the experiment. The sack filled with the growth medium M_1 was the heaviest and more compact (higher bulk density) and M_3 was the lightest and the most porous (lower bulk density). But the physical condition of the growth medium M_2 was found favourable for obtaining higher corm yield. John *et al.* (2015) also observed that yield of bindhi in the growth medium cow dung + coir pith in 1:1 ratio was on a par with soil + sand + cow dung in 1:1:1 ratio.

Table 25. Total weight and bulk density of growth media

Growth medium	Total weight (kg)	Bulk density (Mg m^{-3})	
		Before the experiment	After the experiment
M_1 - soil : sand : FYM 1:1:1	20.00	1.02	1.33
M_2 – soil : coir pith : FYM 1:1:1	15.00	0.89	1.03
M_3- soil: coir pith : FYM 0.75:1.25:1	13.75	0.67	0.84

Corm yield was higher in the treatment receiving N and K application in six splits than in three splits which indicated the need for more split application of N and K for container cultivation of FYM. Nutrient application in six splits resulted in higher LAI which might have resulted in higher photosynthates production as discussed earlier. More frequent irrigation (irrigation once in three days) during non-rainy periods produced higher corm yield than irrigation once in six days. Santosa (2004) also observed that irrigation at seven days' interval reduced corm yield from plastic bags.

At harvest, no marked variation in top yield plant^{-1} in different growth meida was noticed. Higher top yield was obtained by the application of N and K in six splits than three splits. Irrigation schedule did not produce variation in the top yield at harvest.

Although MxN, MxI and NxI failed to exert profound influence on corm yield (Table 13 b), the corm yield was higher when any growth medium was combined with application of N and K in six splits and also when combined with irrigation schedule once in three days. Similarly, higher corm yield was obtained with combination of N and K in three splits or six splits with irrigation schedule once in three days rather than once in six days. Among the twelve treatment combinations of M, N and I (Table 13c), the combination $m_2n_2i_1$ produced the highest corm yield of 2041.61 g plant^{-1}.

By planting corm pieces weighing 250 g, it was possible to harvest corm yield ranging from 1083.33 to 2041.61 g plant^{-1} under the influence of the treatments. The corm bulking efficiency (ratio of final corm weight to weight of the seed corm) ranged from 4.3 to 8.2. According to Ravi *et al.* (2011), the corm bulking efficiency varied with type of seed corm (cut or whole), seed corm weight and spacing adopted. With corm piece weighing 250 g, James and Nair (1993) have obtained corm bulking efficiency of 3 to 4.6 under varied spacing in the field. Hence, higher corm bulking efficiency realized in the present study indicated better yield of elephant foot yam from organic cultivation in containers. Higher yield of elephant foot yam under organic cultivation has been reported by Suja *et al.* (2010 and 2012).

As depicted in Table 13a, the highest UI of 4.01 was noticed in the growth medium M_2 followed by M_1 and M_3 in that order which reflected the effect of growth medium on corm yield. Utilization index did not vary markedly with nutrient schedule while frequent irrigation (once in three days) favoured higher utilization index. Nutrient schedule combined with irrigation schedule had profound influence on UI and application of N and K in six splits and irrigation once in three days recorded the highest UI of 4.06. Though not significant, the treatment combination $m_2n_2i_1$ registered the highest UI of 4.87.

As in the case of corm yield plant^{-1}, the highest TDMP of 321.31 g plant^{-1} was obtained in the growth medium M_2 followed by M_1 (Table 14a). Dry matter production was markedly influenced due to application of N and K in six splits as well as frequent irrigation (once in three days). Although the interactions did not exert marked influence on TDMP (Table 14b and 14c), the treatment combination

$m_2n_2i_1$ recorded the highest value of 367.92 g plant^{-1} which followed the trend of the main effects.

5.1.4. Quality Attributes of Corm

The starch content varied from 13.6 to 16.25 per cent and protein contents varies from 2.48 to 2.84 per cent (Table 15c). According to Moorthy *et al.* (1994) the starch content on fresh weight basis varied from 7 to 14.3 per cent in Indian accessions. Improvement in starch content of corm due to organic farming in elephant foot yam has been reported by Suja *et al.* (2010 and 2012), Suja (2013) and Kolambe *et al.* (2013).

No marked variation in the quality attributes of corm has been observed in different growth media (Fig.13). The quality attributes also did not vary with the nutrient schedule. But higher starch content could be obtained due to frequent irrigation (irrigation once in three days) during non-rainy periods while protein content did not vary with the irrigation schedule.

5.1.5 Nutrient Uptake

It can be seen from Table 16a that nutrient uptake was differently influenced by the treatments. The growth medium M_2 which registered the highest TDMP also recorded the highest uptake of N (6.98 g plant^{-1}) and P (0.78 g plant^{-1}). But no variation between growth medium was observed with respect to K uptake (Fig. 14). Higher uptake of N and K recorded due to more split application (six splits) of N and K. This might be due to slow and steady availability of these nutrients, minimizing the nutrient loss. Application of N and K in three or six splits did not affect P uptake as expected. Nutrient uptake was favoured due to frequent irrigation (once in three days) which might be due to the fact that moisture is necessary for absorption of nutrients. None of the interaction effects had profound influence on nutrient uptake but reflected the trend of the main effects. Corm yield as well as TDMP plant^{-1} were significantly and positively correlated with N, P and K uptake plant^{-1} (Table 21).

Plate 5. Corm yield plant^{-1} at harvest as influenced by growth medium, nutrient schedule and irrigation schedule.

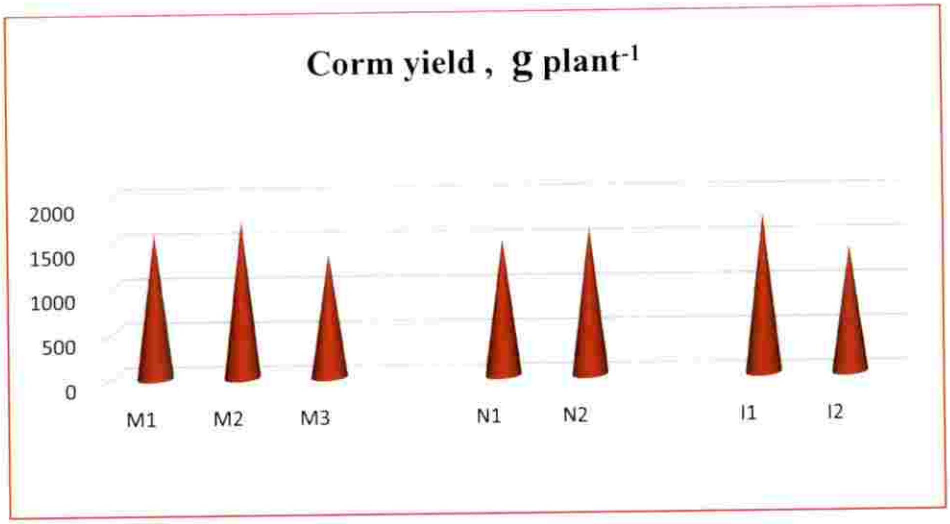

Fig. 4 Effect of growth medium (M), nutrient schedule (N) and irrigation schedule (I) on corm yield plant^{-1} at harvest

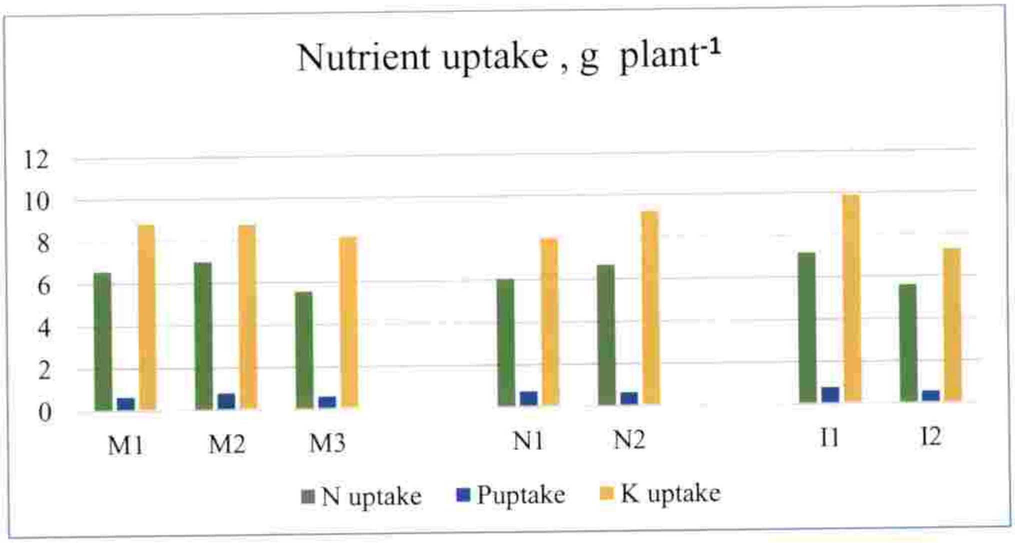

Fig. 5 Effect of growth medium (M), nutrient schedule (N) and irrigation schedule (I) on nutrient uptake, g plant^{-1}

5.1.6 Growth Media Analysis After the Experiment

5.1.6.1 pH

Near neutral soil reaction (pH 6 to 7) is ideally suited for elephant foot yam (George, 2000; Ravi *et al.*, 2011). Coir pith, a component used in the growth medium in the present study is reported to be acidic nature (Mukherjee, 2001; Jeyseel and Raj, 2010). Hence lime @ 10 g $sack^{-1}$ was uniformly applied in all the growth media prior to the experiment and pH of the media were brought near to seven (Table 4). After the experiment, the pH in different treatment combinations (Table 17c) ranged from 7.22 to 7.78. No marked variation in pH due to growth medium or irrigation schedule was observed (Table 17a) but application of N and K in six splits raised pH than that produced by three splits.

5.1.6.2 EC

Electrical conductivity of growth medium M_1 was less than that of M_2 and M_3 prior to the experiment (Table 4) and this difference was maintained even after the experiment (Table 17a). This might be due to slow decomposition of coir pith in the growth media M_2 and M_3 and steady release of soluble salts in the media. Electrical conductivity was markedly increased when N and K were applied in six splits than three splits but not affected by irrigation schedule. However, the EC values ranged from 1.13 to 2.33 in different treatment combinations (Table 17c) but observed to have no negative effect on the growth and yield of the crop.

5.1.6.3 Dehydrogenase Activity

The dehydrogenase activity is commonly used as an indicator of overall soil microbial activity (Gu *et al.,* 2009; Salazer *et al.*, 2011). Initially, the dehydrogenase activity was higher in the growth medium M_1 than M_2 and M_3 (Table 4) which might be due to higher population and increased activity of micro organisms present in the soil in M_1 and temperary suppression of microbial activity due to the raw coir pith present in M_2 and M_3. After the experiment, reverse trend was observed (Table 18a). Nutrient schedule did not affect the dehydrogenase activity. But irrigation once in three days favoured dehydrogenase activity. 125

Increased dehydrogenase activity due to increased soil moisture has been reported by Steinberger *et al.* (1998).

5.1.6.4 Organic Carbon Content

The organic carbon content in the growth media M_2 and M_3 were higher than M_1 before (Table 4) and after the experiment (Table 18a) which might be due to the inclusion of coir pith in M_2 and M_3. However, the organic carbon content was not influenced by any of the treatments. The organic carbon content after the experiment increased over the initial value in M_1 and small increases have been noted in M_2 and M_3 compared to initial values.

