STANDARDIZATION OF MEDIA FOR TRAY NURSERY TECHNIQUE IN RICE

By

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(2013-11-127)

THESIS

Submitted in partial fulfillment of the requirement

for the degree of

Master of Science in Agriculture

(AGRONOMY)

Faculty of Agriculture

Kerala Agricultural University, Thrissur

Department of Agronomy

COLLEGE OF HORTICULTURE

VELLANIKKARA, THRISSUR – 680656

KERALA, INDIA

2015

DECLARATION

I hereby declare that the thesis entitled **"Standardization of media for tray nursery technique in rice"** is a bonafide record of research work done by me during the course of research and the thesis has not been previously formed the basis for the award to me any degree, diploma, fellowship or other similar title, of any other University or Society.

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ACKNOWLEDGEMENT

And so comes the time to look back on the path traversed during the endeavor and to remember the faces and spirits behind the action with a sense of gratitude. Nothing of significance can be accomplished without the acts of assistance, words of encouragement and gestures of helpfulness from the other members of the society.

*First and foremost I bow my head before the **Almighty God** for enlightening and making me confident and optimistic throughout my life and enabled me to successfully complete the thesis work in time.*

*It is with immense pleasure I avail this opportunity to express my deep sense of whole hearted gratitude and indebtedness to my major advisor **Dr. A. Latha**, Associate Professor, Agriculture Research Station, Mannuthy for her expert advice, inspiring guidance, valuable suggestions, constructive criticisms, motherly approach, constant encouragement, affectionate advice and above all, the extreme patience, understanding and wholehearted co-operation rendered throughout the course of my study. I really consider it my greatest fortune in having her guidance for my research work and my obligation to her lasts forever.*

*I consider it as my privilege to express my deep-felt gratitude to **Dr. P.Sreedevi**, Professor and Head, Dept. of Agronomy for his constant support, valuable suggestions, cooperation throughout the research programme and critical scrutiny of the manuscript. I am deeply obliged to **Dr. V. Jaikumaran**, Professor and Head, Agriculture Research Station, Mannuthy for his invaluable help,* guidance and critical assessment throughout the period of work. I thank him for all the help and cooperation he has extended to me.

I express my heartfelt thanks to **Dr. P. Sureshkumar**, Professor and Head, Radiotracer Laboratory for his constant encouragement, critical evaluation, expert advice and support throughout the conduct of experiment and preparation of the thesis.

My heartfelt thanks to my beloved teachers **Dr. P. S. John, Dr. C. T. Abraham, Dr. P. A. Joseph, Dr. Savithri, Dr. Lalitha Bai, Dr. C. George Thomas, Dr. Meera V. Menon, Dr. K. E. Usha, Dr. P. Prameela, Dr. Sindhu** and **Dr. A. Anitha** for their encouragement, valuable help and advice rendered during the course of my study.

I express my gratitude to **Sri. S. Krishnan**, Associate Professor and Head, Dept. of Agricultural Statistics, College of Horticulture, for his valuable assistance, immense help and guidance during the statistical analysis of the data.

I sincerely thank **Dr. P. K. Sushama**, Professor and Head, Dept. of Soil Science and Agricultural Chemistry for her expert advice, constant inspiration, precious suggestions, generous support and constructive criticisms during my entire study which helped in successful completion of this work. I am deeply obliged to **Dr. Jayshree, Dr. Beena** and **Mr. Visveswvran S.** from the Department of Soil Science and Agricultural Chemistry for their sincere help during chemical analysis and constant support during the course of study.

I am grateful to all the members of ARS, Mannuthy, especially ***Biju sir***, *Food Security Army executives, labour chechees and chetas for their constant help and support.*

My special thanks to ***Mrs. Sreela*** *Lab assitant, Department of Agonomy,* ***Mr. Arun, Mr. Ramana, Mrs. Geetha, Mr. Surya, Mrs. Devi, Mrs. Baby and Mrs. Maya*** *Teaching assistants cum Lab Technicians Dept. of Soil Science and Agricultural Chemistry. College of Horticuture, for their immense help and cooperation during the laboratory work.*

I duly acknowledge the encouragement, moral support, precious suggestions and timely persuasions by my dear seniors ***Mrs. Savitha, Mrs. Syama, Miss. Asha, Mrs. Indulekha*** *not only in my research work but also throughout my PG programme. I express my sincere thanks to my classmates* ***Sreedhu, Ashly, Ammu, Shahanila, Faras and Quwat Ali*** *for their affection and kind help offered during my thesis work. I have infinite pleasure to express whole hearted thanks to my loving juniors for their love, innumerable help and support especially* ***Ancy, Reshma, Adheena, Archana, Yansin and Rameesa.*** *I thank my dear friends* ***Nithya, Sumbula, Haritha, Shaheena, Semsheer, Aswathy, Bhavya, Shafna, Gayathri, Arjun, Deepika, Maheswari*** *for the unconditional support, help, timely valuable suggestions and encouragement which gave me enough mental strength and perseverance to get through all odds and tedious circumstances and immense thanks to all M.Sc. classmates for their moral support and encouragement.*

I am in dearth of words to express my love towards ***my beloved family mother Lissy and brother Grintu*** *for their boundless affection, moral support, eternal love, deep concern, prayers and personal sacrifices which sustains peace in my life.*

I owe special thanks to Library, College of horticulture. Dr. Francis and all other staff members of Library, who guided me in several ways, which immensely helped for collection of literature for writing my thesis.

I express my deep sense of gratitude to Kerala Agricultural University for financial and technical support for persuasion of my study and research work.

It would be impossible to list out all those who have helped me in one way or another in the successful completion of this work. I once again express my heartful thanks to all those who helped me in completing this venture in time.

Greeshma V. Mathew

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

Introduction

I. INTRODUCTION

Rice is the staple food crop of India and occupies the highest area among all the crops grown in the country. About half of the world population depends on rice as its energy supplying food grain. Considering the importance of rice, it is described as the 'Grain of life' by the United Nations in 1966. Rice plays a vital role in food security of India, cultivating over an area of 43.95 million hectares with a production of 106.54 million tonnes (GOI, 2015).

The crop is raised either by direct sowing or by transplanting. Chaudhary and Varshney (2003) reported that transplanting takes about 250-300 man hours per ha which is roughly 25 per cent of the total labour requirement of the crop. It is difficult to cover larger area within a short span by manual labour for transplanting. Delay in transplanting from normal date of sowing causes reduction in rice yield by nine per cent (Islam *et al.*, 2008). Decreased availability and increasing cost of labour increased the cost of rice cultivation through conventional methods in the recent years. This reduced the area of rice cultivation in Kerala with increased land conversions and fallowing (Kamboj *et al.,* 2013). Under such situation, a less expensive and labour saving method of rice transplanting, is the need of the hour. Mechanical rice transplanting is an alternate and promising option, as it saves labour, ensures timely transplanting and also contributes to higher grain yield (Sreenivasulu, 2014).

The success of mechanical transplanting depends on the success of the nursery. Raising tray nursery is necessitated with the introduction of mechanical transplanters. It requires lesser area compared to the conventional nursery. Commonly experienced root damage during uprooting of seedlings from conventional nursery bed can be completely avoided in tray nursery since the mats are directly fed to the transplanter without separation. Soil is the commonly used growing media for raising tray nursery in rice. But it limits easy transportation of nursery to the field in the context of commercialisation of tray nursery for the supply of ready-to-transplant paddy mat nursery to farmers and substitution of the growing media with light weight, cheap and easily available materials will lead to commercial production of paddy mat nursery for easy transportation and wider acceptance of the technology.

Research work regarding media for tray nursery for mechanical transplanting in rice cultivation is still in the infant stage. A suitable media for raising tray nursery is needed to bring easiness in transportation of mat nurseries for commercial production. Possibilities of using different media as an alternative to conventional soil media have been studied by research workers (Ko *et al.*, 2005; Shiratsuchi *et al.*, 2008; Ikeura *et al.*, 2012). If soil medium can be replaced by any light weight, low cost and easily available materials, that would be a great help to rice farmers. Rice husk charcoal, a by-product of rice processing industry, found to be a suitable medium for soilless culture due to the properties of good aeration and light weight (Islam, 2008). Vermicompost and coir pith composts are well known nutrient sources used in crops as they enhance the growth of plants.

Hence the present attempt on 'Standardization of media for tray nursery technique in rice' was taken up with the following objectives:

1) To standardize the media for tray nursery technique in rice
2) To evaluate the efficiency of nursery media under field condition

Review of Literature

II. REVIEW OF LITERATURE

Rice is the principal food crop of Kerala. The total paddy area during the year 1975-76 was 8.76 lakh hectares. Thereafter a steady decrease in paddy cultivation and the area of cultivation reached to 2.29 lakh hectares during the agricultural year 2007-08 (GOK, 2015). One of the major for the reduction of area under rice cultivation is the high average daily minimum wages for agricultural workers in Kerala compared to all other states of India (GOI, 2015). The obvious solution to this problem is to encourage mechanised paddy farming and overcome the shortage of labour. In 2008-09, the area of paddy cultivation was slightly increased to 2.34 lakh hectares (GOK, 2015). This was due to initiatives of state government towards mechanization of paddy production system. On comparing with the year 1975-76, area of paddy cultivation is decreased by 77% during the year 2013-14. Sustenance of rice cultivation in the state is important for ensuring food security as well as for preservations of its fragile eco-ecosystem.

2.1 Rice mechanization - general aspects

There is ample scope for reduction in the cost of cultivation of rice in Kerala by the use of machines as the wage rates of Kerala are the highest in India (James *et al.*, 1996). Since rice cultivation is a labour intensive process, traditional practices of rice cultivation increases cost of cultivation of rice and decreases income generated from it. This situation leads the farmers to change their rice fields into any other high-income generated activities.

Transplanting of rice seedlings is the most commonly used rice planting system. Transplanting alone about 15% of total rice production and delayed transplanting due to labour shortage causes substantial loss in yield (Ponnuswamy *et al.*, 1999). Chaudhary and Varshney (2003) reported that the transplanting takes about 250-300 man hours per ha which is roughly 25 per cent of the total labour requirement of the crop. Decreased availability and increasing labour costs have increased the cost of rice cultivation through conventional methods. Islam *et al.* (2008) held a different view. It is very difficult to cover larger area within a short span by using manual labour in manual transplanting. The delay in transplanting from normal date of transplanting due to shortage of labourers causes reduction in rice yield by nine per cent. So mechanization in rice cultivation is becoming the need of the hour in view of the escalating wages of the farm labour and their scarcity particularly in the peak transplanting period. In the current scenario, rice farm mechanization is regarded as the most important ingredient for sustaining cultivation of rice in the state.

Past studies on efficiency of farm mechanization revealed that if the mechanization utilized properly, a farmer can save seeds of 15-20 per cent, fertilizer of 20-30 per cent, time of 20-30 per cent, labourers of 5-20 per cent and increase in cropping intensity of 10-15 per cent and hence higher productivity of 15 – 20 per cent (Singh, 2008).

Manjunatha *et al.* (2009), while studying the performance of self-propelled rice transplanter and its effect on crop yield reported that the productive tillers per hill, panicle length and number of grains per panicle were higher in mechanized transplanting than manual transplanting and mechanized transplanting recorded 10% increase in grain yield over manual transplanting which might be due to transplanting of younger seedlings with uniform spacing. This enabled better translocation of photosynthates from source to sink leading to higher number of productive tillers per hill (14.2) which in turn increased the number of filled grains per panicle (115) and ultimately higher grain yield. Sheeja *et al.* (2012) also observed the increased number of panicles per hill and fertile grains panicle^{-1} in machine planting. According to Yajie *et al.* (2013), mechanically transplanted rice stabilize the yield, save cost, maintain high efficiency and reduce labour also.

On farm trials conducted by Sreenivasulu *et al.* (2014) in seventeen locations of Chittoor district of Andhra Pradesh to assess the performance of mechanized transplanting using Yanji rice transplanter for yield, yield attributes and economics concluded that the mechanical transplanting can be used successfully as an alternative option to manual method of transplanting for obtaining higher grain yield with a cost reduction of Rs. 2784 ha^{-1} as manual tranaplanting involves more labour and drudgery.

Pasha *et al.* (2014) while evaluating the different crop establishment techniques *viz.* machine transplanting, broadcasting, drum seeding and conventional transplanting in puddled rice reported that the machine transplanting recorded maximum panicle length, number of grains per panicle and the grain yield in both the years.

2.2 Mat nursery of rice

Rice seedlings have been cultivated using seedling trays for machine transplanting since 1970s in Korea. Rice nursery can be raised as mats in trays and it is called as tray nurseries. Mat nursery is a special type of rice nursery, necessitated with the introduction of mechanical transplanters where the established seedlings eventually form a dense root mat and can be rolled into a cylindrical shape for transportation and later transplanting. Main advantage of these tray nurseries is that the mats can be fed directly into the mechanical transplanter since it has same dimensions as the seedling box of the machine. Size of the tray changes according to the transplanter used for planting seedlings.

Rajesh (2003), while conducting a field experiment at Agricultural Research Station, Mannuthy in Thrissur to develop a suitable production package for rice mat nursery, evaluated mat nursery under mechanical transplanting and the study revealed that the mechanical or manual transplanting with mat nursery derived better economic return compared to manual transplanting. The experiment standardized the mat nursery for mechanical transplanting and based on the study, production technology of mat nursery has been included in the Package of Practices Recommendations Crops of Kerala Agricultural University (KAU, 2007).

A field experiment was conducted at Tamil Nadu Agricultural University to evaluate the performance of nursery methods with two nursery methods *viz.* mat and conventional nursery revealed that the growth and yield of rice were not affected by nursery methods (Baskar *et al.*, 2012).

2.2.1 Mat nursery raising machine

A prototype of mat nursery raising machine has been designed at Indonesian Agency for Agricultural Research and Development (ICAERD), Serpong Indonesia. This machine could fill base soil of 2 cm depth into nursery box and then distribute 150 g seeds uniformly on the base soil and finally cover with thin layer of soil at 0.5 cm depth. The mechanism of soil filling and seed distribution were the combination of cylindrical type of soil and seed metering devices and speed of belt conveyor which convey boxes to be filled in below the metering cylinder. The capacity of the machine was 100 boxes per hour (Harjono and Handaka, 2007).

Major constraints in the adoption of mechanical transplanters is the complex and labour intensive technique of raising mat type nursery in frames on perforated plastic sheets and the unevenness of plant population in the mats. With a view to reduce the drudgery in raising mat-type nursery, a mat type nursery raising device was developed by G.B. Pant University of Agriculture and Technology and tested. Sharma and Singh (2008) tested the performance of the device and concluded that the desired density of 80-100 g seed per mat with three passes of the device at 1.03 mm sprout length and the thickness of the soil layer could be also maintained to 20 mm, as required in a single pass, throughout the length of the mat. The device saved 72.02% time and 33.33% labour over the manual method and the cost of raising mat type nursery for one hectare (400 mats) was Rs. 299 compared to Rs. 1,609 with manual method.

2.2.2 Automatic paddy mat nursery sowing machine

Automatic paddy mat nursery sowing machine is a special machine for producing mat nurseries for large scale cultivation of rice. It could fill base soil into trays and then distribute seed uniformly on the base soil and finally cover with thin layer of soil. The machine has an output of 600 trays per hour and is powered by an electric motor. It consists of four major parts, a hopper for holding mat media mixture, a pipe system for irrigating mat, a hopper for holding seeds and another for storing soil. Quantities of mat media, water, seeds and soil falling into the trays can be adjusted in the machine. The trays can be taken to field after 15 days for transplanting. This machine was tested and introduced first in Kerala by Agricultural Research Station, Mannuthy in Thrissur (Anon., 2012).

2.3 Nursery growing media

Seedling mats for mechanical transplanting are raised in trays filled with soil. The major problem associated with the existing mat type nursery is the difficulty in transportation for large scale cultivation of rice due to its heavy weight (Tasaka, 1999). So, a soilless media or growing media containing less soil component should be found out.

Successful nursery production of container grown plants is largely dependent on the chemical and physical properties of the growing media. A number of critical chemical and physical properties were needed to be evaluated before making a final media decision. Media pH is a critical issue because it plays a major role in determining the availability of many nutrients. Optimum pH of a container medium differs with plant species, but generally a range between 5.0 and 6.5 is desirable (Fitzpatrick, 2001).

Growing media have three main functions *viz.* it provide aeration and water, allow for maximum root growth and physically support the plant. Growing media should have large particles with adequate pore spaces between the particles (Bilderback *et al.*, 2005). Appropriate particle size selection or combination is critical for a light and fluffy (well-aerated) medium that promotes fast seed germination, strong root growth and adequate water drainage (Olle *et al.*, 2012).

Composts produced from different types of agricultural residues can be a suitable material for growth media or for use in field soils as an amendment. The use of these composts in soilless growing systems (SGS) can improve sustainability.

2.3.1 Influence of soilless growing media on growth of seedlings

Venkataraman (1999), while preparing dapog nursery in four media *viz.* clay + cow dung, composted coir pith, raw coir pith and straw bits, observed that composted coir pith (5.86 t ha^{-1}) and clay + cowdung (5.85 t ha^{-1}) contributed to higher yields than others.

Seven different media were tested by Suharban *et al.* (2004) for the cultivation of anthurium (*Anthurium andreanum* L.) and observed 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 was the best medium for the anthurium cultivation. The increase in flower yield was noticed due to the increased bulk density, particle density, maximum water holding capacity and volume expansion of the medium. Coir pith was also known to increase the oxygen supply to the rooting medium.

In recent years, protected horticulture has changed from soil grown systems to soilless systems. Papafotiou *et al.* (2005) indicated that the composts from agricultural wastes have the potential to replace a significant proportion of peat in the growth medium of ornamental plants.

The effects of three soilless media *viz.* rice hull, poultry manure and river sand in 1:2:3, 1:4:3 and 2:3:1 proportions and a soil based medium on seedling emergence, seedling growth and susceptibility to water stress were studied by Baiyeri and Mbah (2006) using African breadfruit as a test crop and revealed that the percent seedling emergence and plant dry matter content were higher in media comprising rice hull, poultry manure and river sand in 1:2:3 and 2:3:1. The study also proved that the seedlings raised in the soil based medium were generally poorer in most of the parameters measured.

Oselebe *et al.* (2008) noticed that the use of soilless media was the fastest means of plantlet generation for *Musa spp.* at the farm level. Soilless substrates made of peat moss, coconut coir, perlite, rockwool or bark have been used in strawberry production in Europe in troughs or containers. Soilless media ensures raising of disease free crops (Martinez *et al.*, 2013).

Study conducted at Rice Research & Training Centre, Egypt revealed that the substitution of soil by the rice straw seedbed in the nursery media affected the root dry weight, leaf area, crop growth rate and nutrients uptake positively. The seedling mat reduced the working hours for transplanting by one - third compared to conventional soil seed bed system (Haytham *et al.*, 2010).

Wira *et al.* (2011) determined the best medium to be used as an additive in coconut coir dust culture for growing rock melon var. Waka Natsu 1, with five types of composts which consisted of 70% coconut coir dust: 30% rice straw compost, 70% coconut coir dust: 30% empty fruit bunches compost, 70% coconut coir dust: 30% peat moss, 70% coconut coir dust: 30% burnt rice husk and 100% coconut coir dust as control. The experiment proved that a mixture of coconut coir dust and empty fruit bunches compost in a ratio of 7:3 was found to be the best medium for growing rock melon var. Waka Natsu 1 using fertigation system and the plants grown in this melon var. Waka Natsu 1 using fertigation system and the plants grown in this medium produced largest fruit diameter (14.15 cm) with highest fruit fresh weight (1482.9 g) and total soluble solids (15.33%).

Experiments conducted in Benjamin tree (*Ficus benjamina*) to study the effect of different soilless growing media *viz.* peat, perlite, composted tree bark, composted tea wastes and rice husks on biometric characters showed that the effect of different soilless growing media on the growth characteristics was significant and the growing medium containing composted tea wastes + rice husks in the proportions of 50 and 50% (v/v) was the best medium for enhancing all the growth characteristics (Abouzari *et al.*, 2012).

Murumkar *et al.* (2012) studied the effect of growing media under polyhouse condition as a package in beet root variety Nobol with eight different media levels comprising of coir pith, perlite, vermiculite and peat separately as four treatments and another four with vermicompost as 50% on volume basis with three replications. The study revealed that the best performance in terms of growth, yield and quality were observed in treatment with peat: vermicompost in the ratio of 1:1 on volume basis. The highest water use efficiency (6.15×10^{-3} kg / mm per root) and benefit cost ratio (2.11) were also recorded in the same treatment.

An investigation carried out to study the effect of different combinations of soil-less coir pith based nursery mixtures on rooting and growth of black pepper cuttings in the nursery, coir pith with *Trichoderma* and vermicompost recorded significantly higher growth parameters. The study confirmed that composted coir pith with vermicompost and *Trichoderma* was an ideal potting medium for black pepper nursery (Prasath *et al.*, 2014).

Kumar and Sharma (2014) observed that the soilless growing media vermicompost: sand (2:1) along with seedling application of *Azotobacter* and in tomato recorded the maximum number of fruits per cluster and fruits per plant.

2.3.2 Influence of media with soil as component on growth of seedlings

According to Rani *et al.* (2000) mat nursery did not require any fertilizer, as the farm yard manure provided necessary nutrients and the soil was enough for proper growth of roots. The mixture of soil, farm yard manure and sand in the ratio of 7:1:2 were better for heavy texture of soil, while for light soils, a mixture of 9:1 (soil and farm yard manure) would be optimum. Rajesh (2003) while standardizing the mat nursery, observed that the seedling height was highest for soil + chaff in 2:1 ratio, under dry nursery at initial stages, and towards the end, soil cow dung mixture in 2:1 ratio led to the maximum height and under wet system at 15 DAS, soil with cow dung in the ratio 2:1 or 1:2 had the maximum height. The treatments comprising soil and cow dung in 1:2 ratio and soil and coir pith compost in 2:1 ratio produced maximum number of healthy seedlings in dry nursery. The experiment concluded that, as the grain was not affected due to the various treatments, the selection of mat should be based basically on economic consideration. Soil + coir pith raw as well as soil + chaff in the ratio 2:1 under dry system and soil + cow dung in the ratio 1:2 and soil + coir pith compost in the ratio 2:1 under wet system could be better option for mechanical transplanting based on economics.

Field trials conducted by Rajendran *et al.* (2005) at Thanjavur and Aduthurai, Tamil Nadu indicated that the media comprising of soil + rice husk (9:1 w/w) and soil + press mud (1:1, w/w) were identified as the best medium for modified mat nursery production on the basis of seedling growth and vigour characteristics. Mat nursery comprising of soil + pressmud mixture (1:1, w/w) produced the most vigorous seedlings in 15 days, recording the maximum seedling height (20.8 cm), root length (9.9 cm), leaves per seedling (4.2) and seedling vigour index (8.2). 15 days old seedlings produced 16 - 20% higher yield than the rice crop planted with 25 days old seedlings of traditional wet nursery.

During the experiment of developing nursery raising technique for System of Rice Intensification under machine transplanting, Dhananchezhiyan *et al.* (2013) revealed that to achieve 100% seed germination, enough root networks to provide enough rigidity for the mat and to offer conducive growth environment, the growing medium is to be optimized. Result showed that, among the nine treatment media studied, the maximum nursery height and root length of 17.06 cm and 10.75 cm were observed in media comprised of 1:1 proportion of field soil and farm yard manure or vermicompost respectively. Dhananchezhiyan *et al.* also studied the stiffness of the mat where the field soil was mixed with decomposed sieved coir pith and fibrous coir pith each in the ratio of 1:1 and 2:1, and tested with and without base layer. The mat stiffness was found to be maximum for a media mixture of field soil and coir pith at 1:1 and 2:1 ratios with a corrugated sheet base layer. From the results, the soil medium for growth and stiffness was optimized as field soil, FYM and fibrous coir pith in the ratio of 2:1:1.

Mamun *et al.* (2013) while experimenting with different media *viz.* soil alone, 75% soil + 25% decomposed cow dung, 75% soil + 25% ash, 75% soil + 25% saw dust, 75% soil + 25% rice husk and 75% soil + 25% decomposed poultry manure to raise seedlings for rice transplanter using two varieties of rice *viz.* BRRI dhan49 and BRRI dhan29, observed that greener leaves, longer shoot and root length, more seedling vigor and strength, and better nutrient composition as well as field performance was obtained from seedlings grown in soil media containing 25% cow dung or rice husk or poultry manure mixture.

2.3.3 Influence of rice husk charcoal in growing media on growth of seedlings

Rice husk charcoal is made from controlled burning of rice husks, which are generated from harvested rice. Rice hull derived charcoal has been utilized as a common soil ameliorator to improve growing of various crops for more than 300 years. In 1984, charcoal was authorized as soil ameliorator by law No.34 for soil fertility improvement. From that time, charcoal effect has been widely acknowledged and huge number of farmers were utilizing rice hull charcoal.

Rice husk is not permeable to water because the surface of it is formed by neticular tissue with SiO_2 containing 13.7% lignin (Han *et al.*, 1983). When it expands, the physical properties are changed to a more permeable medium (Cha, 1996). The suitability of expanded rice husk to be used as a seedling media for rice was first reported by Han *et al.* (1983). Kim *et al.* (2000) also noticed similar results. The seedling media including expanded rice husk could increase dry mass of seedlings as well as absorption of SiO_2 to plants (Han *et al.*, 1983).

Addition of rice husk charcoal carbonized at 600^0C and 700^0C to soil increases the soil pH, thereby increases the available phosphorus. It also improves aeration in the crop root zone, soil water holding capacity and increase the level of exchangeable potassium and magnesium (FFTC, 2001).

According to Kim *et al.* (2003), the weight of rice seedling trays could be decreased by using expanded rice husk as a seedling medium. The weight of expanded rice husk charcoal is less compared with its volume. Because of less effort in handling the seedling trays, labour can be saved by using expanded rice husk instead of a commercial medium.

Rice husk charcoal has good moisture retentiveness due to its porosity. It mixes well with other substances (Inden and Torres, 2004). Inden and Torres also reported an increase in yield and total soluble solid content in tomato when using coconut coir or perlite + carbonized rice hulls as a growth substrate.

A study was carried out by Ko *et al.* (2005) to develop a method for rice seedling cultivation using expanded rice husk as a seedling medium and revealed that the expanded rice husk medium was not only the lightest in weight but also the cheapest in labour cost.

Growing medium containing 70 peats: 30 Rice husk ash gave higher shoot and dry weigh of *Pinus halepensis* compared to control medium (Marianthi, 2006).

Promchot and Boonprakob (2007) reported that rice husk charcoal was better than agar for embryo culture of nectarines and that it may be a substitute for vermiculite.

Islam (2008) while studying the performance of organic substrates *viz.* coconut coir and rice husk charcoal in comparison to rock wool using tomato as a test crop under three different temperature regimes *viz.* 25^0C, 30^0C and 35^0C in green house condition observed that the coconut coir and rice husk charcoal had the potency as substrates due to their suitable physico-chemical characteristics, better performance on crop productivity, low price, ecological suitability and with no environmental pollution after their use. This result also indicated that these substrates had the potential to be used as growing media under high temperature stress conditions.

Dhatt and Kaler (2009) studied the effect of shade net and growing media on nursery raising of cauliflower in sub-tropical area and observed that the combinations, decomposed cow dung, press mud and rice husk charcoal mixed in 1:1:1 (v/v) ratio gave the best results for nursery and plant growth parameters among 17 nursery growing media.