5.1.6.5 Available N, P and K status

Initially, the growth medium M_1 had higher content of available N and lower content of available P and K compared to M_2 and M_3 (Table 4). After the experiment (Table 19a), the growth media M_2 and M_3 had higher status of available N, P and K which might be due to the decomposition of coir pith which was a component in the growth media M_2 and M_3. No remnants of raw coir pith could be seen in the growth media M_2 and M_3 after the experiment as they have been decomposed over time into black coloured porous media. In general, an increase in available N content and decrease in available K content in all the growth media have been observed after the experiment. Available N and P status in the growth media after the experiment were not influenced by the treatments. Available K status did not vary markedly with the growth medium or with irrigation schedule. But application of N and K in six splits increased the available K status which might be due to steady release of available K from added nutrients.

The nutrient status of the different growth media after the experiment revealed no depletion of nutrients except slight decrease in available P. Hence, the growth media can be reused for organic cultivation of crops by proper replenishment of nutrients depending upon the crop.

5.1.7 Economics of cultivation

The economics of organic cultivation of elephant foot yam in the container was calculated in terms of net income and BCR considering the cost of inputs and market price of produce which prevailed during the cropping period (Appendix II).

A close scrutiny of data presented in Table 20a indicated the significant effects of treatments on net income as well as on BCR. It was possible to realize a net income of ₹27.22 sack^{-1} (Fig. 6) and BCR of 1.63 (Fig. 7) using the growth medium M_2 (soil: coir pith: FYM 1:1:1) followed by M_3 (soil: coir pith: FYM 0.75:1.25:1) with a net income of only ₹9.88 sack^{-1} and BCR of 1.22. The lowest net income of ₹6.97 sack^{-1} and BCR of 1.13 was obtained with growth medium M_1 (soil: sand: FYM 1:1:1). Large difference in net income and BCR between the growth media had occurred due to the difference in corm yield obtained from them and cost of each growth medium. The highest corm yield of 1760.42 g plant^{-1} was obtained from the growth medium M_2 followed by M_1 (1629.17 g plant^{-1}). All other inputs (plastic sack, lime, neem cake, *Trichoderma*, groundnut cake, bone meal, wood ash and *Pseudomonas*) except the growth medium being common, the cost of M_1 was ₹39 sack^{-1} (due to high cost of sand), of M_2 was ₹24 sack^{-1} and of M_3 ₹26.25 sack^{-1} (due to cost of additional quantity of coir pith).

Appreciably higher net income and BCR (Fig. 6 and Fig. 7) could be obtained due to application of N and K in six splits (N_2) rather than three splits (N_1) and irrigation once in three days (I_1) due to higher corm yield produced by N_2 and I_1 treatments.

The highest net income of ₹38.47 sack^{-1} and BCR of 1.89 could be obtained (Table 20c) when M_2 was used as the growth medium with six split application of N and K and irrigation once in three days ($m_2n_2i_1$ with corm yield of 2041.67 g plant^{-1}). The next best net income of ₹30.8 sack^{-1} and BCR of 1.71 was obtained with M_2 as growth medium, three splits of N and K and irrigation once in three days ($m_2n_1i_1$).

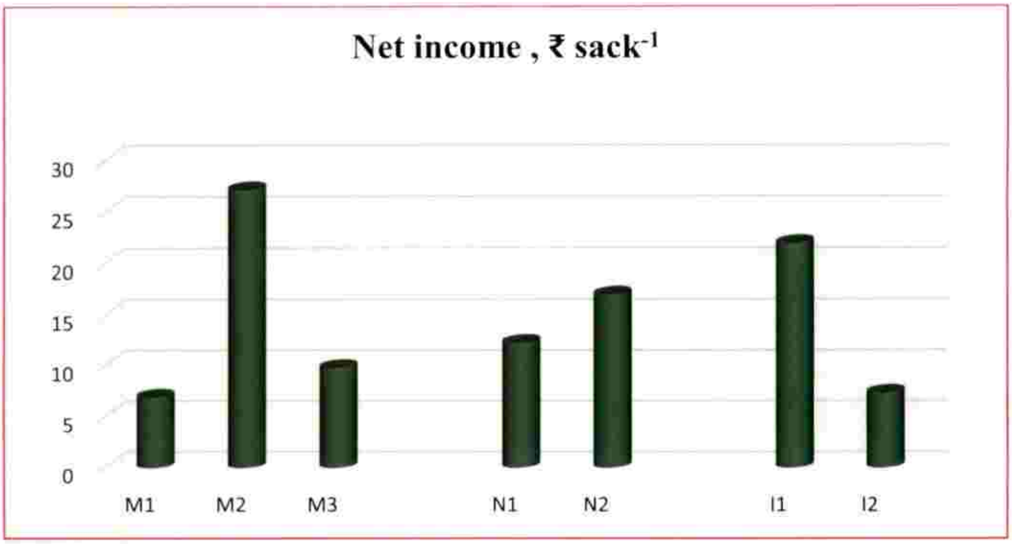

Fig. 6 Effect of growth medium (M), nutrient schedule (N) and irrigation schedule (I) on net income , ₹ sack^{-1}

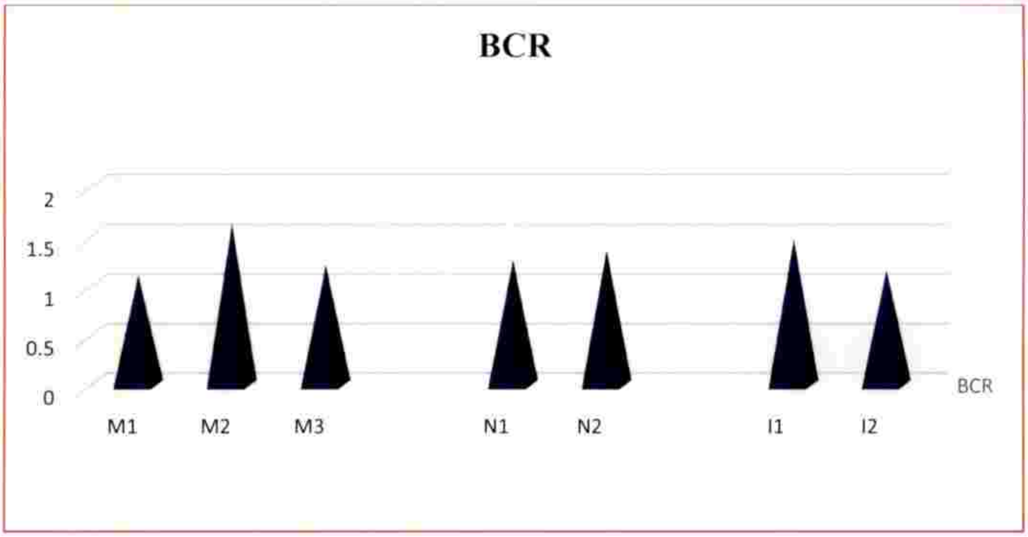

Fig. 7 Effect of growth medium (M), nutrient schedule (N) and irrigation schedule (I) on BCR

The container cultivation is generally advocated especially in urban homesteads where land availability for cultivation is limited where they can utilize whatever space available around house and on house terraces (Padmanabhan and Swadija, 2002; 2006; 2007; 2015). So the cultivation is to be done by using family labour and not hired labour. Hence, in the present study, cost of labour has not been accounted. Even when hired labour (@ 750 for 100 sacks) is utilized for the initial filling of sacks with growth medium, container cultivation is profitable by using M_2 (9 kg soil + 3 kg coir pith + 3 kg FYM). It is also much safer to use on house terrace since the total weight is only 15 kg while it is 20 kg with M_1(9 kg soil + 8 kg sand + 3 kg FYM). Although the growth medium M_3 (7 kg soil + 3.75 kg coir pith + 3 kg FYM) was not as profitable as M_2, it is lighter having only 13.75 kg weight which is advantageous especially for farming on house terrace. Adopting M_3 as growth medium, three or six split application of N and K (N_1 or N_2) and irrigation once in three days, it was possible to realize net income of ₹13.55 (N_1) or ₹22.55 (N_2) and BCR 1.3 (N_1) or 1.5 (N_2) with a corm yield of 1475 g plant^{-1} (N_1) and 1700 g plant^{-1} (N_2).

5. 2. EXPERIMENT II – INCUBATION STUDY – NUTRIENT RELEASE PATTERN IN DIFFERENT GROWTH MEDIA

The three different growth media, supplied with the recommended dose of N, P and K for elephant foot yam through groundnut cake, bone meal and wood ash were incubated for a period of seven months similar to crop duration. Samples of the incubated growth media were analyzed at monthly interval for their pH, EC, dehydrogenase activity and nutrient status in order to study the nutrient release pattern in different growth media.

5.2.1. pH

Initially, the pH of the growth media was stabilized by adding lime uniformly in all the growth media. Prior to the experiment, the growth media M_1 and M_2 showed pH values above seven and growth medium M_3 showed value in the slightly acidic range (Table 4) which might be due to the presence of coir pith in M_2 and M_3 which is acidic in nature as also reported by Mukherjee, 2001 and Jeyseel and Raj, 2010. When growth media were incubated, the pH value decreased in all the growth media upto three months (Table 22 and Fig. 17). Divya (2008) also observed decrease in pH upto 5 MAI when the rock dust was incubated with FYM. At the end of three months of incubation, pH of all the growth media were below seven with M_2 and M_3 more acidic than M_1. Again, the pH values increased in all the growth media with pH more than seven in M_1 and M_2 and nearly seven in M_3 at the end of five months of incubation. After five months, the pH decreased in all the growth media. Still pH of M_1 was more than seven and the value was maintained at the end of seven months of incubation. But in M_2 and M_3, pH were below seven which showed a slight increase (still<seven) from 6 MAI to 7 MAI. At the end of the study, the pH of the growth medium M_1 was above seven without much variation than the initial value and pH of M_2 and M_3 were below seven slightly less than initial values.

Higher pH was observed in the growth medium M_1 at all stages except 5 MAI when it was on a par with M_2.The pH of M_2 was on a par with M_3 at all stages of observation except during initial stages and the end of the study (Fig 8). The optimum pH of soils for crop production is considered to be between 6.5 and 7 (Tisdale *et al.*, 1985) which mainly affects the nutrient availability. In the present study pH of the different growth media ranged from 6.04 to 7.39 which was expected to have no deleterious effect on the crop.

5.2.2 Electrical Conductivity

The growth media M_2 and M_3 had higher EC than M_1 at the start of the experiment (Table 4). Upto 2 MAI, EC was lowered in all the growth media. Afterwards, an increasing trend in EC was observed in all the growth media upto 6 MAI beyond which it showed a slight decrease (Fig. 9). At the end of seven months of incubation, EC in all the growth media showed values much higher than the initial values. This is conformity of the findings of Divya (2008) who noticed an increase in EC upto 1 MAI when rock dust was incubated with FYM.