It was found that the addition of rice husk charcoal carbonized at 600 and 700°C to soil increased the concentrations of calcium, magnesium, potassium and silicon as well as the pH value (lowers soil acidity) of the soil and it was identified as a great soil modifier (Chien *et al.*, 2011). Preliminary greenhouse experiments for chilli crop under fertigation system using 100% rice husk charcoal as growing medium improved the root distribution by 10% and biomass yield by 15% (Theeba *et al.*, 2012).

Rice husks are typically utilized as a medium for ornamental crops (e.g., *Chrysanthemum morifolium*) and as soil cover due to its high cation exchange and aeration properties. It also had good moisture retentiveness due to its porosity and mixed well with other substances (Ikeura *et al.*, 2012). Investigation on the effects of different ratios of rice husk charcoal to peat moss as a medium as well as the optimal amount of fertilizer required for zucchini potted culture by Ikeura *et al.* (2012) revealed that the optimum blend ratio of rice husk charcoal to peat for potted culture of zucchini was 80:20.

Utami *et al.* (2012) observed increased phosphorus uptake by *Brassica sp.* through the application of rice husk charcoal in the soil. Rice husk charcoal reduced bulk density and total porosity and increased pH, available phosphorus, exchangeable potassium and calcium in the soil and resulted in increased maize grain yields (Njoku and Mbah, 2012). Milla *et al.* (2013) reported that rice husk contains a high content of silicon, potassium and other essential nutrients which have great potential for amending soil and the carbonization process improves the water holding capacity of the rice husks.

2.3.4 Influence of vermicompost in growing media on growth of seedlings

Vermicomposting is one of the most promising low cost technologies used for conversion of organic waste into organic fertilizers using earthworms. Vermicompost is finely divided peat like material with high porosity, aeration, drainage and water holding capacity. Nutrients in vermicompost *viz.* nitrates, exchangeable phosphorus, potassium, calcium and magnesium are present in readily available forms for plant uptake (Edwards and Burrows, 1988). Vermicompost has greatly increased surface area, providing more micro-sites for microbial decomposing organisms and strong adsorption and retention of nutrients (Shi-wei and Fu-zhen, 1991).

Vermicompost has finer structure than ordinary compost and it has outstanding chemical and biological properties with plant growth regulators (lacking in other composts) and significantly larger and diverse microbial populations than the conventional thermophilic composts (Tomati and Galli, 1995). Orozco *et al.* (1996) reported that the vermicompost contained most of the nutrients in plant available forms such as nitrates, phosphates, and exchangeable calcium and soluble potassium.

Sainz *et al.* (1998) noticed that the addition of vermicompost to soil resulted in increased mineral contents in the substrate and higher concentrations phosphorus, calcium, magnesium, copper, manganese and zinc in shoot tissues of red clover and cucumber plants in fields. The increase in the shoot and root dry weight of tomato and green gram seedlings was observed due to the addition of vermicompost to the potting media (Szczech, 1999).

Atiyeh *et al.* (2000) observed that the incorporation of 10% or 20% vermicomposted pig solids into a standard commercial horticultural potting medium (Metro-Mix 360) enhanced the growth of marigold and tomato seedlings significantly as compared to the Metro-Mix 360 alone, even when all required mineral nutrients were supplied. Incorporation of vermicompost has been shown to influence the physical properties of plant growing substrates (Hidalgo and Harkess, 2002).

Gajalakshmi and Abbasi (2002) reported that the application of vermicompost obtained from water hyacinth (*Eichhornia crassipes*) significantly enhanced growth and flowering of *Crossandra udulaefolia* compared to untreated control plants.

Atiyeh *et al.* (2002) also noticed that the greater proportions of vermicompost substituted in growth media have not increased plant growth as much as smaller proportions. Several pot and field trials carried out with tomato (*Solanum lycopersicum*) and marigold (*Tagetes patula*) seedlings had shown that vermicompost produced significant positive effects on plant growth and yield at relatively low proportions (up to 20% of the growing media), even when plants are adequately supplied with mineral fertilizers, therefore suggesting the existence of non nutrient mediated mechanisms of plant growth promotion (Edwards *et al.,* 2004).

Incorporation of vermicompost into growing media has shown to significantly improve plant growth, since it constitutes a slow-release source of nutrients that also modifies the physical properties of the potting substrates (Hidalgo *et al.*, 2006).

For pepper, an improvement of the physical structure of the potting medium by vermicompost increased the populations of beneficial microorganisms and enhanced availability of plant growth influencing substances and increased fruit yields (Aracnon *et al.*, 2006).

The study conducted by Prajapati *et al.* (2008) to study the growth promotion of rice (*Oryza sativa* L.) due to dual inoculation of *Azotobacter chroococcum* and *Piriformospora indica* along with vermicompost revealed that the dual inoculated plants in presence of vermicompost gave positive effects on shoot length, root length, fresh shoot and root weight, dry shoot and root weight and panicle number in comparison to single inoculation of *A. chroococcum*, *P. indica* and vermicompost.

The application of different levels of vermicompost increased seedling height, photosynthetic pigments and contents of protein, amino acid and sugar in groundnut seedlings (Mathivanan *et al.*, 2012).

A field experiment was conducted at Directorate of Rice Research farm, Rajendranagar to find the best management practices with six nutrient management practices *viz.* 100% recommended dose of N (RDN) through inorganic fertilizer, 75% RDN (inorganic) + 25% RDN (organic) through vermicompost, 50% RDN (inorganic) + 50% RDN (organic) through vermicompost, 25% RDN (inorganic) + 75% RDN (organic) through vermicompost, 100% RDN (organic) through vermicompost and control (No manure and no fertilizer) under System of Rice Intensification (SRI) revealed that among the different nutrient management practices, application of 50% recommended dose of nitrogen (through urea) and remaining 50% RDN through vermicompost resulted in significantly higher grain and straw yield in addition to nutrient uptake (Ranjitha *et al.*, 2013).

Bejbaruah *et al.* (2013) noticed that the split application of vermicompost in rice resulted higher number of panicles, filled grains per panicle, spikelets per panicle, increased grain yield and nutrient use efficiency (NUE). Higher availability of nitrogen (N) in soil with split applications coincides with higher NUE and thus split application not promoted N losses. Split application of vermicompost enhances the sustainability of rice cropping system.

The study conducted in National Pingtung University of Science and Technology to determine the effect of vermicompost on productivity of muskmelon seedling by Manh and Wang (2014), revealed that vermicompost in combination with rice husk ash and coconut husk had reflected in a better plant growth and they suggested the proportion of vermicompost in substrate for muskmelon seedling production when mixed with coconut husk and rice hulls ash was about 30%.

Bachman and Metzger (2008) observed that the addition of vermicompost in media mixes of 10% vermicompost and 20% vermicompost had positive effects on plant growth. Growth increase up to 40% was observed in dry shoot tissue and leaf area of marigold, tomato, green pepper, and cornflower due to vermicompost.

Field experiments conducted by Manivannan and Sriramachandrasekharan (2009) to study the response of lowland rice to organics and mineral N observed that the highest grain and straw yield were noticed with the application of vermicompost (50% N) + urea (50% N).

Peat replacement by vermicompost in a commercial potting media produced a significant increase in pine seedling shoot height of pine with a significant change in plant morphology and increase in the shoot: root ratio (Lazcano *et al.*, 2010).

The study of influence of different organic amendments *viz.* farm yard manure, vermicompost and biochar on germination and seedling growth of okra

(*Abelmoschus esculentus* L.) revealed that the highest homogeneity of seed germination was in vermicompost (Sarma and Gogoi, 2015).

2.3.5 Influence of coir pith compost in growing media on growth of seedlings

Limitations in the availability of conventional manures like farmyard manure, poultry litter, cow dung etc. can be overcome through the exploitation of new sources of organic matter like coir pith.

Coir pith, an agro waste by-product collected during the process of coir fibre extraction from coconut husk of the coir industry, constitutes about 50-60% of the total weight of the husk (Mathew *et al.*, 2000). The coir dust is neither subjected to burning nor any productive application without composting. Coir pith in its natural form is not a conducive medium for the cultivation of any crop plants. Coir pith is comparatively rich in potash, but low in nitrogen and phosphorus (Abad *et al.*, 2002). Chemical and structural complexity of lignin cellulose complex and low pentosan: lignin ratio (< 0.5) leads to slow rate of decomposition of coir pith (Ramalingam *et al.*, 2004). High content of lignin (28.25%) and C: N ratio also attribute to the slow degradation (Vinodhini *et al.*, 2005). Pollution created by the improper management and due to poly phenol leaching and its resistance for natural degradation has become an important social and environmental issue.

A study conducted by Sureshkumar and Ganesh (2012) at Annamalai University, pointed that the composted coir pith had optimum physical, chemical and biological properties and rich in nutrients also. Thus, in organic farming the agro industrial waste coir pith can be bio-converted into compost which will be definitely bring fruitful yield besides quality of produce.

Thilagavathi and Mathan (1996) noticed that the plots with coir pith compost application recorded significantly higher available N than the control. They also observed the increased yields of grain and straw of the rice due to coir pith application.

Pot experiment conducted by Bhagavathiammal (1997) in rice observed that the composted coir pith increased rice yield and K uptake more than the other organic fertilizers and the yield was highest with composted coir pith along with highest K rate.

Velmurugan *et al.* (2007) observed that the application of coir pith compost + azospirillum + phosphobacteria + VAM expressed highest potassium content (0.9%) and potassium uptake (285.05 kg ha^{-1}) in turmeric plants than the application of 50% recommended dose of fertilizers in field condition. Application of digested compost increased the potassium uptake due to the conversion of the compost into soil humus substances and thereby increased the mobilization of potassium.

To study the efficacy of composted coir pith based potting mixture with garden soil, a pot culture experiment was carried out in Alappuzha district of Kerala using five different potting media with four different medicinal plants. The study revealed that the mixture of garden soil and composted coir pith in proportion of 1:3 recorded increased shoot and root length over 1:1, 3:1 proportion of garden soil and composted coir pith and 100% garden soil (Reghuvaran and Ravindranath, 2010).

Materials and Methods

III. MATERIALS AND METHODS

The present study entitled "Standardization of media for tray nursery technique in rice" was carried out at Agricultural Research Station, Mannuthy in Thrissur district during 2013-2014. The details of materials used and methods adopted for the study are described in this chapter.

The research programme was undertaken under the following two experiments:

- Experiment I : Standardization of growing media for tray nursery in rice
- Experiment II: Field evaluation of best performing media selected from Experiment I

3.1 EXPERIMENT I. STANDARDIZATION OF MEDIA FOR TRAY NURSERY TECHNIQUE IN RICE

The experiment was aimed to standardize the media for tray nursery technique in rice for mechanical transplanting. Four levels of rice husk charcoal, seven levels of soil and two levels of vermicompost or coir pith compost were prepared on volume basis. Filler material was rice husk charcoal, nutrient source was either vermicompost or coir pith compost and the base material was soil.

3.1.1 General details

3.1.1.1 Components of growing media

Components used for preparing different growing media were rice husk charcoal, soil vermicompost and coir pith compost. Rice husk charcoal is a by-product of rice processing mills. Rice husk charcoal for this study was collected from Veejay Rice Mill located at Kalady in Ernakulam district and soil component of the growing media from the nursery area of Agricultural Research Station, Mannuthy.

Vermicompost was purchased from Agricultural Research Station, Mannuthy and coir pith compost from College of Horticulture, Vellanikkara.

3.1.1.2 Variety

The rice variety Jyothi (PTB-39), a red kernelled, short duration variety moderately resistant to BPH and blast, was used for the experiment. The variety is grown extensively in a wide range of field conditions in Kerala, in all the three seasons.

3.1.1.3 Seedling trays

Trays of dimension 60 x 22 cm^2 were used to raise the mat nursery seedlings of rice. The size of the tray is same as the dimension of the seedling box of the 8-row *Yanji Shakthi* paddy transplanter.

3.1.1.4 Automatic paddy mat nursery sowing machine

Automatic paddy mat nursery sowing machine (Redlands automatic paddy mat nursery sowing machine, shown in Plate 1) has three hoppers which is capable of filling growing media into the seedling trays, then distributing seeds uniformly on the media and finally cover with thin layer of media. Pipe system is used for irrigating the trays. The machine is powered by an electric motor. All the activities are done by passing the trays over conveyer belts in the machine. Quantity of media, water, and seeds falling into the trays can be adjusted in the machine. The average fuel consumption of the machine is 500 ml of diesel per hour and 600 trays can be filled in one hour.

3.1.2 Experimental methods

The Experiment I was conducted at Agricultural Research Station, Mannuthy during March, 2013. The experimental design was CRD with five replications.

Plate 1. Automatic paddy mat nursery sowing machine

3.1.2.1 Preparation of growing media

Four levels (20%, 40%, 60% and 80%) of rice husk charcoal, seven levels (10%, 20%, 30%, 40%, 50%, 60% and 70%) of soil and two levels (10% and 20%) of vermicompost or coir pith compost were mixed in different proportions in order to get the various treatments.

3.1.2.2 Treatment details

The treatment details are given in Table 3.1.

3.1.2.3 Filling of trays with media and seeds

Components of each treatment were mixed manually on volume basis and filled in the trays using automatic paddy mat nursery sowing machine. Seeds @ 120 g per tray were distributed uniformly on the trays using the machine. The average quantity of each component for filling the tray was ranged from 0.25 kg to 1.4 kg.

3.1.3 Observations in nursery

3.1.3.1 Biometric observations on growth of seedlings

All the biometric observations except mean germination time, root length, scoring of pest and disease incidence, number of normal and abnormal seedlings and mat characteristics were recorded at 5 days interval up to 15 days in the nursery.

3.1.3.1.1 Mean germination time

The number of days taken to germinate 50% seeds in the tray was considered as the mean germination time. The observation was recorded on per cm^2 basis.

3.1.3.1.2 Height of seedlings

Height of ten plants was measured in cm from collar region to the tip of the seedling at five days interval and mean height was computed.

Table 3.1 Details of treatments in Experiment I

Treatments	
T_1	80% Rice husk charcoal + 20% Vermicompost
T_2	60% Rice husk charcoal + 20% Soil + 20% Vermicompost
T_3	40% Rice husk charcoal + 40% Soil + 20% Vermicompost
T_4	20% Rice husk charcoal + 60% Soil + 20% Vermicompost
T_5	80% Rice husk charcoal + 10% Soil + 10% Vermicompost
T_6	60% Rice husk charcoal + 30% Soil + 10% Vermicompost
T_7	40% Rice husk charcoal + 50% Soil + 10% Vermicompost
T_8	20% Rice husk charcoal + 70% Soil + 10% Vermicompost
T_9	80% Rice husk charcoal + 20% Coir pith compost
T_{10}	60% Rice husk charcoal + 20% Soil + 20% Coir pith compost
T_{11}	40% Rice husk charcoal + 40% Soil + 20% Coir pith compost
T_{12}	20% Rice husk charcoal + 60% Soil + 20% Coir pith compost
T_{13}	80% Rice husk charcoal + 10% Soil + 10% Coir pith compost
T_{14}	60% Rice husk charcoal + 30% Soil + 10% Coir pith compost
T_{15}	40% Rice husk charcoal + 50% Soil + 10% Coir pith compost
T_{16}	20% Rice husk charcoal + 70% Soil + 10% Coir pith compost
T_{17}	80% Rice husk charcoal + 20% Soil
T_{18}	Absolute control (soil alone)

3.1.3.1.3 Biomass production

Fresh weight of ten seedlings in the nursery was measured in grams at five days interval and mean weight was computed.

3.1.3.1.4 Shoot dry weight

Shoots of seedlings were kept in hot air oven at 60 ± 5°C. Weight of shoots of ten seedlings was measured in grams at five days interval and mean weight was computed.

3.1.3.1.5 Root dry weight

Roots of seedlings were kept in hot air oven at 60 ± 5°C. Weight of roots of ten seedlings was measured in grams at five days interval and mean weight was computed.

3.1.3.1.6 Dry matter production

Weight of ten seedlings was measured in grams at five days interval after drying the fresh seedlings in hot air oven at 60 ± 5°C and mean weight was computed.

3.1.3.1.7 Root length at transplanting

Length of roots of ten plants was measured in cm from collar region to the tip of the root at 15 DAS (at the time of transplanting) and mean length was computed.

3.1.3.1.8 Scoring for pests and diseases

The pest and disease incidence were not noticed and hence, the scoring was not done in the nursery.

3.1.3.1.9 Number of normal and abnormal seedlings per m^2

Seedlings of minimum 10 cm height are most preferred for mechanical transplanting in rice. Seedlings of height 10 cm or more were considered as normal seedlings and those with less than 10 cm height was considered as abnormal seedlings. Number of normal and abnormal seedlings in strips of 3 cm x 3 cm was counted and converted it into an area of 1 m x 1 m.

3.1.3.2 Mat characteristics

3.1.3.2.1 Thickness of the media at the time of transplanting

Thickness of the root bed of three mat strips of each treatment at the time of transplanting was measured using the vernier calipers and mean thickness was expressed in cm.

3.1.3.2.2 Mat weight per unit area at the time of transplanting

Three strips of mat with the size 3 cm x 3 cm were cut at the time of transplanting. Weight of the mat was measured using a precision balance and the values were converted into an area of 1 m x 1 m. The mean weight was computed and expressed in kg/ m^2.

3.1.3.2.3 Mat strength at the time of transplanting

The strength of mat was measured using an instrument (Plate 2) specially fabricated for this purpose. The mat is fixed on this device and by providing weight on the other end, tension is created and at a particular weight, mat will break due to the tension. That particular weight was noticed and strength of the mat was recorded based on force by area and mean strength was expressed in kg/ m^2.

Plate 2. Instrument used for finding out mat strength

3.1.4 Physical properties of growing media

3.1.4.1 Physical properties of components and combinations of growing media

The components of growing media *viz.* rice husk charcoal, vermicompost and coir pith compost as well as the different combinations of growing media were air dried and passed through 2 mm sieve. A representative sample of sieved material was used for analyzing physical properties of the media. The various methods used for the analysis of the components are depicted in Table 3.2.

Table 3.2 Methods for analyzing the physical properties of components and combinations of growing media

No.	Properties	Method
1	Water holding capacity	Keen and Racksowski, 1921
2	Bulk density	FCO, 1985

3.1.4.2 Physical properties of soil media

Soil was air dried, powdered and passed through 2 mm sieve. A representative sample of sieved material was used for analyzing physical characteristics of the soil. Various methods used for the analysis of soil media are given in Table 3.3.

Table 3.3 Methods for analyzing physical properties of soil media

No.	Properties	Method
1	Water holding capacity	Keen and Racksowski, 1921
2	Bulk density	Keen and Racksowski, 1921

3.1.5 Chemical analysis of growing media

3.1.5.1 Chemical analysis of components and combinations of growing media

The components of growing media *viz.* rice husk charcoal, vermicompost and coir pith compost as well as the different combinations of growing media were air dried and passed through 2 mm sieve. A representative sample of sieved material was used for analyzing chemical properties of the media. The various methods used for the analysis are given in Table 3.4.

3.1.5.2 Chemical analysis of soil media

Soil was air dried, powdered and passed through 2 mm sieve. A representative sample of sieved material was used for analyzing chemical characteristics of the soil. The various methods used for the analysis are given in Table 3.5.

3.1.6 Plant analysis

The seedlings were selected at random from each tray. Plant samples were collected at 15 DAS (at the time of transplanting) for analysis. The seedlings were dried in hot air oven at 60 ± 5°C, ground well and analyzed for different nutrients. The methods used for the analysis of different nutrients are given in Table 3.6.

3.1.7 Nutrient uptake by seedlings

Each tray contained 120 g seeds. 120 g seeds were germinated to form an average of 3878 seedlings per tray. Uptake of nutrients by the seedlings was calculated by multiplying the particular nutrient content of the seedlings at the time of transplanting with the dry matter production of total seedlings per tray at the time of transplanting and expressed in g/ tray.

Table 3.4 Methods used for chemical analysis of components and combinations of growing media

No.	Nutrient	Method
1	pH	Media water suspension of 1:2 and read in pH meter (FCO, 1985)
2	Electrical conductivity	Media water suspension of 1:5 and read in EC meter (FCO, 1985)
3	N	Microkjeldhal digestion and distillation method (Jackson, 1958)
4	P	Diacid digestion of media sample followed by filtration. Vandadomolybdate phosphoric yellow colour in nitric acid system (Piper, 1966)
5	K	Diacid extract using Flame Photometer (Piper, 1966)
6	Ca	Diacid extract using Inductively Coupled Plasma Optical Emission Spectrometry (Piper, 1966)
7	Mg	Diacid extract using Inductively Coupled Plasma Optical Emission Spectrometry (Piper, 1966)
8	Fe, Mn, Cu & Zn	Diacid extract using Inductively Coupled Plasma Optical Emission Spectrometry (Piper, 1966)
9	B	By dry ashing (Gaines and Mitchell, 1979) and Azomethine-H method (Bingham, 1982)
10	Si	Boric acid extract using Inductively Coupled Plasma Optical Emission Spectrometry (Ma *et al.*,2004)

Table 3.5 Methods for chemical analysis of soil

No.	Particulars	Method
1	pH	Soil water suspension of 1:2.5 and read in pH meter (Jackson,1958)
2	Electrical conductivity	Soil water suspension of 1:2.5 and read in EC meter (Jackson,1958)
3	Organic carbon	Walkley and Black method (Walkley and Black, 1934)
4	Available N	Alkaline permanganate method (Subbiah and Asija, 1956)
5	Available P	Ascorbic acid reduced molybdophosphoric blue colour method (Bray and Kurtz, 1945)
6	Available K	Neutral normal ammonium acetate extract using flame photometer (Jackson, 1958)
7	Available Ca	Neutral normal ammonium acetate extract using Atomic Absorption Spectrophotometer (Jackson, 1958)
8	Available Mg	Neutral normal ammonium acetate extract using Atomic Absorption Spectrophotometer (Jackson, 1958)
9	Available S	$CaCl_2$ extract- turbidimetry method (Chesnin and Yien, 1951)
10	Available Fe, Mn, Cu & Zn	0.1M HCl acid extract method using Atomic Absorption Spectrophotometer (Sims and Johnson, 1991)
11	Available B	Hot water extraction and Azomethine- H method using Spectrophotometer (Berger and Truog, 1945; Gupta, 1967)
12	Available Si	0.5M acetic acid extract method using Inductively Coupled Plasma Optical Emission Spectrometry (Korndorfer *et al.*, 2001)

Table 3.6 Methods used for chemical analysis of plant

No.	Nutrient	Method
1	N	Microkjeldhal digestion and distillation method (Jackson, 1958)
2	P	Diacid digestion of leaf sample followed by filtration. Vandadomolybdate phosphoric yellow colour in nitric acid system (Piper, 1966)
3	K	Diacid extract using Flame Photometer (Piper, 1966)
4	Ca	Diacid extract using Atomic Absorption Spectrophotometer (Piper, 1966)
5	Mg	Diacid extract using Atomic Absorption Spectrophotometer (Piper, 1966)
6	Fe, Mn, Cu & Zn	Diacid extract using Atomic Absorption Spectrophotometer (Piper, 1966)
7	B	By dry ashing (Gaines and Mitchell, 1979) and Azomethine-H method (Bingham, 1982)
8	Si	Boric acid extract using Inductively Coupled Plasma Optical Emission Spectrometry (Ma *et al.*,2004)

3.2 SELECTION OF BEST PERFORMING MEDIA FOR EXPERIMENT II

Scoring technique was utilized to rank the growing media based on the most important parameters influencing a quality mat nursery.

Parameters selected for scoring the growing media were:

- Seedling height at 15 DAS (at the time of transplanting)
- Biomass production at 15 DAS (at the time of transplanting)
- Root length at 15 DAS (at the time of transplanting)
- Mat thickness at 15 DAS (at the time of transplanting)
- Mat weight per unit area at 15 DAS (at the time of transplanting)
- Mat strength at 15 DAS (at the time of transplanting)
- Number of normal seedlings at 15 DAS (at the time of transplanting)
- Nitrogen content of seedlings at 15 DAS (at the time of transplanting)
- Phosphorus content of seedlings at 15 DAS (at the time of transplanting)
- Potassium content of seedlings at 15 DAS (at the time of transplanting)

The range of values of the selected parameters was classified into three as high, medium and low and score of 5, 3 and 2 were given to high, medium and low classes respectively. The recorded value of the selected parameter of different treatments were classified and given scores as mentioned above. The aggregate score for each growing medium was calculated and the different media were ranked based on the sum of scores obtained. Best performing 10 growing media based on the rank were selected for Experiment II.

3.3 EXPERIMENT II. FIELD EVALUATION OF BEST PERFORMING MEDIA SELECTED FROM EXPERIMENT I

3.3.1 General details

3.3.1.1 Location

The Experiment II was conducted at Agricultural Research Station, Mannuthy, from 24th July, 2013 to 8th November 2013. The experimental site is situated at 12^{0} 32^{1} latitude and 74^{0} 20^{1} E longitude at an altitude of 22.5 m above mean sea level.

3.3.1.2 Climate and weather conditions

The experimental site enjoys typical humid tropical climate. The maximum and minimum temperature during the cropping period varied from 31.9°C to 23.1°C respectively. Maximum rainfall was received during the month of July. The mean monthly averages of important meteorological parameters observed during the experimental period are presented in Appendix I.

3.3.1.3 Soil characters

The soil of the experimental site is sandy clay loam in texture. The physico-chemical characteristics of the soil of the experimental field are presented in Table 3.7.

3.3.1.4 Cropping history of the experimental site

The experimental site is a double crop paddy wet land and vegetables are cultivating during summer season.

Table 3.7 Physico-chemical characteristics of the soil prior to the field experiment

Properties	Value
a. Physical properties	
Bulk density (g cm^{-3})	1.34
Particle density (g cm^{-3})	2.16
Water holding capacity (%)	46.1
Particle size composition	
Coarse sand (%)	27.1
Fine sand (%)	23.9
Silt (%)	22.8
Clay (%)	26.2
Texture	Sandy clay loam
b. Chemical properties	
Soil reaction (pH)	5.46
Electrical conductivity (dS/ m)	0.08
Organic Carbon (%)	0.78
Available N (kg/ ha)	200.70
Available P_2O_5 (kg/ ha).	24.89
Available K_2O (kg/ ha)	465.90

3.3.2 Experimental details

The experimental design was RBD with three replications. There were 10 treatments. The plot size was 7 m x 3 m. The mechanical transplanting using 8-row *Yanji Shakthi* transplanter (Plate 3) was adopted for planting. The layout of the experiment is depicted in Fig.3.1. The treatment details are given in Table 3.9.

3.3.2.1 Fertilizers

Urea, Rajphos and Muriate of potash were used as the nutrient sources for nitrogen, phosphorus and potassium respectively. The nutrient content of the fertilizers used in the experiment is given in Table 3.8.

Table 3.8 Nutrient content of the fertilizers used in the Experiment II

Nutrients	Fertilizer	Nutrient content (%)
Nitrogen	Urea	46
Phosphorous	Rajphos	18
Potassium	Muriate of potash	60

3.3.3 Crop culture

3.3.3.1 Land preparation and manure application

Plots of 7 m x 3 m were taken after ploughing and leveling the field by tractor. The lime @ 350 kg/ ha was applied basally at the time of first ploughing. Remaining dose of lime @ 250 kg/ ha was applied one month after sowing.FYM @ 5 t/ ha was applied after 10 days of lime application.