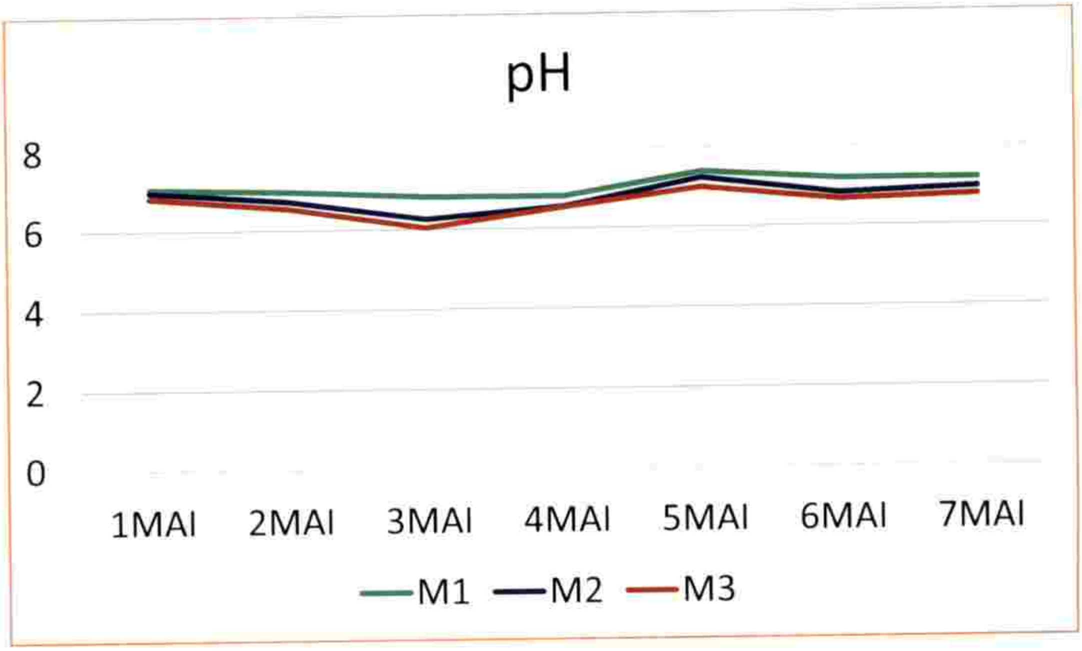

Fig. 8 pH of incubated growth media

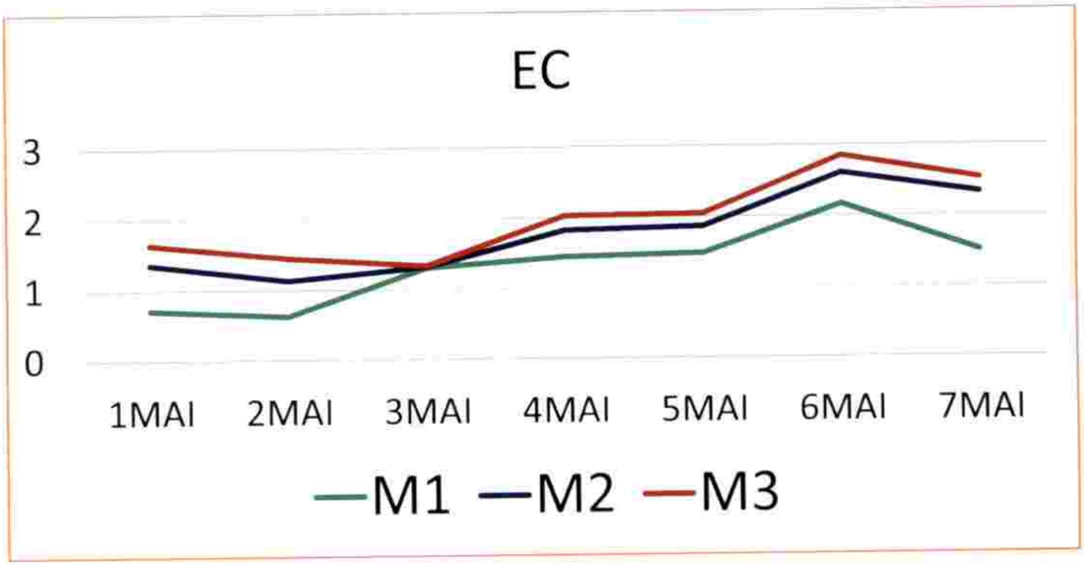

Fig. 9 EC of incubated growth media, dSm^{-1}

In general, higher EC values were observed in the growth media M_2 and M_3 than M_1 which might be due to the release of more soluble salts by decomposition of the coir pith present in them. However, the EC values (Table 22) were found within the tolerable limits (less than four dSm^{-1})for crop production.

5.2.3 Dehydrogenase Activity

Dehydrogenase activity was the highest in the growth medium M_1 prior to incubation (Table 4). Dehydrogenase activity increased upto the end of one month of incubation but it showed a decreasing trend afterwards upto 4 MAI (Fig 10). An increase in dehydrogenase activity was observed from 4 MAI to 5 MAI which further decreased to values lower than the initial values at the end of seven months of incubation. As already stated, dehydrogenase activity is an indicator of the biological activity in the soil (Gu *et al.*, 2009; Salazar *et al.*, 2011), because they occur intracellular in all living microbial cell (Moeskops *et al.*, 2010) while all other soil enzymes are mostly extra cellular.

Although the highest activity of dehydrogenase was noticed in the growth medium M_1 upto 5 MAI, the growth medium M_2 was found superior during later stages. The dehydrogenase activity in the growth medium M_3 was observed to be lower than that in M_2. It might be due to slight temporary inhibitory effect of raw coir pith on microbial activity.

5.2.4 Organic Carbon Content

At the start of the experiment, the organic carbon contents in the growth media M_2 and M_3 were higher than that in M_1 (Table 4). When incubated, a decreasing trend in organic carbon content was observed upto 4 MAI in the growth media M_2 and M_3 which increased at 5 MAI (Table 23). The organic carbon content in M_1 increased upto 5 MAI (Fig. 11). Afterwards, the organic carbon status showed a decreasing trend in all the growth media registering lower values compared to their respective initial values. In general, the organic carbon status followed the trend of the dehydrogenase activity.

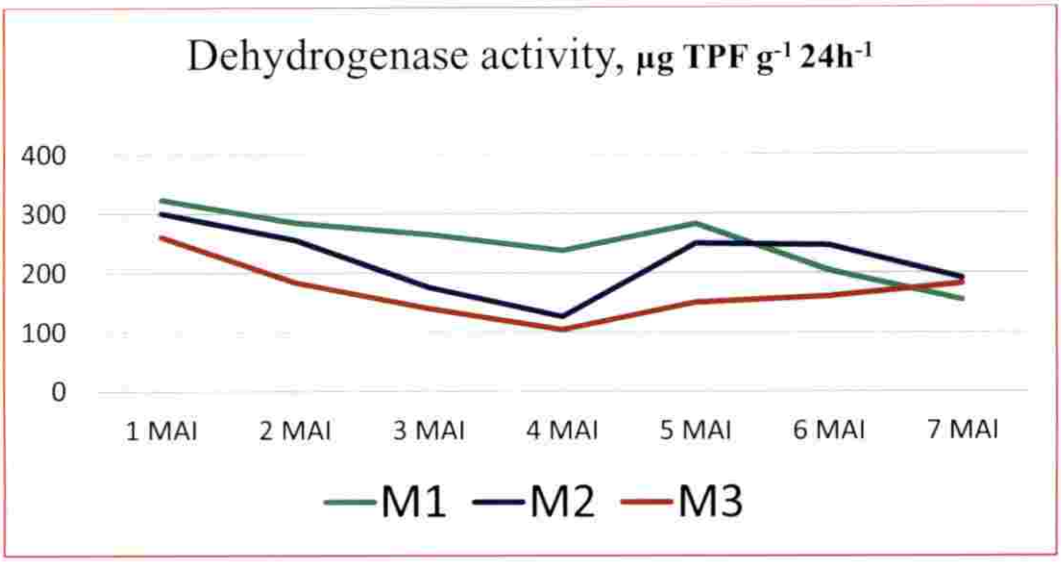

Fig. 10 Dehydrogenase activity in incubated growth media, µg TPF g^{-1} $24h^{-1}$

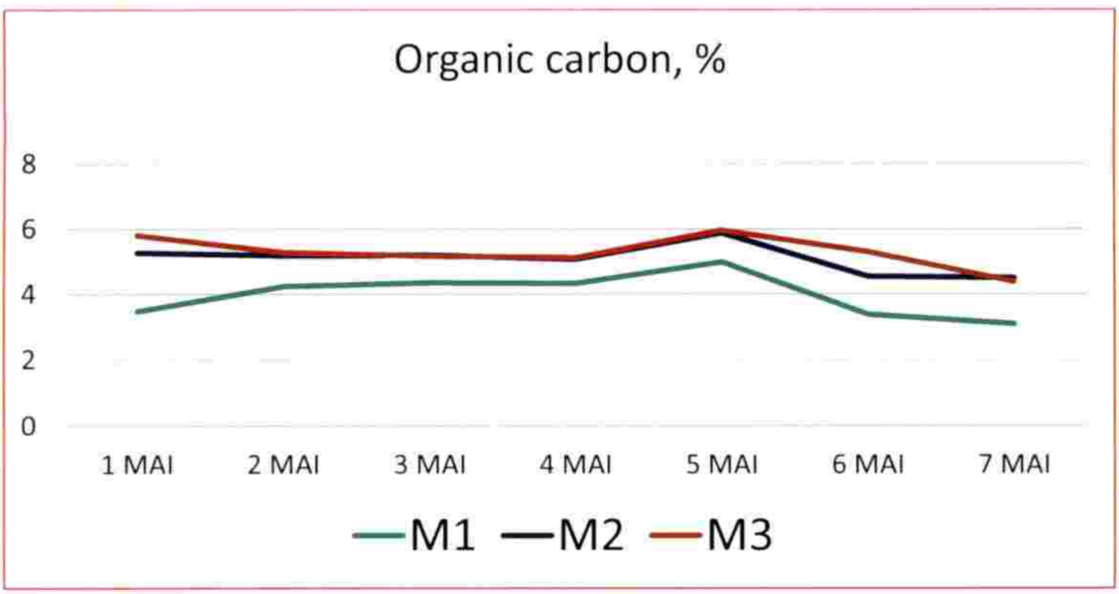

Fig. 11 Organic carbon content in incubated growth media, %

At all stages of observation, significantly higher contents of organic carbon were observed in the growth media M_2 and M_3 which were superior to M_1 which might be due to the higher content of organic matter (in the form of coir pith) in M_2 and M_3.

5.2.5 Available N Status

Initially, N content in the growth medium M_1 was the highest followed by M_2 (Table 4). In general, available N status showed an increasing trend upto 5 MAI which decreased afterwards (Fig.12). This is in agreement with findings of Vipitha (2011) who also noticed increase in available N content upto 3 MAI which decreased afterwards when different organic manure mixtures were incubated for six months. At 7 MAI, M_1 registered lower status of available N and M_2 and M_3 registered higher values compared to the initial status (Table 24). This might be due to decomposition of coir pith releasing nitrogen in available form in M_2 and M_3.

Availability of N was observed to be higher in the growth medium M_2 followed by M_1 upto 4 MAI and followed by M_3 during later stages. Increased dehydrogenase activity at 5 MAI resulted in higher availability of nitrogen.

5.2.6 Available P Status

Available P content was the highest in the growth medium M_2 initially followed by M_3 and M_1 in that order (Table 4). When incubated (Fig. 13), available P content in all the growth media showed an increasing trend upto 2 MAI or 3 MAI and then decreased to lower values at 7 MAI when compared to initial values. Initial increase and further lowering of available P status was observed by Sheeba (2004), Divya (2008) and Vipitha (2011) in their incubation studies.

Though marked variation in available P status between growth media was observed during initial two months of incubation, available P content in M_1 was lower than in M_2 and M_3 at all stages. On decomposition over time, coir pith included in M_2 and M_3 might have released P in available form.

5.2.7 Available K Status

Initially, K content was slightly higher in the growth media M_2 and M_3 than M_1 (Table 4) and the same trend continued at 7 MAI (Table 24). The final K status was enhanced by more than three times than the initial values in all the growth media. Divya (2008) also observed build up of available K at the end of six months when rock dust was incubated with FYM.

At all stages of incubation except 1 MAI, significant difference in K status was observed between growth media. Available K content was the highest in M_3 throughout the period of incubation (Fig.14) which might be due to higher content of coir pith in it and consequent higher release of K in available form.

The results of the incubation study with different growth media indicated that pH and EC of all the media were within permissible limits for crop production. Higher organic carbon and increased availability of N, P and K throughout the period of incubation were observed in the growth media M_2 and M_3 in which, sand in the conventional growth medium M_1 was substituted with coir pith. Thus it can be concluded that the nutrient release pattern in M_2 and M_3 is favourable for crop production.