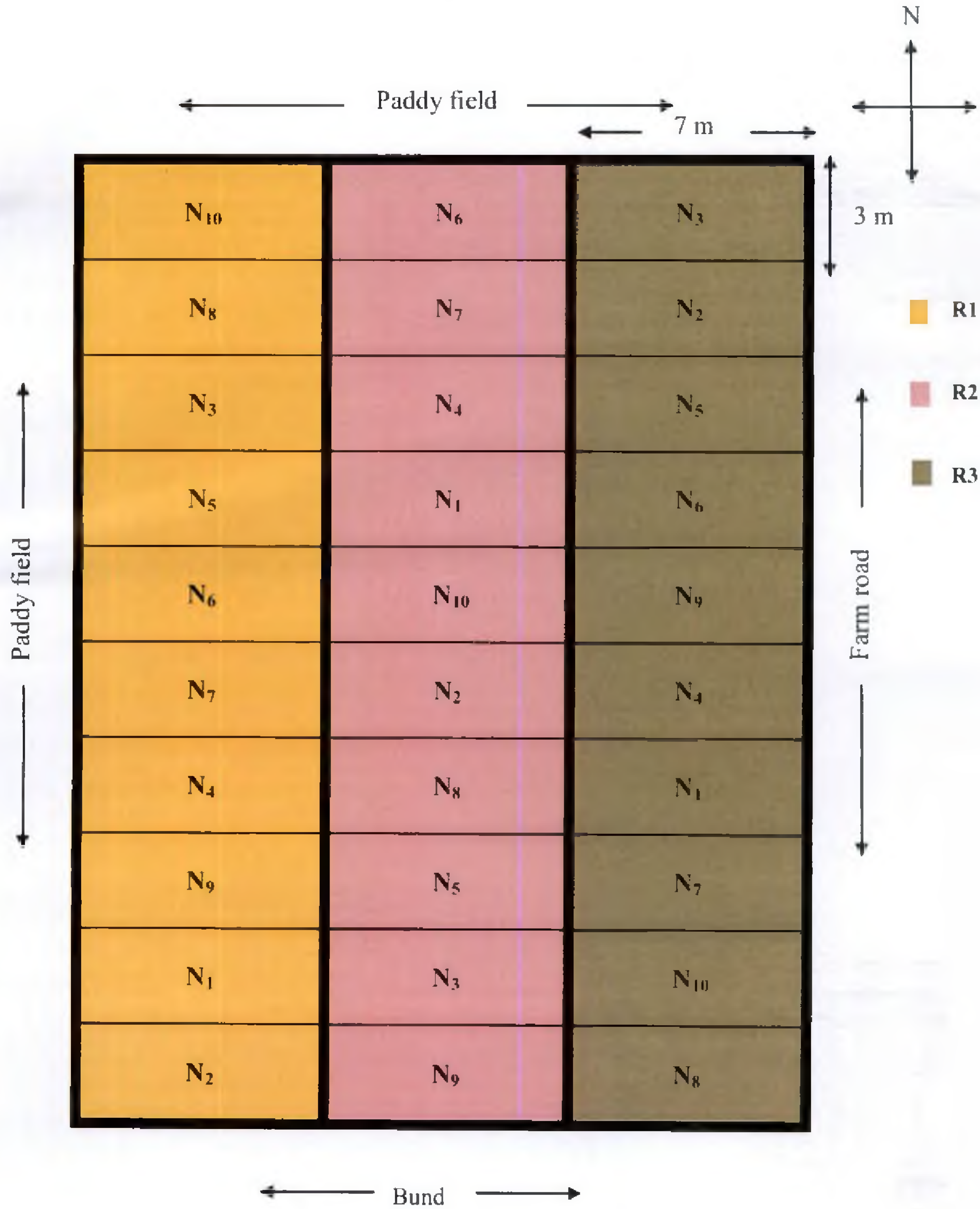

Fig. 3.1 Lay out of the experimental plot

Plate 3. Eight row *Yanji Shakti* transplanter

Table 3.9 Details of treatments in Experiment II

Treatments	
N_1	80% Rice husk charcoal + 20% Vermicompost
N_2	60% Rice husk charcoal + 20% Soil + 20% Vermicompost
N_3	40% Rice husk charcoal + 40% Soil + 20% Vermicompost
N_4	20% Rice husk charcoal + 60% Soil + 20% Vermicompost
N_5	60% Rice husk charcoal + 30% Soil + 10% Vermicompost
N_6	40% Rice husk charcoal + 50% Soil + 10% Vermicompost
N_7	20% Rice husk charcoal + 70% Soil + 10% Vermicompost
N_8	80% Rice husk charcoal + 20% Coir pith compost
N_9	60% Rice husk charcoal + 20% Soil + 20% Coir pith compost
N_{10}	60% Rice husk charcoal + 30% Soil + 10% Coir pith compost

3.3.3.2 Mechanical transplanting using Yanji Shakthi transplanter

Eight row *Yanji Shakthi* transplanter (Plate 3) is a Chinese transplanter and this machine was used for transplanting seedlings at a spacing of 23.8 cm x 14 cm. The machine needed one driver and two workers for feeding the mat into the seedling box of the transplanter. The average fuel consumption of the machine was 500 ml of diesel per hour. Nursery was prepared on 09.07.2014 and transplanting of the seedlings was done on 24.07.2014.

3.3.3.3 Fertilizer application

Urea, Rajphos and Muriate of potash were applied at 15 days after transplanting of the seedlings. Nitrogen was applied in three equal splits as basal, maximum tillering and at panicle initiation stage, potassium in two equal splits at basal and at panicle initiation and phosphorus at full dose as basal.

3.3.3.4 After cultivation

The cultural operations were carried out as per the Package of Practices recommendations of the Kerala Agricultural University (KAU, 2011). The plots were kept weed free by herbicide application followed by hand weeding. Londax @ 1 kg/ ha was applied as pre-emergence herbicide on fifth day of transplanting.

3.3.3.5 Plant protection

Plant protection measures were also taken up. Cartap hydrochloride @ 25 kg/ ha was applied when incidence of stem borer was noticed. Propiconazole @ 1 ml/ lit was applied against sheath blight. Acephate @ 3 g/ lit.was sprayed when incidence of leaf roller was noticed. Rice bug was controlled by Flubendiamide @ 0.1 ml/ 10 lit and Cypermethrin @ 20 ml/ lit.

3.3.3.6 Harvesting

The crop was harvested on 08.11.2014. Plants in the border rows from four sides of the field were harvested first and net plot area was harvested. Threshing was done with mechanical thresher (Redlands mechanical thresher and winnower) and grain and straw were separated and the weight was recorded. The weight of grain was expressed at 12 per cent moisture content and that of straw as air dry weight in kg/ ha.

3.3.4 Observations recorded

3.3.4.1 Performance of transplanter

3.3.4.1.1 Number of hills planted per metre run

Number of hills planted per metre run was counted from five random places per plot using a metre scale and the mean was worked out.

3.3.4.1.2 Number of seedlings per hill

Number of seedlings planted per hill was counted from ten random places per plot and the mean was worked out.

3.3.4.1.3 Number of missing hills per m^2

Number of missing hills per m^2 was counted from five random places per plot using a quadrate and the mean was worked out.

3.3.4.1.4 Plant population per m^2 at planting

Number of plants per m^2 from five random places per plot at planting was counted using a quadrate and the mean was worked out.

3.3.4.2 Biometric observations

3.3.4.2.1 Plant population per m^2 at maximum tillering and harvest stages

Number of plants per m^2 from five random places per plot at maximum tillering and harvest stages were counted using a quadrate and the mean was worked out.

3.3.4.2.2 Plant height

Height of ten plants was measured in cm from ground level to the tip of the longest leaf at 30 and 60 days after sowing (DAS) and at harvest were measured and mean was worked out.

3.3.4.2.3 Tiller count per m^2

The number of tillers per m^2 at 30 and 60 DAS and at harvest was counted at three random places from each plot using a quadrate and the mean was worked out.

3.3.4.2.4 Weed count per m^2

The number of weeds per m^2 at 20 and 40 DAS was counted from each plot and the mean was worked out.

3.3.4.3 Yield attributes

3.3.4.3.1 Number of panicles per m^2

Number of panicles per m^2 was counted from five random places per plot using a quadrate and the mean was worked out.

3.3.4.3.2 Number of spikelets per panicle

The number of spikelets per panicle was counted from twenty five randomly selected panicles and mean was worked out.

3.3.4.3.3 Number of filled grains per panicle

The number of filled grains per panicle was counted from twenty five randomly selected panicles and mean was worked out.

3.3.4.3.4 Thousand grain weight

One thousand filled grains taken randomly were weighed to get the test weight.

3.3.4.3.5 Spikelet sterility

Grains were collected from randomly selected twenty five panicles and separated into filled grains and chaff. The number of filled grains of each panicle was counted and expressed as percentage of total grain.

3.3.4.4 Grain and Straw yield

The crop was harvested from each plot, threshed, grain and straw were separated and winnowed. The weight of grain and straw from each plot was recorded separately and expressed in t/ ha.

3.3.4.5 Harvest index

The proportion of biological yield to economic yield is called as harvest index. The HI was calculated by the formula given by Redford (1967).

$$HI = \frac{\text{Economical yield}}{\text{Biological yield}} \times 100$$

3.3.5 Chemical analysis

3.3.5.1 Soil analysis

Soil samples were collected from the plot before and after the experiment. Samples air dried, powdered and passed through 2 mm sieve, was used for analyzing physico - chemical characteristics of the soil. pH and EC of soil were also measured. The various methods used for the analysis are mentioned in Table 3.5.

3.3.5.2 Plant analysis

Five plants were selected at random from each plot. Plant samples were collected at harvest for analysis. Samples were dried in a hot air oven at 60 ± 5°C, ground well and analyzed for different nutrients. The methods used for the analysis of different nutrients are given in Table 3.6.

3.3.6 Uptake of nutrients

Uptake of nutrients is calculated by multiplying the particular nutrient content in plant at harvest with dry matter production at harvest.

3.4 Economics of nursery and cultivation

The cost for raising nursery was calculated on the basis of prevailing market price of different inputs used for raising nursery. Details of cost of nursery are presented in Appendix II.

The cost of cultivation, gross returns and benefit: cost ratio (gross return/ cost of cultivation) was calculated on the basis of prevailing market price of different inputs and outputs. The price of rice and that of straw bale at current local market prices were taken as Rs. 19/ kg and Rs. 70 per bale (12 kg/ bale) respectively. Benefit cost ratio was worked out by dividing the gross return with total expenditure per hectare. Details of cost of cultivation are presented in Appendix III and that of inputs used for the study are depicted in Appendix IV.

3.5 Statistical analysis

Statistical packages such as MSTAT-C and Microsoft excel spread sheets were used for computation and analysis (Freed, 1986). Duncan's multiple range test (DMRT) was used to compare means (Duncan, 1955; Gomez and Gomez, 1984).

Plate 4. Trays prepared for mat nursery

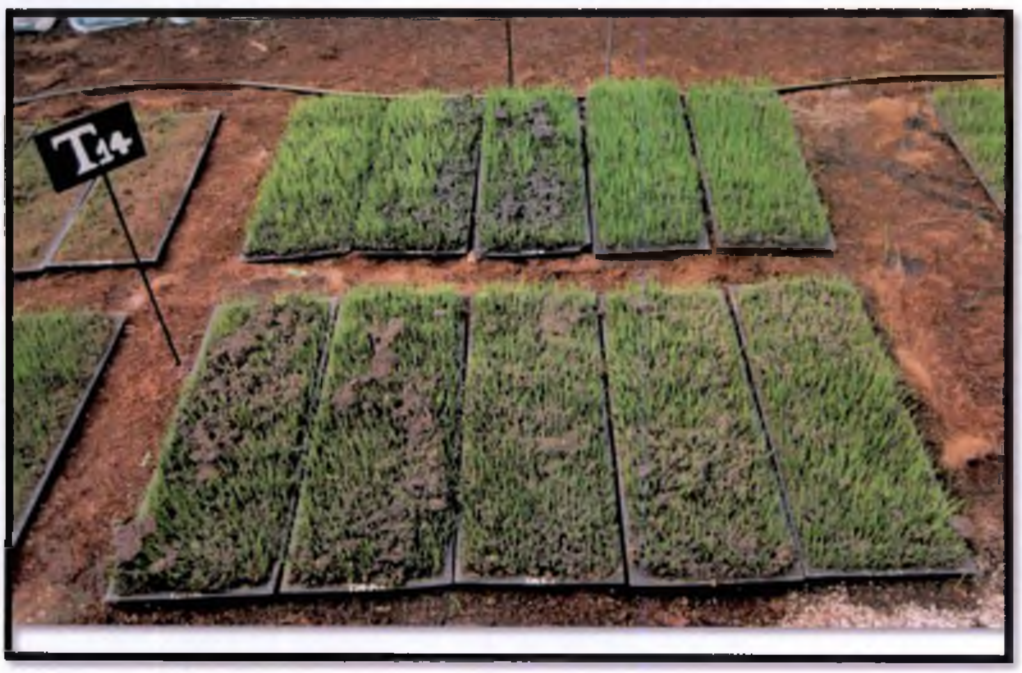

Plate 5. Tray nursery at 5 DAS

Plate 6. General view of the field after mechanical transplanting

Plate 7. General view of the field at 60 DAT

Results

IV. RESULTS

A field experiment on "Standardization of media for tray nursery technique in rice" was conducted during 2013-2015 at Agricultural Research Station, Mannuthy in Thrissur district. The data obtained from the two experiments of the study are described here with appropriate tables after statistical analysis.

4.1 STANDARDIZATION OF MEDIA FOR TRAY NURSERY TECHNIQUE IN RICE

The Experiment I was conducted for the standardization of suitable growing media for tray nursery of rice with 18 growing media and they consisted of four levels of rice husk charcoal, seven levels of soil and two levels of vermicompost or coir pith compost. The results of the experiment are discussed in this chapter involving different parameters that contribute to the strength of a mat for rice seedlings.

4.1.1 Biometric characters of seedlings

The biometric characters did not show significant variation with respect to growing media at 5 and 10 days after sowing (DAS).

4.1.1.1 Mean germination time

50 per cent of seedlings were germinated by five days after sowing for all the 18 media.

4.1.1.2 Seedling height

The height of seedlings recorded at five days interval is presented in table 4.1. As regards the different media, T_1 (80% RHC + 20% VC) contributed to the maximum height (13.08 cm). It was followed by T_2 (60% RHC + 20% soil + 20%

VC) and T_{10} (60% RHC + 20% soil + 20% CC). Shorter seedlings (7.36 cm) were produced in control media (T_{18}) throughout the seedling growth.

4.1.1.3 Biomass production

The biomass production of seedlings as influenced by variation in growing media at five days interval is presented in Table 4.2. The highest (1.07 g) biomass production was observed in T_1 (80% RHC + 20% VC) and it was on par with T_2 (60% RHC + 20% soil + 20% VC) and T_3 (40% RHC + 40% soil + 20% VC). The biomass production of seedlings was the lowest (0.45 g) in the media of 40% RHC + 40% soil + 20% CC (T_{11}).

4.1.1.4 Shoot dry weight

The data on shoot dry weight of seedlings at 5 DAS, 10 DAS and 15 DAS are presented in Table 4.3. The shoot dry weight of seedlings at 15 DAS was higher (0.15 g) in the media T_1 (80% RHC + 20% VC) and T_2 (60% RHC + 20% soil + 20% VC) which were followed by T_9 (80% RHC + 20% CC). The lowest (0.05 g) root dry weight was noticed in the control media (T_{18}).

4.1.1.5 Root dry weight

The root dry weight of seedlings at five days interval is shown in Table 4.4. The control media produced the highest (0.1 g) root dry weight at 15 DAS and it was on par with T_4 (20% RHC + 60% soil + 20% VC), T_8 (20% RHC + 70% soil + 10% VC), T_{14} (60% RHC + 30% soil + 10% CC) and T_{16} (20% RHC + 70% soil + 10% CC). The root dry weight of seedlings at 15 DAS was the lowest (0.02 g) in T_{13} (80% RHC + 10% soil + 10% CC).

4.1.1.6 Dry matter production

The dry matter production of seedlings at 5 DAS, 10 DAS and at 15 DAS as influenced by variation in growing media is presented in Table 4.5.

Table 4.1 Height of seedlings (cm) as influenced by variation in growing media

Treatment		5 DAS	10 DAS	15 DAS
T_1	80% RHC + 20% VC	4.26^{a}	8.40^{a}	13.08^{a}
T_2	60% RHC + 20% soil + 20% VC	3.34^{bcdefg}	5.60^{fg}	12.18^{b}
T_3	40% RHC + 40% soil + 20% VC	3.18^{cdefgh}	6.52^{cdef}	11.48^{d}
T_4	20% RHC + 60% soil + 20% VC	2.86^{fgh}	5.72^{efg}	9.32^{gh}
T_5	80% RHC + 10% soil + 10% VC	3.72^{abc}	7.90^{ab}	12.08^{bc}
T_6	60% RHC + 30% soil + 10% VC	2.94^{defgh}	6.68^{cdef}	11.50^{d}
T_7	40% RHC + 50% soil + 10% VC	2.88^{efgh}	6.02^{defg}	9.82^{fg}
T_8	20% RHC + 70% soil + 10% VC	2.74^{gh}	7.10^{bcd}	9.24^{h}
T_9	80% RHC + 20% CC	4.00^{ab}	6.84^{bcde}	10.46^{e}
T_{10}	60%RHC + 20% soil + 20% CC	3.64^{abcde}	6.94^{bcd}	12.44^{b}
T_{11}	40% RHC + 40% soil + 20% CC	3.00^{cdefgh}	6.42^{cdefg}	11.62^{cd}
T_{12}	20% RHC + 60% soil + 20% CC	3.18^{cdefgh}	5.40^{g}	9.28^{h}
T_{13}	80% RHC + 10% soil + 10% CC	3.34^{bcdefg}	6.26^{defg}	9.90^{f}
T_{14}	60% RHC + 30% soil + 10% CC	3.62^{abcdef}	6.36^{defg}	9.56^{fgh}
T_{15}	40% RHC + 50% soil + 10% CC	3.70^{abcd}	6.80^{cde}	9.60^{fgh}
T_{16}	20% RHC + 70% soil + 10% CC	2.54^{h}	5.76^{efg}	8.52^{i}
T_{17}	80% RHC + 20% soil	4.30^{a}	7.52^{abc}	10.76^{e}
T_{18}	Control	2.50^{h}	4.38^{h}	7.36^{j}

* The means followed by common alphabets do not differ significantly at 5% level in DMRT

Table 4.2 Biomass production of seedlings (g) as influenced by variation in growing media

Treatment		5 DAS	10 DAS	15 DAS
T_1	80% RHC + 20% VC	0.10^{def}	0.34^{d}	1.07^{a}
T_2	60% RHC + 20% soil + 20% VC	0.11^{cdef}	0.18^{k}	0.97^{ab}
T_3	40% RHC + 40% soil + 20% VC	0.10^{def}	0.34^{d}	0.90^{abc}
T_4	20% RHC + 60% soil + 20% VC	0.11^{cdef}	0.25^{g}	0.73^{cdefg}
T_5	80% RHC + 10% soil + 10% VC	0.11^{cdef}	0.40^{a}	0.50^{hi}
T_6	60% RHC + 30% soil + 10% VC	0.12^{cde}	0.39^{b}	0.61^{defghi}
T_7	40% RHC + 50% soil + 10% VC	0.10^{def}	0.34^{cd}	0.81^{bcd}
T_8	20% RHC + 70% soil + 10% VC	0.12^{cd}	0.27^{e}	0.67^{defgh}
T_9	80% RHC + 20% CC	0.12^{cdef}	0.27^{e}	0.66^{defgh}
T_{10}	60%RHC + 20% soil + 20% CC	0.09^{f}	0.35^{c}	0.55^{ghi}
T_{11}	40% RHC + 40% soil + 20% CC	0.10^{ef}	0.18^{k}	0.45^{i}
T_{12}	20% RHC + 60% soil + 20% CC	0.13^{bc}	0.25^{g}	0.56^{fghi}
T_{13}	80% RHC + 10% soil + 10% CC	0.17^{a}	0.20^{j}	0.63^{efghi}
T_{14}	60% RHC + 30% soil + 10% CC	0.18^{a}	0.22^{i}	0.73^{cdef}
T_{15}	40% RHC + 50% soil + 10% CC	0.13^{c}	0.22^{i}	$0. 66^{defgh}$
T_{16}	20% RHC + 70% soil + 10% CC	0.16^{ab}	0.26^{f}	0.66^{defgh}
T_{17}	80% RHC + 20% soil	0.16^{ab}	0.24^{h}	0.74^{cde}
T_{18}	Control	0.18^{a}	0.18^{k}	0.63^{efghi}

* The means followed by common alphabets do not differ significantly at 5% level in DMRT

Table 4.3 Shoot dry weight of seedlings (g) as influenced by variation in growing media

Treatment		5 DAS	10 DAS	15 DAS
T_1	80% RHC + 20% VC	0.03^{ab}	0.06^{b}	0.15^{a}
T_2	60% RHC + 20% soil + 20% VC	0.02^{de}	0.06^{b}	0.15^{a}
T_3	40% RHC + 40% soil + 20% VC	0.03^{abcd}	0.06^{b}	0.09^{d}
T_4	20% RHC + 60% soil + 20% VC	0.02^{de}	0.04^{de}	0.06^{fg}
T_5	80% RHC + 10% soil + 10% VC	0.02^{de}	0.05^{b}	0.10^{c}
T_6	60% RHC + 30% soil + 10% VC	0.03^{abcd}	0.06^{b}	0.08^{de}
T_7	40% RHC + 50% soil + 10% VC	0.03^{abc}	0.05^{b}	0.08^{e}
T_8	20% RHC + 70% soil + 10% VC	0.03^{abc}	0.04^{b}	0.06^{fg}
T_9	80% RHC + 20% CC	0.03^{abcd}	0.06^{b}	0.12^{b}
T_{10}	60%RHC + 20% soil + 20% CC	0.03^{bcd}	0.07^{a}	0.07^{f}
T_{11}	40% RHC + 40% soil + 20% CC	0.03^{abc}	0.05^{b}	0.07^{f}
T_{12}	20% RHC + 60% soil + 20% CC	0.02^{e}	0.05^{b}	0.06^{fg}
T_{13}	80% RHC + 10% soil + 10% CC	0.02^{e}	0.04^{b}	0.09^{d}
T_{14}	60% RHC + 30% soil + 10% CC	0.03^{abc}	0.04^{b}	0.06^{fg}
T_{15}	40% RHC + 50% soil + 10% CC	0.04^{a}	0.04^{b}	0.06^{fg}
T_{16}	20% RHC + 70% soil + 10% CC	0.03^{cde}	0.03^{b}	0.05^{gh}
T_{17}	80% RHC + 20% soil	0.03^{abcd}	0.07^{b}	0.10^{c}
T_{18}	Control	0.02^{e}	0.03^{b}	0.05^{h}

* The means followed by common alphabets do not differ significantly at 5% level in DMRT

Table 4.4 Root dry weight of seedlings (g) as influenced by variation in growing media

Treatment		5 DAS	10 DAS	15 DAS
T_1	80% RHC + 20% VC	0.02^{def}	0.03^{d}	0.05^{g}
T_2	60% RHC + 20% soil + 20% VC	0.02^{efg}	0.03^{abcd}	0.04^{h}
T_3	40% RHC + 40% soil + 20% VC	0.03^{bcd}	0.03^{abcd}	0.08^{de}
T_4	20% RHC + 60% soil + 20% VC	0.01^{h}	0.03^{abcd}	0.09^{ab}
T_5	80% RHC + 10% soil + 10% VC	0.02^{cdef}	0.03^{abcd}	0.03^{hi}
T_6	60% RHC + 30% soil + 10% VC	0.01^{h}	0.02^{d}	0.05^{fg}
T_7	40% RHC + 50% soil + 10% VC	0.03^{bcde}	0.05^{d}	0.09^{bcd}
T_8	20% RHC + 70% soil + 10% VC	0.04^{a}	0.06^{ab}	0.09^{abc}
T_9	80% RHC + 20% CC	0.02^{cdef}	0.03^{abcd}	0.03^{hij}
T_{10}	60%RHC + 20% soil + 20% CC	0.03^{bcde}	0.04^{bcd}	0.05^{fg}
T_{11}	40% RHC + 40% soil + 20% CC	0.02^{abcd}	0.05^{abc}	0.07^{e}
T_{12}	20% RHC + 60% soil + 20% CC	0.03^{abcd}	0.05^{abcd}	0.07^{de}
T_{13}	80% RHC + 10% soil + 10% CC	0.01^{fgh}	0.02^{cd}	0.02^{j}
T_{14}	60% RHC + 30% soil + 10% CC	0.04^{a}	0.06^{abc}	0.09^{abc}
T_{15}	40% RHC + 50% soil + 10% CC	0.03^{ab}	0.06^{ab}	0.08^{cd}
T_{16}	20% RHC + 70% soil + 10% CC	0.03^{cde}	0.06^{abcd}	0.09^{ab}
T_{17}	80% RHC + 20% soil	0.03^{abc}	0.04^{abcd}	0.06^{f}
T_{18}	Control	0.01^{gh}	0.06^{a}	0.10^{a}

* The means followed by common alphabets do not differ significantly at 5% level in DMRT

The highest (0.2 g) dry matter production of seedlings at 15 DAS was observed in T_1 (80% RHC + 20% VC) and it was on par with T_2 (60% RHC + 20% soil + 20% VC) and T_3 (40% RHC + 40% soil + 20% VC). The lowest (0.1 g) dry matter production was recorded in T_{10} (60% RHC + 20% soil + 20% CC).

4.1.1.7 Root length at transplanting

The data on root length of seedlings at transplanting are given in Table 4.6. The root length was found to be maximum (11.28 cm) with regards to T_2 (60% RHC + 20% soil + 20% VC) and it was on par with T_1 (80% RHC + 20% VC) and T_{13} (80% RHC + 10% soil + 10% CC). The lowest root length of 6.2 cm was recorded in control media (T_{18}).

4.1.1.8 Pest and disease incidence scoring

There was no pest and disease incidence in the nursery, scoring was hence not done.

4.1.1.9 Number of normal and abnormal seedlings per m^2

The number of normal and abnormal seedlings as influenced by variation in growing media is shown in Table 4.7. The highest (30370) number of normal seedlings per m^2 was obtained in the media comprised of 80% RHC + 20% VC (T_1) and it was on par with the media of T_2 (60% RHC + 20% soil + 20% VC), T_5 (80% RHC + 10% soil + 10% VC), T_9 (80% RHC + 20% CC) and T_{13} (80% RHC + 10% soil + 10% CC). The least (20741) number of normal seedlings were recorded in control media (T_{18}). As a complementary phenomenon, the number of abnormal seedlings was recorded the maximum (16667) in control media (T_{18}) and the minimum (4444) in T_1 (80% RHC + 20% VC).