Based on the results of the present study, a cost effective agronomic package for container cultivation of elephant foot yam can be formulated as follows:

- Plastic sacks of uniform size filled with 9 kg soil + 3 kg coir pith + 3 kg FYM can be used as containers.
- Apply lime @ 10g and neem cake @ 100g sack^{-1} and bring the moisture content of growth medium to field capacity.
- Plant corm pieces of 250 g (treated with *Trichoderma* – cow dung slurry and shade dried) in each sack.
- Apply the recommended dose of 100:50:150 kg NPK ha^{-1} for elephant foot yam (KAU, 2011) through organic manures like groundnut cake , bone meal and wood ash.

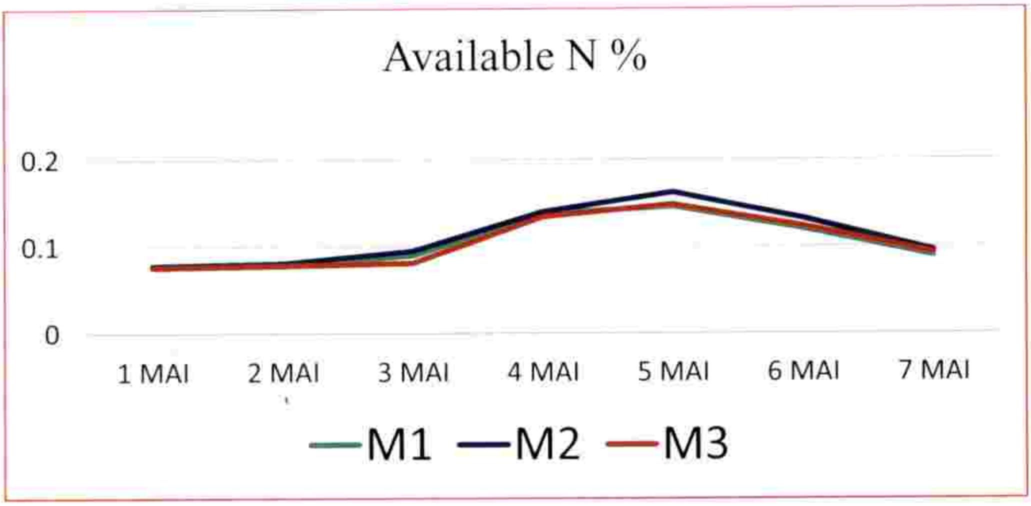

Fig. 12 Available N status of incubated growth media, %

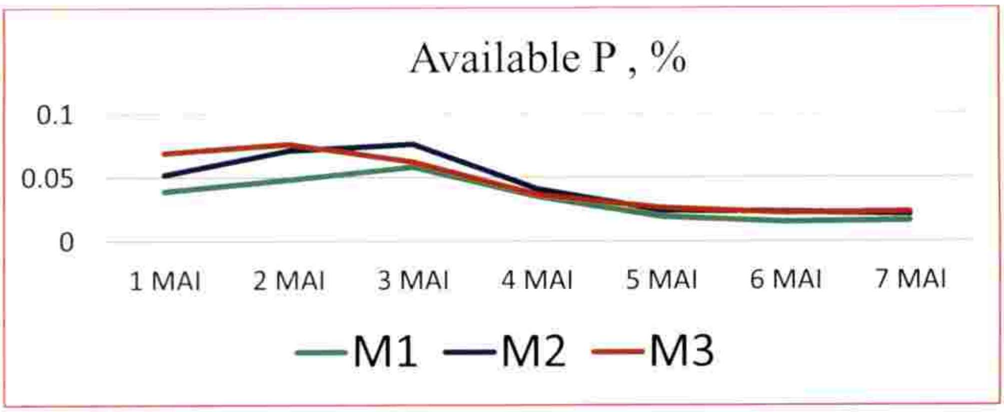

Fig. 13 Available P status of incubated growth media, %

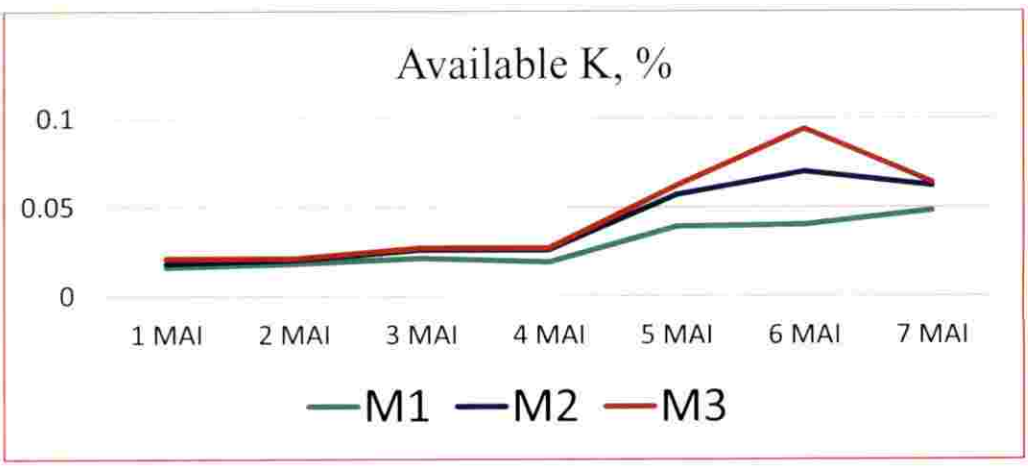

Fig. 14 Available K status of incubated growth media, %

- Apply 10 g of bone meal $sack^{-1}$ as basal dose and 50 g of groundnut cake and 100 g of wood ash $sack^{-1}$ in six splits at monthly interval starting from 1 MAP.
- Irrigate the crop once in three days during non-rainy periods.

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SUMMARY

6. SUMMARY

The present study entitled "Agronomic package for container grown elephant foot yam" was undertaken at College of Agriculture, Vellayani to standardize growth medium and nutrient and irrigation schedule for elephant foot yam grown in containers, to study tuberisation pattern in elephant foot yam and to study nutrient release pattern in different growth media in order to formulate a cost effective agronomic package for elephant foot yam grown in containers. The investigation comprised of two separate experiments: (1) Standardization of growth medium and nutrient and irrigation schedule for container grown elephant foot yam and (2) Incubation study – Nutrient (N P K) release pattern in different growth media. The first experiment was conducted during April to November 2016 by raising elephant foot yam var. Gajendra in plastic sacs with 12 treatment combinations involving three growth media (M_1 - soil : sand : FYM 1:1:1, M_2 - soil : coir pith : FYM 1:1:1 and M_3 - soil : coir pith : FYM 0.75:1.25:1), two nutrient schedule (N_1 – N and K in three splits and N_2 – N and K in six splits) and two irrigation schedule (I_1 - irrigation once in three days and I_2 - irrigation once in six days) with four replications in completely randomized design. The second experiment was also conducted during the same period in small plastic pots with three growth media and five replications in CRD to study the nutrient release pattern in different growth media.

Different growth media used in the experiment were prepared with soil, sand, FYM and coir pith in different proportions by volume .The growth medium M_1 was prepared by mixing 9 kg soil, 3 kg sand and 3 kg FYM, M_2 with 9 kg soil, 3 kg coir pith and 3kg FYM and M_3 with 7 kg soil, 3.75 kg coir pith and 3 kg FYM. Lime @ 10g and neem cake @ 100g sack^{-1} were applied initially in all growth media. Initially, the moisture content of growth media was brought to field capacity. Corm pieces of 250 g, treated with *Trichoderma* – cow dung slurry and shade dried, were planted in each sack on 11-04-2016. The recommended dose of 100:50:150 kg NPK ha^{-1} for elephant foot yam (KAU, 2011) was applied to each sack through organic manures like groundnut cake , bone meal and wood ash. The calculated quantities of groundnut cake (50 g), bone meal (10 g) and wood ash (100 g) based on their nutrient contents were applied in each sack. Uniform dose of bone meal was applied as a single basal dose in all sacs prior to planting of corm. The crop was harvested on 23-11- 2016.

Lime @ 1.33 g and neem cake @ 13.33 g were applied uniformly in all the plastic pots in experiment II. The growth media was uniformly supplied with the recommended NPK dose of 100:50:150 kg ha^{-1} for elephant foot yam as groundnut cake, bone meal and wood ash. Full dose of bone meal (1.33 g pot^{-1}) was given as basal dose. Groundnut cake (6.67 g pot^{-1}) and wood ash (13.33 g pot^{-1}) were applied in three equal splits at bimonthly interval starting from 2 MAP. Moisture content of the growth media was maintained at field capacity. Samples of growth media were analyzed at monthly interval for their physico – chemical properties to study the nutrient release pattern.

In experiment I, growth characters of elephant foot yam were recorded at monthly interval from 2 MAP upto harvest. Height of the plant and canopy spread increased with age of the crop irrespective of the treatment. Faster rate of increase in plant height was observed upto 6 MAP and canopy spread upto 4 MAP. Leaf area index increased upto 4 MAP and retained values at 6 MAP and started declining afterwards.

Growth medium showed significant effect on plant height at all growth stages except 2 MAP and the growth medium M_2 recorded the tallest plants at all stages. Nutrient schedule significantly influenced plant height at 6 MAP and harvest and N_2 (six splits) produced taller plants than N_1 (three splits). The plant height was not significantly influenced by irrigation schedule. Among the interactions, only MxN interaction was significant at 6 MAP and the treatment combination m_2n_1 produced the tallest plants which was on a par with m_2n_2 and m_1n_2.

Canopy spread at all stages was significantly influenced by the growth medium and M_2 recorded the highest value at all stages. No marked influence of nutrient schedule or irrigation schedule on canopy spread was observed at any stage of the crop. The second order and third order interactions failed to show any significant effect on canopy spread at any growth stage.

Leaf area index was significantly influenced by growth medium at all growth stages and M_2 recorded the highest value at all stages. In the case of nutrient schedule, the treatment N_2 was found superior to N_1 at all stages except 2 MAP. Irrigation schedule had significant effect on LAI during later stages of the crop and the treatment I_1 (once in three days) produced higher LAI at 6 MAP and harvest. Among the interactions, MxI interaction effect was significant at harvest stage of the crop. The treatment combination m_2i_1 recorded the highest value which was on a par with m_2i_2.

Sample plants were uprooted at monthly interval from all treatments in the fourth replication in order to study the tuberisation pattern in elephant foot yam as influenced by growth medium, nutrient schedule and irrigation schedule.

Number and fresh weight of roots plant^{-1}showed an increasing trend upto 5 MAP and started declining afterwards. Root number and weight plant^{-1} was the highest in the growth medium M_2 at all stages of observation. There was marked difference in root number and weight plant^{-1} due to nutrient schedule from 5 MAP. Application of N and K in six splits (N_2) registered higher values of root number and weight plant^{-1}. Higher number and fresh weight of roots plant^{-1} were produced due to irrigation once in three days from 4 MAP onwards.

Corm initiation have occurred between 1 MAP and 2 MAP irrespective of the treatments as observed by destructive sampling. At 2 MAP, the corm weight was the highest in growth medium M_1 and the lowest in M_3. At all other stages of observation, corm weight plant^{-1} was the highest in M_2 and the lowest in M_3. Higher variation in corm weight plant^{-1} due to nutrient schedule was observed from 5 MAP onwards and N and K application in six splits (N_2) recorded the highest value at each stage. Higher values of corm weight was observed from 4 MAP onwards due to irrigation once in three days (I_1) than once in six days (I_2).

An increasing trend in BR of corm was noticed in all the treatments upto 5 MAP beyond which the rate was lowered towards harvest. The peak values were observed between 4 MAP and 5 MAP in all the treatments. The growth medium M_2 registered the highest BR at all stages of observation. Application of N and K in six splits (N_2) and irrigation once in three days (I_1) registered higher bulking rate of corm.

The corm yield plant^{-1} at harvest was significantly influenced by the growth medium, nutrient schedule and irrigation schedule. The growth medium M_2 produced the highest corm yield plant^{-1} and M_3 recorded the lowest yield plant^{-1}. Significantly higher corm yield could be produced due to application of N and K in six splits (N_2) than N_1 (three splits). Irrigation once in three days (I_1) was found superior to irrigation once in six days (I_2) in its effect on corm yield. The corm yield per plant^{-1} was not significantly influenced by the second order and third order interactions. Correlation analysis revealed significant and positive correlation of corm yield with LAI at 4 MAP and 6 MAP and N, P and K uptake plant^{-1}.

Top yield plant^{-1} at harvest was not significantly influenced by growth medium and irrigation schedule but application of N and K in six splits (N_2) registered higher top yield than three splits (N_1).

The highest UI was obtained in the growth medium M_2 and the lowest in M_3. Utilization index did not vary with the nutrient schedule. Irrigation once in three days (I_1) registered higher UI than once in six days (I_2). The interaction NxI also had significant effect on UI and the treatment combination n_2i_1 produced the highest UI which was on a par with n_1i_2.

Total dry matter production plant^{-1} at harvest was significantly influenced by the growth medium and the highest value was produced by M_2 followed by M_1. Higher dry matter production plant^{-1} was registered when N and K were applied in six splits (N_2) compared to application in three splits (N_1) and irrigation once in three days (I_1) than once in six days (I_2). The correlation coefficients revealed that

TDMP plant^{-1} was significantly and positively correlated with LAI at 4 MAP and 6 MAP and N, P and K uptake plant^{-1}.

No significant variation in the quality attributes of corm like starch and crude protein contents of corm was observed due to growth medium and nutrient schedule. But irrigation schedule could produce significant variation in the starch content. Irrigation once in three days (I_1) produced higher starch content than once in six days (I_2).

The growth medium had profound influence only on N and P uptake and the growth medium M_2 registered the highest uptake of N and P. Significant effect of nutrient schedule was observed with respect to N and K uptake only when application of N and K in six splits (N_2) was found superior than three splits (N_1). Irrigation once in three days (I_1) recorded significantly higher N, P and K uptake than once in six days (I_2).

Incidence of pest and disease was monitored throughout the cropping period. When symptom of collar rot was observed in one or two plants, the disease could be brought under control by foliar spraying and drenching of two percent *Pseudomonas* twice at 4 MAP and 5 MAP.

After the experiment, pH and EC of the growth media increased over the initial status. No significant variation was recorded in pH of the growth media but EC was the lowest in M_1. Higher pH and EC were registered in all growth media when N and K were applied in six splits (N_2) than three splits (N_1). Irrigation schedule had no significant effect on pH and EC of the growth media.

Prior to the experiment, dehydrogenase activity was higher in the growth medium M_1 while it was the lowest in M_1 after the experiment. Nutrient schedule had no significant effect on dehydrogenase activity but irrigation once in three days (I_1) significantly increased dehydrogenase activity than once in six days (I_2). The interaction MxN had significant effect on dehydrogenase activity. The treatment combinations m_3n_1 and m_2n_2, which were on a par, recorded higher dehydrogenase activity.

Organic carbon content was higher in growth media M_2 and M_3 than in M_1 before and after the experiment but was not affected by the treatments.

An increase in available N content, a decreasing trend in available P content and a marked increase in available K content were observed in all the growth media compared to the initial status. However, none of the treatments could produce any marked variation in the available N and P status of the growth media after the experiment. But available K status in different growth media was markedly increased due to application N and K in six splits (N_2) than three splits (N_1).

The economics of cultivation worked out in terms of net income and BCR revealed that significantly higher net income and BCR could be obtained when M_2 was used as the growth medium. Application of N and K in six splits (N_2) compared to three splits (N_1) and irrigation once in three days (I_1) compared to irrigation once in six days (I_2) recorded significantly higher net income and BCR. The treatment combination $m_2n_2i_1$ registered the highest net income and BCR.

The results of the incubation study with three different growth media for a period of seven months revealed higher pH and lower EC in the growth medium M_1 than M_2 and M_3 throughout the period of incubation. At the end of seven months, lower pH compared to the initial status was observed in all the growth media. But EC showed an increasing trend in all the growth media.

Dehydrogenase activity was found to be higher in the growth medium M_1 compared to M_2 and M_3 upto four months of incubation and was on a par with M_2 at 5 MAI. At 6 MAI, higher dehydrogenase activity was observed in M_2 which was on a par with M_1. At 7 MAI, M_2 was found superior in this respect. Higher content of organic carbon was registered in the growth media M_2 and M_3 throughout the period of incubation.

The growth media M_2 and M_3 showed higher percentage of available N, P and K before and after incubation compared to M_1. The same trend was followed throughout the period of incubation. An increasing trend in available N content upto 5 MAI and in available P content upto 3 MAI was observed in all growth media after which available N and P contents showed decreasing trend towards the end of incubation period . But a marked increase in available K content was observed in all the incubated growth media throughout the period of incubation. When analyzed monthly, no significant variation in the percentage of available N in different growth media was observed except after five months of incubation when M_2 was found superior. Available P status showed variation between growth media only during first two months of incubation when M_2 and M_3 were superior to M_1. Significant variation in available K status throughout the incubation period (except 1 MAI) was observed and M_2 and M_3 were superior to M_1.

The results of the study revealed that the best growth medium for container cultivation of elephant foot yam is soil, coir pith and FYM in 1:1:1 ratio by volume (9 kg soil + 3 kg coir pith + 3 kg FYM). The recommended dose of 100:50:150 kg NPK $ha^{-1}$was supplied to each plant through groundnut cake, bone meal and wood ash. Basal application of P (bone meal @ 10 g $sack^{-1}$) and application of N (groundnut cake @ 50 g $sack^{-1}$) and K(wood ash @ 100 g $sack^{-1}$) in six splits at monthly interval starting from 1 MAP resulted in higher corm yield $sack^{-1}$, net income (₹ $sack^{-1}$) and BCR. Irrigation once in three days during non-rainy period than once in six days was found effective for producing higher corm yield $sack^{-1}$, net income (₹ $sack^{-1}$) and BCR.

FUTURE LINE OF WORK

- The study may be conducted with small seed corms of elephant foot yam weighing 200, 150 and 100 g to produce corms of desired size for home consumption.
- Cost of organic nutrition may be reduced by using biofertilizers .
- Container cultivation may be experimented for rapid multiplication of seed tuber.
- Container cultivation for other tuber crops may be experimented.

REFERENCES

REFERENCES

Acharya, C. L., Bisnoi, S. K., and Yaduvanshi, H. S. 1988. Effect of long – term application of fertilizers and organic and inorganic amendments under continuous cropping on soil physical and chemical properties in an Alfisol. *Indian J. Agric. Sci.* 58: 509-516.

Archana, B. and Swadija, O. K. 2000. Influence of different organic manures, P level and biofertilizers on the growth and yield of coleus. *J. Root Crops* 26 (2): 78-81.

Ayyaswamy, M., Chinnaswamy, C., and Sundarsingh, S. D. 1996. Effect of irrigation regimes, comrade cropping and soil amendments on the yield and economics of cassava, groundnut and sesamum. *Madras Agric. J.* 83(1):338-341.

Benbi, D. K., Biswas, C. R., Bawa, S. S., and Kumar, K. 1998. Influence of farmyard manure, inorganic fertilizer and weed control practices on some soil physical properties in a long- term experiment. *Soil Use Manag.* 14: 52-54.

Bhagat, R. M. and Verma, T. S. 1991. Impact of rice straw management on soil physical properties and wheat yield. *Soil Sci.* 152: 108-115.

Bharadwaj, V. and Omanwar, P. K. 1994. Long term effect of continuous rotational cropping and fertilization on crop yields and soil properties- II. Effect on EC, pH, organic matter and available nutrients of soil. *J. of Indian Soc. Soil Sci.* 42: 387-392.

Bhowmic, B. B. and Debnath, C. R. 1985. Coir fibre, part II. Potentiality of coir fibre products, *Indian coconut J.* 16: 7-10.

Bopaiah, B. M. 1991. Recycling the coconut wastes to improve the soil fertility in coconut gardens. *Indian Coconut J.* 22(3): 2-3.

Bragg, N. C., Walker, J. A. R., Stentiford, M., and Tantini, M. 1993. The use of composted refuse and sewage as medium additives for container grown plants. *Acta Hort.* 342:155-165.

Casida, L., Klein, D., and Santoro, T., 1964. Soil dehydrogenase activity. *Soil Sci.* 98: 371-376.

Changuler, B. A. and Khot,B. D. 1963. Effect of size of seed corm and spacing on growth and yield of fourth year suran. *Indian J. Agron*. 71(4):310-318.

Clark, M. S., Horwarth, W. R., Shennan, C., and Scow, K. M. 1998. Changes in soil chemical properties resulting from organic and low input farming systems. *Agron. J.* 90: 662-671.

Cochran, W. G. and Cox, G. M. 1965. *Experimental Designs*. Asia Publishing House, Bombay, 611p.

Colla, G., Mitchell, J. P., Joyce, B. A., Huyck, L. M., Wallender, W. W., Temple, S. R., Hsiao, T. C., and Poudel, D. D. 2000. Soil physical properties and tomato yield and quality in alternative cropping systems. *Agron. J.* 92: 924-932.

Cresswell, G. C. 1992. Coir dust – A viable alternative to peat?. In: *Proceedings of the Austrlaian Potting Mix Manufacturers Conference,* Sydney, pp.1-5.

Cuckoorani, M. 2013. Organic nutrient scheduling in soilless vegetable cultivation. M.Sc.(Ag) thesis, Kerala Agricultural University, Thrissur, 101p.

Das, A. R. 1992. Coirpith- potential wealth in India. In: *Proceedings of the National Seminar on Utilization of Coirpith.* Tamil Nadu Agricultural University, Coimbatore, pp. 1-8.

Das, P. K., Sen, H., Banerjee, N. C., and Panda, P. K., 1997. Bio-mass production and growth rate at different phenophases of elephant foot yam as influenced by chemical treatments. *Indian J. Agric. Res*. 31: 115-121.

Devaza, K. S. and Holmer, R. J. 2002. Container gardening : A way of growing vegetables in the city. *Environ. Qual.* 25: 962-972.

Dhanya, T. 2011. Production technology for organic sweet potato. M.Sc.(Ag.) thesis, Kerala Agricultural University, Thrissur, 82p.

Divya, S. S. R. 2008. Rock dust as a nutrient source for coleus (*Solenostemon rotundifolius* (Poir) Morton). M.Sc.(Ag.) thesis, Kerala Agricultural University, Thrissur, 72p.

Evans, M. R., Condor, S. and Stamps, R. H. 1996. Source variation and chemical properties of coconut coir dust. *Hort. Sci.* 31:965-967.

George, J. 2000. Cultural and manurial requirements of yams and aroids. In: Mohankumar, C. R., Nair, G. M., George, J., Ravindran,C. S., and Ravi, V. (eds), *Production Technology of Tuber Crops*. Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, pp. 73-115.

George, J., Kumar, P. S., Venkatesan, K., Rananadhan, G., and Singh, P. K. 2011. Performance of elephant foot yam under fertigation treatments in various agro climatic zones of India. In: Misra, R. S. and Nedunchezhiyan, M. (eds.). *Global Conference on Aroids: opportunities and challenges,* Orissa, India.

Gerhardt, R. A. 1997. A comparative analysis of the effects of organic and conventional farming systems on soil structure. *Biol. Agric. Hort*. 14: 139-157.

Goyal, S., Mishra, M. M., Dhankar, S. S., Kapoor, K. K., and Batra, R. 1993. Microbial biomass turn over and enzyme activities following the application of farm yard manure to field soils with and without previous long term applications. *Biol. Fertil. Soils* 15: 60-64.

Gu, Y., Wag, P., and Kong, C. 2009. Urease, invertase, dehydrogenase and polyphenoloxidase activities in paddy soils influenced by allelopathic rice variety. *Eur. J. of Soil Biol*. 45: 436-441.