Table 4.5 Dry matter production of seedlings (g) as influenced by variation in growing media

Treatment		5 DAS	10 DAS	15 DAS
T_1	80% RHC + 20% VC	0.06^{cd}	0.09^{cdef}	0.20^{a}
T_2	60% RHC + 20% soil + 20% VC	0.04^{efg}	0.09^{bcd}	0.18^{ab}
T_3	40% RHC + 40% soil + 20% VC	0.06^{cd}	0.09^{bcde}	0.17^{abc}
T_4	20% RHC + 60% soil + 20% VC	0.03^{g}	0.08^{fg}	0.15^{cdefg}
T_5	80% RHC + 10% soil + 10% VC	0.05^{cde}	0.11^{a}	0.13^{hi}
T_6	60% RHC + 30% soil + 10% VC	0.06^{bcd}	0.09^{bcde}	0.13^{hi}
T_7	40% RHC + 50% soil + 10% VC	0.06^{bcd}	0.09^{cdefg}	0.16^{bcd}
T_8	20% RHC + 70% soil + 10% VC	0.07^{ab}	0.09^{bcde}	0.15^{defgh}
T_9	80% RHC + 20% CC	0.05^{cde}	0.09^{bcd}	0.15^{defgh}
T_{10}	60%RHC + 20% soil + 20% CC	0.06^{cd}	0.11^{defg}	0.12^{i}
T_{11}	40% RHC + 40% soil + 20% CC	0.06^{abc}	0.09^{bcde}	0.14^{defghi}
T_{12}	20% RHC + 60% soil + 20% CC	0.05^{def}	0.08^{efg}	0.14^{fghi}
T_{13}	80% RHC + 10% soil + 10% CC	0.04^{fg}	0.09^{bcde}	0.14^{efghi}
T_{14}	60% RHC + 30% soil + 10% CC	0.07^{ab}	0.10^{ab}	0.15^{cdef}
T_{15}	40% RHC + 50% soil + 10% CC	0.07^{a}	0.09^{bcd}	0.15^{defgh}
T_{16}	20% RHC + 70% soil + 10% CC	0.05^{cde}	0.09^{bcdef}	0.15^{defgh}
T_{17}	80% RHC + 20% soil	0.06^{abc}	0.10^{abc}	0.16^{cde}
T_{18}	Control	0.03^{g}	0.07^{g}	0.14^{efghi}

* The means followed by common alphabets do not differ significantly at 5% level in DMRT

Table 4.6 Root length (cm) of seedlings at the time of transplanting (15 DAS) as influenced by variation in growing media

Treatment		**Root length at transplanting (cm)**
T_1	80% RHC + 20% VC	11.00^{ab}
T_2	60% RHC + 20% soil + 20% VC	11.28^{a}
T_3	40% RHC + 40% soil + 20% VC	8.84^{gh}
T_4	20% RHC + 60% soil + 20% VC	9.32^{efg}
T_5	80% RHC + 10% soil + 10% VC	8.54^{h}
T_6	60% RHC + 30% soil + 10% VC	10.16^{cd}
T_7	40% RHC + 50% soil + 10% VC	9.82^{def}
T_8	20% RHC + 70% soil + 10% VC	8.52^{h}
T_9	80% RHC + 20% CC	10.46^{bcd}
T_{10}	60%RHC + 20% soil + 20% CC	10.00^{de}
T_{11}	40% RHC + 40% soil + 20% CC	8.67^{gh}
T_{12}	20% RHC + 60% soil + 20% CC	9.28^{fg}
T_{13}	80% RHC + 10% soil + 10% CC	10.80^{abc}
T_{14}	60% RHC + 30% soil + 10% CC	9.18^{fgh}
T_{15}	40% RHC + 50% soil + 10% CC	9.08^{gh}
T_{16}	20% RHC + 70% soil + 10% CC	8.94^{gh}
T_{17}	80% RHC + 20% soil	10.42^{bcd}
T_{18}	Control	6.20^{i}

* The means followed by common alphabets do not differ significantly at 5% level in DMRT

Table 4.7 Number of normal and abnormal seedlings per m^2 (15 DAS) as influenced by variation in growing media

Treatment		Number of normal seedlings per m^2	Number of abnormal seedlings per m^2
T_1	80% RHC + 20% VC	30370^{a}	4444^{e}
T_2	60% RHC + 20% soil + 20% VC	28889^{ab}	4815^{e}
T_3	40% RHC + 40% soil + 20% VC	25556^{c}	9529^{bc}
T_4	20% RHC + 60% soil + 20% VC	25556^{bc}	8148^{cd}
T_5	80% RHC + 10% soil + 10% VC	28889^{ab}	5185de
T_6	60% RHC + 30% soil + 10% VC	25556^{bc}	8889^{bc}
T_7	40% RHC + 50% soil + 10% VC	24444^{c}	10370^{bc}
T_8	20% RHC + 70% soil + 10% VC	23704^{cd}	10000^{bc}
T_9	80% RHC + 20% CC	28889^{ab}	4815de
T_{10}	60%RHC + 20% soil + 20% CC	25185^{c}	10370^{bc}
T_{11}	40% RHC + 40% soil + 20% CC	23704^{cd}	11111^{bc}
T_{12}	20% RHC + 60% soil + 20% CC	25185^{c}	10000^{bc}
T_{13}	80% RHC + 10% soil + 10% CC	28889^{ab}	5185de
T_{14}	60% RHC + 30% soil + 10% CC	25185^{c}	8889^{bc}
T_{15}	40% RHC + 50% soil + 10% CC	25556^{c}	9630^{bc}
T_{16}	20% RHC + 70% soil + 10% CC	22222^{cd}	16296^{a}
T_{17}	80% RHC + 20% soil	25556^{bc}	11852^{b}
T_{18}	Control	20741^{d}	16667^{a}

* The means followed by common alphabets do not differ significantly at 5% level in DMRT

4.1.2 Mat characteristics

4.1.2.1 Thickness of the media

The thickness of the media was measured and is presented in Table 4.8. The thickness of the media was highest (1.7 cm) in media comprised of 20% RHC + 60% soil + 20% VC (T_4) and it was on par with T_6 (60% RHC + 30% soil + 10% VC). The thickness of the growing media was poor (1.3 cm) in T_3 (40% RHC + 40% soil + 20% VC), T_{11} (40% RHC + 40% soil + 20% CC) and T_{14} (60% RHC + 30% soil + 10% CC).

4.1.2.2 Mat weight

The data pertaining to the weight of mat are given in Table 4.8. The highest (12.97 kg/ m^2) mat weight was recorded in the control media (T_{18}) which was on par with T_3 (40% RHC + 40% soil + 20% VC), T_8 (20% RHC + 70% soil + 10% VC), T_{15} (40% RHC + 50% soil + 10% CC) and T_{16} (20% RHC + 70% soil + 10% CC). The mat weight was found to be the lowest (5.19 kg/ m^2) in media comprised of 80% RHC + 20% CC (T_9).

4.1.2.3 Strength of mat

The effect of different growing media on strength of mat is presented in Table 4.8. The strength of mat was found to be the highest (74.47 kg/ m^2) in media comprised of 80% RHC + 20% CC (T_9) which was on par with T_2 (60% RHC + 20% soil + 20% VC), T_3 (40% RHC + 40% soil + 20% VC), T_6 (60% RHC + 30% soil + 10% VC), T_7 (40% RHC + 50% soil + 10% VC), T_8 (20% RHC + 70% soil + 10% VC), T_{14} (60% RHC + 30% soil + 10% CC) and T_{15} (40% RHC + 50% soil + 10% CC). The media T_4 (20% RHC + 60% soil + 20% VC) and T_{10} (60% RHC + 20% soil + 20% CC) recorded the poor mat strength.

Table 4.8 Thickness (cm), weight (kg/ m^2) and strength (kg/ m^2) of mat at the time of transplanting (15 DAS) as influenced by variation in growing media

Treatment		Thickness of media (cm)	Mat weight (kg/ m^2)	Mat strength (kg/ m^2)
T_1	80% RHC + 20% VC	1.33^{ef}	5.92^{jk}	44.19^{ef}
T_2	60% RHC + 20% soil + 20% VC	1.56^{bc}	6.30^{jk}	62.12^{abcde}
T_3	40% RHC + 40% soil + 20% VC	1.30^{f}	11.86^{abc}	70.68^{ab}
T_4	20% RHC + 60% soil + 20% VC	1.70^{a}	10.74^{cde}	37.65^{f}
T_5	80% RHC + 10% soil + 10% VC	1.33^{ef}	7.03^{ij}	46.89^{def}
T_6	60% RHC + 30% soil + 10% VC	1.60^{ab}	8.89^{gh}	60.61^{abcde}
T_7	40% RHC + 50% soil + 10% VC	1.33^{ef}	10.37^{def}	65.12^{abcd}
T_8	20% RHC + 70% soil + 10% VC	1.57^{bc}	9.26^{ab}	58.11^{abcde}
T_9	80% RHC + 20% CC	1.43^{de}	5.19^{k}	74.47^{a}
T_{10}	60%RHC + 20% soil + 20% CC	1.43^{de}	6.67^{j}	37.88^{f}
T_{11}	40% RHC + 40% soil + 20% CC	1.30^{f}	8.52^{gh}	46.67^{def}
T_{12}	20% RHC + 60% soil + 20% CC	1.47^{cd}	8.14^{hi}	53.03^{bcdef}
T_{13}	80% RHC + 10% soil + 10% CC	1.57^{bc}	9.63^{efg}	46.68^{def}
T_{14}	60% RHC + 30% soil + 10% CC	1.30^{f}	11.48^{bcd}	60.61^{abcde}
T_{15}	40% RHC + 50% soil + 10% CC	1.43^{de}	11.85^{abc}	69.47^{ab}
T_{16}	20% RHC + 70% soil + 10% CC	1.33^{ef}	12.59^{ab}	49.24^{cdef}
T_{17}	80% RHC + 20% soil	1.33^{ef}	7.03^{ij}	42.96^{ef}
T_{18}	Control	1.53^{bcd}	12.97^{a}	54.32^{bcdef}

* The means followed by common alphabets do not differ significantly at 5% level in DMRT

4.1.3 Physical properties of RHC, VC and CC

The physical properties of components of growing media *viz.* rice husk charcoal, vermicompost and coir pith compost are presented in Table 4.9. Vermicompost recorded higher water holding capacity of 302.5% among the three different components of growing media analysed. The water holding capacity of rice husk charcoal and coir pith compost was 285.69% and 274.08% respectively. Among the three components of growing media analysed, coir pith compost recorded the highest bulk density (2.4 g cm^{-3}) and the bulk density of the rice husk charcoal was the lowest (0.5 g cm^{-3}).

Table 4.9 Physical properties of RHC, VC and CC

No.	Parameters	Rice husk charcoal	Vermicompost	Coir pith compost
1	Water holding capacity (%)	285.69	302.50	274.08
2	Bulk density (g/ cm^3)	0.50	1.96	2.40

4.1.4 Physical properties of growing media

The physical properties *viz.* water holding capacity and bulk density of media are given in Table 4.10. The media of 80% RHC + 20% CC (T_9) recorded the highest (371.83%) water holding capacity and it was followed by T_1 (80% RHC + 20% VC) and T_5 (80% RHC + 10% soil + 10% VC). The media T_4 (20% RHC + 60% soil + 20% VC), T_8 (20% RHC + 70% soil + 10% VC) and T_{12} (20% RHC + 60% soil + 20% CC) recorded lower water holding capacity. The bulk density of the media found to be highest (5.69 g/ cm^3) in T_{16} (20% RHC + 70% soil + 10% CC) followed by T_8 (20% RHC + 70% soil + 10% VC). The media of 80% RHC + 20% CC (T_9) recorded the lowest (0.57 g/ cm^3) bulk density among the different growing media.

Table 4.10 Physical properties of growing media

Treatment		Water holding capacity (%)	Bulk density (g/ cm^3)
T_1	80% RHC + 20% VC	273.76^{b}	0.76^{kl}
T_2	60% RHC + 20% soil + 20% VC	114.52^{e}	1.82^{g}
T_3	40% RHC + 40% soil + 20% VC	54.51^{gh}	2.43^{f}
T_4	20% RHC + 60% soil + 20% VC	39.13^{h}	3.30^{d}
T_5	80% RHC + 10% soil + 10% VC	265.16^{b}	1.07^{hij}
T_6	60% RHC + 30% soil + 10% VC	118.20^{e}	1.97^{g}
T_7	40% RHC + 50% soil + 10% VC	64.24^{fg}	1.93^{g}
T_8	20% RHC + 70% soil + 10% VC	45.36^{h}	4.92^{b}
T_9	80% RHC + 20% CC	371.83^{a}	0.57^{l}
T_{10}	60% RHC + 20% soil + 20% CC	167.85^{d}	1.34^{h}
T_{11}	40% RHC + 40% soil + 20% CC	75.32^{f}	3.12^{d}
T_{12}	20% RHC + 60% soil + 20% CC	43.80^{h}	3.63^{c}
T_{13}	80% RHC + 10% soil + 10% CC	239.76^{c}	0.91^{jk}
T_{14}	60% RHC + 30% soil + 10% CC	150.87^{d}	1.81^{g}
T_{15}	40% RHC + 50% soil + 10% CC	79.50^{f}	2.82^{e}
T_{16}	20% RHC + 70% soil + 10% CC	47.89^{gh}	5.69^{a}
T_{17}	80% RHC + 20% soil	153.10^{d}	1.31^{hi}
T_{18}	Control	45.76^{gh}	1.33^{ijk}

* The means followed by common alphabets do not differ significantly at 5% level in DMRT

4.1.5 Chemical properties of RHC, VC and CC

The data pertaining to the chemical properties of rice husk charcoal, vermicompost and coir pith compost are shown in Table 4.11. Among the three components of growing media *viz.* rice husk charcoal, vermicompost and coir pith compost, rice husk charcoal recorded alkaline pH (7.74). Vermicompost (6.86) and coir pith compost (6.72) were acidic in nature. The coir pith compost was recorded higher electrical conductivity of 3.38 dS m^{-1} while the EC of rice husk charcoal and vermicompost were medium in nature. Among the three components of growing media *viz.* rice husk charcoal, vermicompost and coir pith compost analysed, coir pith compost recorded the highest (46.94%) organic carbon content. Rice husk charcoal, vermicompost and coir pith compost recorded nitrogen content of 0.25%, 1.05%, 0.28% respectively. The rice husk charcoal, vermicompost and coir pith compost recorded phosphorus content of 0.46%, 0.81% and 0.08% respectively. The K content of rice husk charcoal, vermicompost and coir pith compost were 0.42%, 1.83% and 0.38% respectively. Rice husk charcoal, vermicompost and coir pith compost recorded calcium content of 0.82%, 2.94% and 1.34% respectively and the Mg content of rice husk charcoal, vermicompost and coir pith compost were 0.44%, 0.91% and 0.54% respectively. Rice husk charcoal, vermicompost and coir pith compost recorded sulphur content of 0.23%, 0.85% and 0.2% respectively and the Fe content of rice husk charcoal, vermicompost and coir pith compost were 4372 mg kg^{-1}, 3952 mg kg^{-1} and 2635 mg kg^{-1} respectively. Rice husk charcoal, vermicompost and coir pith compost recorded Mn content of 182 mg kg^{-1}, 328 mg kg^{-1} and 97 mg kg^{-1} respectively and the Cu content of rice husk charcoal, vermicompost and coir pith compost were 15 mg kg^{-1}, 67 mg kg^{-1} and 36 mg kg^{-1} respectively. Rice husk charcoal, vermicompost and coir pith compost recorded zinc content of 23 mg kg^{-1}, 802 mg kg^{-1} and 65 mg kg^{-1} respectively. The B content of rice husk charcoal, vermicompost and coir pith compost were 382 mg kg^{-1}, 673 mg kg^{-1} and 74 mg kg^{-1} respectively and the silicon content was 6.34%, 5.73% and 7.14% respectively.