Guar, A. C., Neelakantan, S., and Dargan, K. S. 1984. *Organic Manures* . ICAR. New Delhi, 159p.

Hore, J. K., Bandopadhyay, A., and Ghosh, D. K. 2003. Response of varying levels of FYM and NPK fertilization on elephant foot yam grown in coconut plantation. *Indian Coconut J*. 34(6): 10-13.

Hume, E. P. 1949.Cocopeat- A by product of coconut fibre industry. *Madras Agric. J.* p.36.

Jackson. M. L. 1973. *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd., New Delhi, 991p.

James, G. and Nair, G. M. 1993.Influence of spacing and seed corm size on yield and yield attributes of elephant foot yam. *J. Root Crops* 19(1): 57-59.

Jeyaseel, D. M. and Raj, S. P. 2010. Chemical characteristics of coir pith as a function of its particle size to be used as soilless medium. *The Ecoscan* 4(2&3): 163-169.

John, J., Varghese, K., Rani, B., and Padmanabhan, V. B. 2015. Agroclimatic Zone Specific Research through Five Zonal Research Stations- Sub Project entitled " *Participatory development and evaluation of model terrace gardens in urban homesteads." Research report.* Kerala Agricultural University, Thrissur, pp 3-26.

Kabeerathumma, S., Mohankumar, C. R., Nair, G. M., and Nair, P. G. 1993. Effect of continuous cropping of cassava with organics and inorganics on the secondary and micronutrient elements status of an Ultisol. *J. Indian Soc. Soil Sci*. 41(4): 710-713.

KAU [Kerala Agricultural University] 2007. *Package of Practices Recommendations: Crops* (13th Ed.). Kerala Agricultural University, Thrissur, 334p.

KAU [Kerala Agricultural University] 2011. *Package of Practices Recommendations: Crops* (14th Ed.). Kerala Agricultural University, Thrissur, 360p.

Khaleel, R., Reddy, K. R., and Overcash, M. R. 1981. Changes in soil physical properties due to organic waste application: a review. *J. Environ. Qual.* 10: 133-141.

Kolambe, B. N., Patel, K. G., Kaswala, A. R., Patel, V. S., and Desai, K. D. 2013. Organic management affects growth, yield, quality and soil properties in elephant foot yam. *J. Root Crops* 39(1): 62-66.

Krishnaswamy, R., Manickam, T. S., and Kothandaraman, G. V. 1984. Effect of application of organic matter and P on the yield of the maize grain and immobilization of P in the soil. *Madras Agric. J.* 77: 204-208.

Kumar, A. S., Bhagavan, B. V. K., Vani, V. S., Reddy, A. R., and Nagalakshmi, R. 2015. Effect of integrated nutrient management on yield and quality of elephant foot yam (*Amorphophallus paeoniifolius* (Dennst) Nicolson) var. Gajendra. *Envt. And Ecol.* 33(2):645-648.

Kumar, M. C.R. 1986. Agronomic investigation on taro (*Colocasia esculenta* L.) var. Thamarakkannan. Ph. D. thesis, Kerala Agricultural University, Thrissur, 240p.

Mapa, R. B. and Kumara, G. K. K. P. 1995. Potential of coir dust for agricultural use. *Sri Lankan J. Agric. Sci.* 32: 161-164.

Mastol, R. E., Chhonkar, P. K., Singh, D., and Patra, A. K. 2006. Changes in soil biological and biochemical characteristics in a long – term field trial on a subtropical inceptisol. *Soil Biol. Biochem.* 37: 1577-1582.

Mbah, B. N. and Pdili, P. N. 1998. Changes in moisture retention properties of five waste materials during short term mesophilic composting. *Compost Sci. Utilization* 6(4): 67-73.

Misra, R. S., Shivalingaswamy, T. M., and Maheswari, S. K. 2001. Improved production technology for commercial and seed crops of elephant foot yam. *J. Root Crops.* 27(1): 197-201.

Moeskops, B., Buchan, D., Sleutel, S., Herawaty, L., Husen, E., Saraswati, R., Setyorini, D., and Neve, D. S. 2010. Soil microbial communities and activities under intensive organic and conventional vegetable farming in West Java, Indonesia. *Appl. Soil Ecol.* 45: 112-120.

Mohankumar, B., Nair, P. G. and Rajendran, N. 1976. Potassium fertilization of cassava in acid laterite soil. *J. Root Crops* 2: 35-37.

Moorthy, S. N., Unnikrishnan, M., and Lakshmi, K. R. 1994. The physiochemical and functional properties of starch of some accessions of *Amorphophallus paeoniifolius*. *Trop. Sci.* 34: 371-376.

More, S. D. 1994. Effect of farm wastes and organic manures on soil properties, nutrient availability and yield of rice- wheat grown on sodic Vertisol. *J. Indian Soc. Soil Sci.* 42(2):253-256.

Mukherjee, P. S. 2001. Use of coir pith as soil conditioner for growing tuber crops. *J. Root Crops* 27: 271-274.

Mukhopadhayay, S. K. and Sen, H. 1986. Effect of nitrogen and potassium on yield and quality of elephant foot yam (*Amorphophallus companulatus* Blume). *J. Root Crops* 12: 103-106.

Nagarajan, R., Manickam, T. S., Kothandaraman, G. V., Ramaswamy, K. and Paliniswamy, G. V. 1985. Manurial value of coir pith. *Madras Agric. J.* (B) 72: 533-535.

Nair, P. G., Mohankumar, C.R., and Saraswathi, P. 1991. Effect of different levels of NPK on growth and yield of *Amorphophallus* under rainfed upland conditions in acid utlisols. *J. Root Crops* 17: 83-86.

Nambiar, C. K. B., Khan, H. H., Joshi, O. P., and Pillai, N. G. 1983. A rational approach to management of coastal sands for establishment and production of coconuts. *J. Plant. Crops* 11:24-32.

Padmanabhan, V. B. 2015. Guidelines for urban organic farming on house terrace. In: *Proceedings of Kerala Environment Congress*, 6 – 8 May, 2015, Kottyam. Centre for Environment and Development, Thiruvananthapuram, pp. 195-198.

Padmanabhan, V. B. and Swadija, O. K. 2002. Nagarathilum nattinpurangal. *Keralakarshakan* 51 (3): 57-59.

Padmanabhan, V. B. and Swadija, O. K. 2006. Swasrayakrishiyiloode swayamparyapthatha. *Yojana* 35(1): 49-52.

Padmanabhan, V. B. and Swadija, O. K. 2007. Veettuvalappilum noorumeni. *Keralakarshakan* 53(5): 16-18.

Padmanabhan, V. B. and Swadija, O. K. 2015. Promotion of organic farming in homesteads and urban house terraces- A step to attain nutritional security. In: Oommen, O. V. and Laladhas, K. P (eds.). *Biocultural Heritage and Sustainability*. Kerala State Biodiversity Board, Thiruvananthapuram. 240p.

Palaniappan, S. P. and Annadurai, K. 1999. *Organic Farming – Theory and Practice.* Scientific Publishers, Jodhpur, India. 257p.

Palaniswami, M. S. and Anil, S. R. 2008. Improved varieties in India. In: Palaniswami, M. S. and Peter, K. V. (eds). *Tuber and Root Crops.* New India Publishing Agency, New Delhi. 131p.

Pamila, V. R. 2003. Integrated nutrient management for short duration cassava in low lands. M.Sc.(Ag.) thesis, Kerala Agricultural University, Thrissur, 73p.

Pandian, B. J. 2007. Standardization of micro irrigation and fertigation systems. In: Chinnusamy, C., Meena, S., Vaiyapuri, K., Muthukrishnan, P., and Martin, J. G. (eds). *Natural Resource Management for Sustainable Agriculture - A New Paradigm*. Tamil Nadu Agricultural University, Coimbatore. 300p.

Patel, B. M. and Mehta, H. M. 1987. Effect of farmyard manure, spacing and nitrogen application on chemical constituents of elephant foot yam (*Amorphophallus companulatus*). *Gujarat Agric. Univ. Res. J.* 13(1): 46-47.

Patil, P. V., Chalwade, P. B., Solanke, A. S., and Kulkarni, V.K. 2003. Effect of fly ash and FYM on physio- chemical properties of vertisols. *J. Soils and Crops* 13(1): 59-64.

Pillai, N. G., Mohankumar, B., Nair, P G., Kabeerathumma, S., and Mohankumar, C. R. 1987. Effect of continuous application of manures and fertilizer on the yield and quality of cassava in laterite soils. In: *Proceedings of the National Symposium on Production and Utilization of Tropical Tuber Crops*. 27-29 November, 1985. Central Tuber Crops Research Institute, Thiruvananthapuram, pp. 109-114.

Piper, C. S. 1966. *Soil and Plant Analysis*. University of Adelaide, Australia, 368p.

Prabhu, S. R. and Thomas, G. V. 2002. Biological conversion of coir pith into a value added organic resources and its application in agri- horticulture: Current status, prospectus and perspective. *J. Platn. Crops* 30:1-17.

Ramamoorthy, V., Meena, B., Muthuswamy, M., Seetharaman, K., and Alice, D. 1999. Composting coir pith using lignocellulolytic fungi for the management of root rot of blackgram. *Mushroom Res.* 8(2): 13-17.

Ramamoorthy, V., Muthuswamy, M., Meena, B., Seetharaman, K., and Alice, D. 2000. Biodegradation of coir pith using native microflora. *J. Plant. Crops* 28:218-221.

Rathod, V. E., Sagare, B. N., Ravanka, H. N., Sarap, P. A., and Hadole, S. S. 2003. Efficacy of amendments for improvement in soil properties and yield of cotton grown in sodic vertisols of Vidarbha using alkali water. *J. Soils and Crops* 13(1): 176-178.

Ravi, V., George, J., Ravindran, C. S., Suja, G., Nedunchezhiyan, M., Byju, G., and Naskar, S. K. 2010. Method of leaf area determination in elephant foot yam (*Amorphophallus paeoniifolius* (Dennst.) Nicolson). *J. Root Crops*. 36(1): 78-82.

Ravi, V., Ravindran, C. S., and Suja, G. 2009. Growth and Productivity of elephant foot yam (*Amorphophallus paeoniifolius* (Dennst.) Nicolson): An overview. *J. Root Crops*. 36(2): 131-142.

Ravi, V., Ravindran, C. S. and Suja, G., George, J., Nedunchezhiyan, M., Byju, G., and Naskar, S. K. 2011. Crop physiology of elephant foot yam (*Amorphophallus paeoniifolius* (Dennst.) Nicolson). *Adv. Hort. Sci*. 25(1): 51-63.

Ravi, V., Suja, G., George, J., Nedunchezhiyan, M., Saravanan, R., and Byju, G. 2015. Critical period of crop sensitivity to water deficit stress in elephant foot yam (*Amorphophallus paeoniifolius*). *Indian J. of Agri. Sci.* 85 (2): 274–277.

Ravindran, C. S. 1997. Nutrient – moisture- light interactions in a coconut based homestead cropping system. Ph. D. thesis, Kerala Agricultural University, Thrissur, 109p.

Ravindran, C. S. and Balanambisan. 1987. Effect of FYM and NPK on the yield and quality of sweet potato. *J. Root Crops*. 13(1): 35-44.

Ray, R. N., Sengupta, S., Chowdhary, B. M., and Nath, S. 2006. Effect of manures and fertilizer on growth, yield and productivity of elephant foot yam at Ranchi condition in Jharkhand. In: Naskar, S. K., Nedunchezhiyan, M., Rao, K. R., Sivakumar, P. S., Ray, R. C., Misra, R. S., and Mukherjee, A. (eds), *Root and Tuber Crops: in nutrition,food security and sustainable environment*. Regional Centre of Central Tuber Crops Research Institute, Indian Council of Agricultural Research, Bhuvaneswar, Orissa, pp 177-179.

Reghuvaran, A. and Ravindranath, A. D. 2012. Biochemical aspects of formation of phenolic compounds by coir pith degraded by *Pleurotus sajor caju* . *J. Toxicol. Environ. Health Sci.* 4: 29-36.

Sahoo, B., Nedunchezhiyan, M., and Acharyya, P. 2015. Productivity potential of elephant foot yam (*Amorphophallus paeoniifolius* (Dennst.) Nicolson) in alfisols as influenced by fertility levels. *The Bioscan.* 10(3): 1255-1257.

Salazar, S., Sanchez, L., Alvarez, J., Valverde, A., Galindo, P., Igual, J., Peix, A., and Regina, S. I. 2011. Correlation among soil enzyme activities under different forest system management practices. *Ecol. Eng*. 37: 1123-1131.

Sankar, V. Thamburaj, S. Kannan, M., and Veeraraghavathatham, D. 1999. Effect of sequential cropping of vegetable cowpea (*Vigna unguiculata* L Walp) and different levels of FYM and P on growth and yield of cassava(*Manihot esculenta* Crantz). *South Indian Hort.* 47(1):89-94.

Santosa, E., Sugiyama, N., Sulistyono, E., and Sopandie, D. 2004. Effects of watering frequency on the growth of elephant foot yam. *Japanese J. Trop. Agric.* 48(4): 235-239.

Savithri, P. and Khan, H. H. 1994. Characteristics of coconut coir pith and its utilization in agriculture. *J. Plant. Crops.* 22(1): 1-18.

Savithri, P., Murugappan, M., and Nagarajan, R. 1993. Possibility of economizing potassium fertilization by composted coir pith application. *Fert. News* 38: 39-40.

Sheeba, P. S. 2004. Vermicompost enriched with organic additives for sustainable soil health. M.Sc.(Ag.) Thesis, Kerala Agricultural University, Thrissur, 110p.

Simpson, J. E., Adair, C. R., Kohler, G. O., Dawson, E. N., Debald, H.A., Kester, E. B., and Klick, J. T. 1965. *Quality Evaluation Studies of Foreign and Domestic Rices.* Technical Bulletin No. 1331, Services, USDA, pp. 1-86.

Singh, A. and Wadhwa, N.2014. A review on multiple potential of aroid : *Amorphophallus paeoniifolius. Int. J. Pharm. Sci.* 24 (1): 55-60.

Soumya, A. 2015. Performance and evaluation of tomato in soilless culture. M.Sc.(Ag) thesis, Kerala Agricultural University, Thrissur, 39p.

Srinivas, T. and Ramanathan, A. 2005. A study on economic analysis of elephant foot yam production in India. *Agric. Econ. Res. Rev.* 18(2):241-252.

Srivastava, O. P. 1985. Role of organic matter in soil fertility. *Indian J. Agric. Chem.* 18(92): 257.

Steinberger, Y. Vishnevetsky , S. Barness , G., and Lavee, H. 1998. Effects of topoclimatic gradient on soil dehydrogenase activity in a Judean desert ecosystem. *Arid Soil Res. and Rehabil* .12(4).

Subbiah, B. V. and Asija, G. L. 1956. Rapid procedure for estimation of available nitrogen in soils. *Curr. Sci*. 25: 259-260.

Suharban, M., Geetha, D., Nair, K. H., and Nair, N. P. 2004. Bioefficacy evaluation of coir pith compost in anthurium (*Anthurium andreanum* L.) *Indian Coconut J*. 35(1): 18-19.

Suja, G. 2013. Comparison of tuber yield, nutritional quality and soil health under organic versus conventional production in tuberous vegetables. *Indian. J. Agric. Sci*. 83(11): 1153-1158.

Suja, G., John, K. S., Ravindran, C. S., Prathapan, K., and Sundaresan, S. 2010. On farm validation of organic farming technology in elephant foot yam (*Amorphophallus paeoniifolius (*Dennst.) Nicolson). *J. Root Crops* 36(1): 59-64.

Suja, G., Sundaresan, S. John, K. S., Sreekumar, J., and Misra, R. S. 2012. Higher yield, profit and soil quality from organic farming of elephant foot yam. *Agron. Sustain. Dev*. 32: 755-764.

Sunitha, S., Ravi, V., George, J., and Suja, G. 2013. Aroids and water relations*:* An overview. *J. Root crops*. 39 (1):10-21.

Swadija, O. K. and Padmanabhan, V. B. 2002. Terracile pachakarikrishi. *Keralakarshakan* 47(11): 12,15.

Swadija, O. K., Padmanabhan, V. B., and Vijayaraghavakumar. 2013. Growth and yield of arrowroot intercropped in coconut garden as influenced by organic management. *J. Root Crops* 39 (1): 67-72.

Tisdale, S. L., Nelson, W. L., and Beaton, J. D. 1985. *Soil Fertility and Fertilizers* (4^{th} Ed). Macmillan Publishing Company, New York. 750p.

Venkatesan, K., Saraswathi, T., Pugalendhi, L., and Jansirani, P. 2014. Impact of irrigation and fertigation levels on the growth and yield of elephant foot yam (*Amorphophallus paeoniifolius* (Dennst.) Nicolson). *J. Root Crops* 40(1):52-55.

Verhagen, J. B. G. M. and Papadopoulos, A. P. 1997. CEC and the saturation of the adsorption complex of coirdust. *Acta Hort.* 481: 151-155.

Vipitha, V. P. 2011. Development and evaluation of bio- organic composite manure for vegetables. M.Sc.(Ag.) thesis, Kerala Agricultural University, Thrissur, 122p.

Ward and Pigman, 1970. *Analytical Methods for Carbohydrates- The Carbohydrates Vol.,II B.* Academic press, New York and London. 763p.

Watson, D. J. 1947. The physiological basis of variation in yield. *Adv. Agron.* 4: 101-105.

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APPENDICES

APPENDIX I

Weather data during the cropping period

(9th April to 25th November 2016)

Standard week	Temperature (°C)		Relative humidity (%)	Rain fall (mm)	Number of rainy days	Evaporation (mm)
	Maximum	Minimum				
15	35.4	26.3	83.8	0.9	0	33.6
16	35.5	26.4	86.4	17.1	2	32.3
17	35.2	26.9	82.5	0	0	34.9
18	35.7	26.0	82.5	21.3	1	39.6
19	34.8	24.8	87.3	35.9	3	30.5
20	32.5	24.1	88.9	333.1	6	20.9
21	33.1	24.7	83.1	73	3	26.8
22	32.7	24.8	83.3	0	0	25.2
23	31.5	25.1	89.9	240	5	15.8
24	31.1	23.4	90.4	119.2	6	17.3
25	31.5	24.4	88.8	38.9	4	15.8
26	31.3	24.2	87.5	43.9	3	19.9
27	32.4	25	84.6	28	2	27.2
28	31.3	24.3	87.3	59.7	5	22.1
29	31.8	24.7	85.4	0	0	27.9
30	31.1	24.6	87.7	38.9	3	23.3
31	31.2	24.9	84.3	6	1	29.2
32	32.3	25.2	82	1	0	29.7
33	31.8	24.5	84.8	9.6	2	30.5
34	31.9	25	83.5	20.8	2	31.9
35	31.7	24.5	84.2	2	0	29.1
36	31.5	24.4	84.5	0.2	0	26.6
37	31.9	24.5	83.1	0	0	29.5
38	32	24.7	84.5	2.6	1	30.4
39	31.9	24.7	82.7	0	0	29.8
40	31.7	24.3	82.5	0	0	29.7
41	31.6	24.3	83.3	0	0	30.1
42	32.1	24.3	81	12	1	28.7
43	31.5	24.1	83.6	0	0	26.6
44	31.9	24.4	86.4	30	2	23.8
45	32	24.2	84.2	0	0	25.7
46	31.7	24	84.9	2	0	24.8
47	32.2	24.2	88.8	10.2	2	16.4

APPENDIX II

AVERAGE COST OF INPUTS AND MARKET PRICE OF PRODUCE

INPUTS

Cost of Cultivation Sack^{-1}(₹)

- Cost of sack - 5.00
- Seed corm (250 g) - 7.50
- Neem cake (100 g) - 2.30
- Lime (10 g) - 0.15
- Groundnut cake (50 g) - 2.50
- Bone meal (10 g) - 0.20
- Wood ash (100 g) - 0.20
- *Trichoderma* (5g kg^{-1}) - 0.15
- *Pseudomonas* (16 g sack^{-1}) - 1.20

Cost of Growth Media Sack^{-1}(₹)

- M_1 (sand 8 kg, FYM 3kg) - 39.00
- M_2 (coir pith 3 kg, FYM 3 kg) - 24.00
- M_3 (coir pith 3.75 kg, FYM 3 kg) - 26.25

(sand – ₹3 kg^{-1}, FYM – ₹5 kg^{-1}, coir pith – ₹3 kg^{-1})

OUTPUT

- Market price of produce - ₹ 40 kg^{-1}

Abstract

AGRONOMIC PACKAGE FOR CONTAINER GROWN ELEPHANT FOOT YAM

By

LIMISHA N. P.

(2015 - 11 - 024)

ABSTRACT

Submitted in partial fulfillment of the requirement for the degree of

MASTER OF SCIENCE IN AGRICULTURE

Faculty of Agriculture

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DEPARTMENT OF AGRONOMY

COLLEGE OF AGRICULTURE

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ABSTRACT

An investigation entitled "Agronomic package for container grown elephant foot yam" was undertaken at College of Agriculture, Vellayani to standardize growth medium and nutrient and irrigation schedule for elephant foot yam grown in containers, to study tuberisation pattern in elephant foot yam and to study nutrient release pattern in different growth media in order to formulate a cost effective agronomic package for elephant foot yam grown in containers. The investigation comprised of two separate experiments: (1) Standardization of growth medium and nutrient and irrigation schedule for container grown elephant foot yam and (2) Incubation study – Nutrient (N P K) release pattern in different growth media. The experiments were conducted during April to November 2016.

The first experiment was done in the Instructional Farm, Vellayani by raising elephant foot yam var. Gajendra in plastic sacks of uniform size with 12 treatment combinations involving three growth media (M_1 - soil : sand : FYM 1:1:1, M_2 - soil : coir pith : FYM 1:1:1 and M_3 - soil : coir pith : FYM 0.75:1.25:1), two nutrient schedule (N_1 – N and K in three splits and N_2 – N and K in six splits) and two irrigation schedule (I_1 - irrigation once in three days and I_2 - irrigation once in six days) with four replications in completely randomized design . The second experiment was conducted in plastic pots with three growth media and five replications in completely randomized design to study the nutrient release pattern in different growth media. The pots were kept in the laboratory of the Department of Agronomy. Lime @ 10g and neem cake @ 100g sack^{-1} (1.33 g lime and 13.33 g neem cake pot^{-1}) were applied initially in all growth media. The recommended dose of 100:50:150 kg NPK ha^{-1} for elephant foot yam was applied to each sack and pot through organic manures like groundnut cake, bone meal and wood ash.

Observations on growth characters were recorded at bimonthly interval from two months after planting (MAP) upto harvest. The growth medium M_2 was found superior with respect to growth characters at all growth stages. Application of N and K in six splits produced significantly taller plants from 6 MAP and higher

leaf area index from 4 MAP. Irrigation once in three days registered higher leaf area index at 6 MAP and harvest.

Corm initiation had occurred between 1 MAP and 2 MAP irrespective of the treatments. When observed monthly, higher root number and weight plant $^{-1}$, corm weight plant $^{-1}$ and bulking rate of corm were recorded in the growth medium M_2. Application of N and K in six splits and irrigation once in three days produced higher values of these parameters. Bulking rate of corm was observed to be higher between 4 MAP and 5 MAP in all the treatments.

Higher corm yield plant^{-1} (1760.42 g), utilization index (4.01) and total dry matter production plant^{-1} (321.31 g) could be produced by the growth medium M_2 followed by M_1, application of N and K in six splits and irrigation once in three days .The treatment combination $m_2n_2i_1$ registered the highest corm yield plant $^{-1}$.

No significant variation in quality attributes of corm like starch and crude protein contents was noticed due to growth medium and nutrient schedule. Higher starch content could be obtained due to irrigation once in three days.

The highest uptake of N and P was noticed with the growth medium M_2, application of N and K in six splits and irrigation once in three days. Corm yield and total dry matter production plant $^{-1}$ were positively and significantly correlated with LAI at 4 MAP and 6 MAP and N, P and K uptake plant $^{-1}$.

After the experiment, no marked variation in pH and the status of organic carbon and available N, P and K was observed due to different composition of the growth medium. But the growth media M_2 and M_3 registered higher EC and dehydrogenase activity. Application of N and K in six splits recorded higher pH, EC and available K status in the growth medium than three splits. Irrigation once in three days registered higher dehydrogenase activity in the growth medium.

Higher net income and benefit cost ratio could be obtained with the growth medium M_2, application of N and K in six splits and irrigation once in three days. The treatment combination $m_2n_2i_1$ recorded higher net income (₹ 38.47sack^{-1}) and benefit cost ratio (1.89).

The incubation study with three growth media for a period of seven months revealed higher pH and lower EC in the growth medium M_1 than M_2 and M_3 throughout the period of incubation. Dehydrogenase activity was found to be higher in the growth medium M_1 upto four months of incubation and was on a par with M_2 from five months onwards. But M_2 was found superior at end of seven months. Higher contents of organic carbon and available N, P and K were registered in the growth media M_2 and M_3 throughout the period of incubation.

The results of the study revealed that the best growth medium for container cultivation of elephant foot yam is soil, coir pith and FYM in 1:1:1 ratio by volume (9 kg soil + 3 kg coir pith + 3 kg FYM). The recommended dose of 100: 50:150 kg NPK ha^{-1} for elephant foot yam was supplied through groundnut cake, bone meal and wood ash. Basal application of P (10 g bone meal $sack^{-1}$) and application of N (50 g groundnut cake $sack^{-1}$) and K (100 g wood ash $sack^{-1}$) in six splits at monthly interval starting from 1 MAP and irrigation once in three days during non – rainy period resulted in higher corm yield $sack^{-1}$, net income $sack^{-1}$ and benefit cost ratio.

സംഗ്രഹം

"കണ്ടയനറുകളിൽ വളർത്തുന്ന ചേനയുടെ പരിപാലനമുറകൾ"എന്ന വിഷയത്തിൽ ഒരു പഠനം, വെള്ളായണി കാർഷിക കോളേജിൽ നടത്തുകയുണ്ടായി. കണ്ടയനറുകളിൽ വളർത്തുന്ന ചേനയ്ക്ക് അനുയോജ്യമായ വളർച്ചാമാദ്ധ്യമം കണ്ടെത്തുക, വളപ്രയോഗവും, ജലസേചനാവൃത്തിയും ക്രമീകരിക്കുക, ചേനയിൽ കിഴങ്ങുണ്ടാകുന്ന രീതി പഠിക്കുക എന്നിവയായിരുന്നു ഈ പഠനത്തിന്റെ ഉദ്ദേശ്യങ്ങൾ. ഇതിലേക്കായി രണ്ടു പരീക്ഷണങ്ങൾ നടത്തുകയുണ്ടായി. (1) കണ്ടയനറുകളിൽ വളർത്തുന്ന ചേനയ്ക്ക് അനുയോജ്യമായ വളർച്ചാമാദ്ധ്യമവും വളപ്രയോഗവും, ജലസേചനാവൃത്തിയും ക്രമീകരിക്കൽ, (2) വിവിധ വളർച്ചാമാദ്ധ്യമങ്ങളിൽ നിന്നും പാക്യജനകം, ഭാവഹം, പൊട്ടാഷ് ലഭ്യമാകുന്ന രീതി പഠനം. ഈ രണ്ടു പരീക്ഷണങ്ങളും 2016 ഏപ്രിൽ മാസം മുതൽ നവംമ്പർ വരെ നടത്തുകയുണ്ടായി.

പ്ലാസ്റ്റിക്ക് ചാക്കുകളിൽ ഗജേന്ദ്ര എന്ന ഇനം ചേന, 250 ഗ്രാം വീതം നട്ട് , ചാക്കുകൾ വെള്ളായണി ഇൻസ്ട്രക്ഷണൽ ഫാമിൽ നിരത്തി വച്ച് ആദ്യത്തെ പരീക്ഷണം നടത്തി. മൂന്ന് വളർച്ചാമാദ്ധ്യമങ്ങളും (മണ്ണ് : മണൽ :ചാണകം- 1:1:1 ; മണ്ണ് : ചകിരിച്ചോറ് : ചാണകം - 1:1:1 ; മണ്ണ് : ചകരിച്ചോറ് : ചാണകം - 0.75:1.25:1) രണ്ട് വളപ്രയോഗ രീതിയും (പാക്യജനകവും, പൊട്ടാഷും മൂന്ന് തവണകളായും, ആറ് തവണകളായും) രണ്ട് ജലസേചനാവൃത്തിയും (മൂന്ന് ദിവസത്തിലൊരിക്കലും, ആറ് ദിവസത്തിലൊരിക്കലും), ചേർത്ത് 12 ട്രീറ്റ്മെന്റുകളായി നാല് പ്രാവശ്യം ആവർത്തിച്ച് കംപ്ലീറ്റിലി റാൻഡമൈസ്ഡ് ഡിസൈൻ എന്ന സ്റ്റാറ്റിസ്റ്റിക്കൽ പഠന രീതി അവലംബിച്ച് ആദ്യത്തെ പരീക്ഷണം നടത്തി.

എല്ലാ ചാക്കുകളിലും 10 ഗ്രാം വീതം കുമ്മായവും, 100 ഗ്രാം വീതം വേപ്പിൻ പിണ്ണാക്കും നൽകി നല്ലതുപേലെ ജലസേചനം നടത്തി ഹെക്ടർ ഒന്നിന് ചേനക്ക് ശുപാർശ ചെയ്തിട്ടുള്ള പാക്യജനകം,ഭാവഹം, പൊട്ടാഷ് എന്നിവ ചെടിയുടെ എണ്ണം കണക്കാക്കി കടലപിണ്ണാക്ക്, ചാരം എന്നീ ജൈവ വളങ്ങളിലൂടെ ഓരോ ചാക്കിലും നൽകി. ഇതിലേക്കായി 10 ഗ്രാം വീതം എല്ലുപൊടി നടുന്നതിനുമുമ്പ് ഒരോ ചാക്കിലും ചേർത്ത് കൊടുത്തു. 50 ഗ്രാം വീതം കടലപിണ്ണാക്കും 100 ഗ്രാം വീതം ചാരവും ട്രീറ്റ്മെന്റ് അനുസരിച്ച് ചേന നട്ട് ഒന്നാം മാസം മുതൽ മൂന്നു തവണകളായും ആറ് തവണകളായും ചാക്കുകളിൽ ചേർത്തു കൊടുത്തു. മഴയില്ലാത്ത സമയത്ത് ട്രീറ്റ്മെന്റ് അനുസരിച്ച് മൂന്നു ദിവസത്തിലൊരിക്കലും ആറ് ദിവസത്തിലൊരിക്കലും ചാക്കുകൾ നനച്ചു. നട്ട് ഏഴ് മാസമായപ്പോൾവിളവെടുത്തു.

ചേന നട്ട് ഒന്നാം മാസത്തിലും രണ്ടാം മാസത്തിനുമിടയിൽ എല്ലാ ചാക്കുകളിലും കിഴങ്ങ് ഉണ്ടാകാൻ തുടങ്ങി. നട്ട് നാലാം മാസത്തിനും അഞ്ചാം മാസത്തിനുമിടയിൽ എല്ലാ ചാക്കുകളിലും ഏറ്റവും കൂടിയനിരക്കിൽ കിഴങ്ങ് വലിപ്പം വയ്ക്കുന്നതായി കണ്ടെത്തി. മണ്ണ്, ചകിരിച്ചോറ്, ചാണകം എന്നിവ 1:1:1 എന്ന അനുപാതത്തിൽ (9 കിലോഗ്രാം മണ്ണ് + 3 കിലോഗ്രാം ചകിരിച്ചോറ് + 3 കിലോഗ്രാം ചാണകം) ഉ ണ്ടക്കിയെടുത്ത വളർച്ചാമാദ്ധ്യമത്തിൽ ചേനയുടെ മെച്ചപ്പെട്ട വളർച്ചയും വിളവും അധികരിച്ച അറ്റാദായവും, വരവ് - ചെലവ് അനുപാതവും ലഭിക്കുകയുണ്ടായി. മുഴുവൻ ഭാവഹം അടിവളമായി നൽകി, പക്യജനകവും, പൊട്ടാഷും ഒന്നാം മാസം മുതൽ ആറ് തവണകളായി നൽകുന്നതാണ് നല്ലതെന്ന് കണ്ടെത്തി. മഴയില്ലാത്ത സമയത്ത് മൂന്നു ദിവസത്തിലൊരിക്കൽ ചാക്കിൽ ജലസേചനം നടത്തുന്നതാണ് ഉത്തമമെന്ന് പരീക്ഷണം തെളിയിച്ചു.

മേൽപറഞ്ഞ, മൂന്ന് വളർച്ചാമാദ്ധ്യമങ്ങൾ അഞ്ചുതവണ ആവർത്തിച്ച് കംപ്ലീറ്റിലി റാൻഡമൈസ്ഡ് ഡിസൈൻ എന്ന സ്റ്റാറ്റിസ്റ്റിക്കൽ പഠനരീതി അവലംബിച്ച് ര ണ്ടമത്തെ പരീക്ഷണം ചെറിയ പ്ലാസ്റ്റിക്ക് ചട്ടികളിൽ അഗ്രോണമി വിഭാഗത്തിലെ പരീക്ഷണശാലയിൽ നടത്തുകയുണ്ടായി. ഒരോ പ്ലാസ്റ്റിക് ചട്ടിയിലും 1.33 ഗ്രാം വീതം കുമ്മായവും 13.33 ഗ്രാം വീതം വേപ്പിൻ പിണ്ണാക്കും ചേർത്ത് നല്ലതുപോലെ നനച്ച് ചാക്കുകളിൽ ചേർത്തതുപോലെ 1.33 ഗ്രാം എല്ലുപൊടി എല്ലാ ചട്ടികളിലും ഒരുതവണയായി നൽകി പാക്യജനകവും (6.66 ഗ്രാം വീതം കടലപ്പിണ്ണാക്ക്), പൊട്ടാഷും (13.3 ഗ്രാം വീതം ചാരം) രണ്ട്മാസത്തിലൊരിക്കൽ മൂന്ന് തവണകളായി ചട്ടികളിൽ ചേർത്തുകൊടുത്തു.ഒന്നിടവിട്ട ദിവസങ്ങളിൽ ജലസേചനം നൽകി ചട്ടികളിലെ മണ്ണ് ഉണങ്ങാതെ സൂക്ഷിച്ചു. എല്ലാമാസവും ചട്ടികളിൽ നിന്ന് സാമ്പിളുകൾ ശേഖരിച്ച് പോഷകങ്ങൾ ലഭ്യമാകുന്ന രീതി പഠിച്ചു. മണലിനുപകരം ചകിരിച്ചോറ് ചേർത്തുണ്ടാക്കിയ വളർച്ചാമാദ്ധ്യമങ്ങളിൽ നിന്നും കൂടിയ അളവുകളിൽ പോഷകങ്ങൾ (പാക്യജനകം, ഭാവഹം, പൊട്ടാഷ്) ലഭിക്കുന്നതായികണ്ടെത്തി.