Table 4.11 Chemical characteristics of RHC, VC and CC

No.	Properties	Rice husk charcoal	Vermi compost	Coir pith compost
1	pH	7.74	6.86	6.72
2	Electrical conductivity (dS/ m)	2.00	1.85	3.38
3	Organic carbon (%)	8.73	33.50	46.94
4	Nitrogen (%)	0.25	1.05	0.28
5	Phosphorus (%)	0.46	0.81	0.08
6	Potassium (%)	0.42	1.83	0.38
7	Calcium (%)	0.82	2.94	1.34
8	Magnesium (%)	0.44	0.91	0.54
9	Sulphur (%)	0.23	0.85	0.20
10	Iron (mg kg^{-1})	4372	3952	2635
11	Manganese (mg kg^{-1})	182	328	97
12	Copper (mg kg^{-1})	15	67	36
13	Zinc (mg kg^{-1})	23	802	65
14	Boron (mg kg^{-1})	382	673	74
15	Silicon (%)	6.34	5.73	7.14

4.1.6 Chemical properties of growing media

4.1.6.1 pH, EC and organic carbon content of growing me.....

The data pertaining to chemical properties *viz.* pH, electrical conductivity (EC) and organic carbon content of growing media are presented in Table 4.12. All the media recorded acidic pH. The electrical conductivity of different growing media varied from 0.11 to 0.53 dS/ m. The media T_9 (80% RHC + 20% CC) recorded the highest (22.63%) organic carbon content and it was followed by T_1 (80% RHC + 20% VC). The lowest (1.38%) organic content was recorded in soil media (T_{18}).

4.1.6.2 N, P and K contents of growing media

The N, P and K contents of different growing media are presented in Table 4.13. The highest N content of 0.99% was observed in T_4 (20% RHC + 60% soil + 20% VC) and it was followed by the media of 60% RHC + 20% soil + 20% VC (T_2), 40% RHC + 50% soil + 10% VC (T_7) and 40% RHC + 50% soil + 10% CC (T_{15}). The N content of growing media was lowest (0.12%) in soil media (T_{18}). The media T_8 (20% RHC + 70% soil + 10% VC) and T_{12} (20% RHC + 60% soil + 20% CC) were recorded higher P content (1.1%) and the media T_6 (60% RHC + 30% soil + 10% VC), T_{11} (40% RHC + 40% soil + 20% CC), T_{15} (40% RHC + 50% soil + 10% CC) and T_{18} (soil media) were recorded lower P content of media. The K content of media was higher in media of 80% RHC + 20% VC (T_1) and 80% RHC + 20% soil (T_{17}) and the soil media (T_{18}) recorded the lowest (0.02%) K content of growing media.

4.1.6.3 Ca, Mg and S contents of growing media

The data on calcium, magnesium and sulphur contents of growing media are given in Table 4.14. The highest (5559 mg kg^{-1}) Ca content was recorded in T_1 (80% RHC + 20% VC) and it was followed by the media of 60% RHC + 20% soil + 20% VC (T_2). The lowest (732 mg kg^{-1}) Ca content was recorded in soil media (T_{18}).

Table 4.12 pH, electrical conductivity and organic carbon content of growing media

Treatment		pH	Electrical conductivity (dS/ m)	Organic carbon (%)
T_1	80% RHC + 20% VC	6.16	0.17	19.16[b]
T_2	60% RHC + 20% soil + 20% VC	5.78	0.11	11.56[e]
T_3	40% RHC + 40% soil + 20% VC	5.69	0.53	8.79[f]
T_4	20% RHC + 60% soil + 20% VC	5.61	0.22	7.56[h]
T_5	80% RHC + 10% soil + 10% VC	5.80	0.08	12.19[d]
T_6	60% RHC + 30% soil + 10% VC	5.73	0.19	8.79[f]
T_7	40% RHC + 50% soil + 10% VC	5.36	0.19	7.56[h]
T_8	20% RHC + 70% soil + 10% VC	5.47	0.14	5.79[k]
T_9	80% RHC + 20% CC	6.27	0.22	22.63[a]
T_{10}	60% RHC + 20% soil + 20% CC	5.63	0.20	12.19[d]
T_{11}	40% RHC + 40% soil + 20% CC	5.26	0.15	8.14[g]
T_{12}	20% RHC + 60% soil + 20% CC	5.09	0.13	5.79[k]
T_{13}	80% RHC + 10% soil + 10% CC	5.06	0.12	13.36[c]
T_{14}	60% RHC + 30% soil + 10% CC	5.30	0.13	6.92[i]
T_{15}	40% RHC + 50% soil + 10% CC	5.11	0.13	5.23[l]
T_{16}	20% RHC + 70% soil + 10% CC	5.06	0.11	4.05[m]
T_{17}	80% RHC + 20% soil	5.32	0.11	6.37[j]
T_{18}	Control	4.90	0.27	1.38[n]

* The means followed by common alphabets do not differ significantly at 5% level in DMRT

Table 4.13 N, P and K contents of growing media

	Treatment	Nitrogen (%)	Phosphorus (%)	Potassium (%)
T_1	80% RHC + 20% VC	0.47[d]	0.58[ef]	2.39[a]
T_2	60% RHC + 20% soil + 20% VC	0.82[b]	0.68[d]	0.51[de]
T_3	40% RHC + 40% soil + 20% VC	0.41[de]	0.53[f]	0.46[ef]
T_4	20% RHC + 60% soil + 20% VC	0.99[a]	0.30[h]	0.55[d]
T_5	80% RHC + 10% soil + 10% VC	0.24[fg]	0.44[g]	0.46[ef]
T_6	60% RHC + 30% soil + 10% VC	0.47[d]	0.21[i]	0.13[i]
T_7	40% RHC + 50% soil + 10% VC	0.82[b]	0.30[h]	0.27[g]
T_8	20% RHC + 70% soil + 10% VC	0.47[d]	1.10[a]	0.20[gh]
T_9	80% RHC + 20% CC	0.41[de]	0.58[ef]	2.08[b]
T_{10}	60% RHC + 20% soil + 20% CC	0.35[def]	1.03[b]	0.12[i]
T_{11}	40% RHC + 40% soil + 20% CC	0.41[de]	0.21[i]	0.15[hi]
T_{12}	20% RHC + 60% soil + 20% CC	0.47[d]	1.10[a]	0.40[f]
T_{13}	80% RHC + 10% soil + 10% CC	0.47[d]	0.43[g]	1.99[c]
T_{14}	60% RHC + 30% soil + 10% CC	0.47[d]	1.00[bc]	0.10[i]
T_{15}	40% RHC + 50% soil + 10% CC	0.82[b]	0.21[i]	0.10[i]
T_{16}	20% RHC + 70% soil + 10% CC	0.64[c]	0.96[c]	0.02[j]
T_{17}	80% RHC + 20% soil	0.29[efg]	0.61[e]	2.42[a]
T_{18}	Control	0.12[g]	0.01[i]	0.02[j]

* The means followed by common alphabets do not differ significantly at 5% level in DMRT

The media T_1 (80% RHC + 20% VC), T_2 (60% RHC + 20% soil + 20% VC), T_9 (80% RHC + 20% CC), T_{12} (20% RHC + 60% soil + 20% CC), T_{13} (80% RHC + 10% soil + 10% CC) and T_{17} (80% RHC + 20% soil) recorded higher Mg content in media. The soil media (T_{18}) recorded the lowest (177 mg kg^{-1}) Mg content of growing media.

The highest S content of 3178 mg kg^{-1} was recorded in T_1 (80% RHC + 20% VC) and it was followed by T_8 (60% RHC + 20% CC). The S content of media was the lowest (21 mg kg^{-1}) in soil media (T_5).

4.1.6.4 Content of micronutrients in growing media

The data pertaining to content of micronutrients of different growing media are given in Table 4.15. The Fe content was higher in T_7 (40% RHC + 50% soil + 10% VC) and T_8 (20% RHC + 70% soil + 10% VC). The Fe content of media was lowest (55 mg kg^{-1}) in soil media (T_{18}). The highest (892 mg kg^{-1}) Mn content was recorded in T_7 (40% RHC + 50% soil + 10% VC) and it was followed by T_8 (20% RHC + 70% soil + 10% VC). The lowest (24 mg kg^{-1}) Mn content was recorded in soil media (T_{18}). The highest (264 mg kg^{-1}) Cu content was recorded in T_7 (40% RHC + 50% soil + 10% VC) and it was followed by T_2 (60% RHC + 20% soil + 20% VC). The media T_{15} (40% RHC + 50% soil + 10% CC) recorded the lowest (12 mg kg^{-1}) Cu content in media. The highest (94 mg kg^{-1}) Zn content was observed in the media of 20% RHC + 60% soil + 20% CC (T_{12}) and it was on par with T_1 (80% RHC + 20% VC), T_2 (60% RHC + 20% soil + 20% VC), T_7 (40% RHC + 50% soil + 10% CC), T_8 (20% RHC + 70% soil + 10% VC), T_{13} (80% RHC + 10% soil + 10% CC) and T_{14} (60% RHC + 30% soil + 10% CC).

Table 4.14 Ca, Mg and S contents of growing media

Treatment		Calcium (mg/ kg)	Magnesium (mg/ kg)	Sulphur (mg/ kg)
T_1	80% RHC + 20% VC	5559[a]	3178[a]	9863[a]
T_2	60% RHC + 20% soil + 20% VC	5295[b]	3141[a]	9306[e]
T_3	40% RHC + 40% soil + 20% VC	1137[n]	2696[bcd]	4377[m]
T_4	20% RHC + 60% soil + 20% VC	5113[c]	2797[b]	4755[l]
T_5	80% RHC + 10% soil + 10% VC	2811[i]	2705[bcd]	3240[n]
T_6	60% RHC + 30% soil + 10% VC	2310[k]	2752[bc]	5892[h]
T_7	40% RHC + 50% soil + 10% VC	1980[l]	2655[cd]	6902[f]
T_8	20% RHC + 70% soil + 10% VC	4200[f]	2655[cd]	9380[d]
T_9	80% RHC + 20% CC	3741[g]	3174[a]	9613[b]
T_{10}	60% RHC + 20% soil + 20% CC	3543[h]	2524[e]	1994[q]
T_{11}	40% RHC + 40% soil + 20% CC	798[j]	2657[cd]	5442[i]
T_{12}	20% RHC + 60% soil + 20% CC	4581[d]	3097[a]	9538[c]
T_{13}	80% RHC + 10% soil + 10% CC	4299[e]	3107[a]	3136[op]
T_{14}	60% RHC + 30% soil + 10% CC	1200[n]	2598[de]	4935[k]
T_{15}	40% RHC + 50% soil + 10% CC	1140[n]	2499[e]	5212[j]
T_{16}	20% RHC + 70% soil + 10% CC	1830[m]	2529[e]	6042[g]
T_{17}	80% RHC + 20% soil	4524[d]	3158[a]	9562[c]
T_{18}	Control	732[o]	177[f]	21[r]

* The means followed by common alphabets do not differ significantly at 5% level in DMRT

Table 4.15 Fe, Mn, Cu and Zn contents of growing media

Treatments		F (mg/ kg)	Mn (mg/ kg)	Cu (mg/ kg)	Zn (mg/ kg)
T_1	80% RHC + 20% VC	1034^{f}	419^{c}	45^{d}	68^{abc}
T_2	60% RHC + 20% soil + 20% VC	3601^{e}	332^{f}	81^{b}	59^{abcd}
T_3	40% RHC + 40% soil + 20% VC	6672^{b}	259^{j}	14^{ghi}	49^{bcde}
T_4	20% RHC + 60% soil + 20% VC	6673^{b}	298^{g}	36^{def}	56^{bcd}
T_5	80% RHC + 10% soil + 10% VC	6638^{b}	343^{e}	34^{defgh}	34^{cde}
T_6	60% RHC + 30% soil + 10% VC	6659^{b}	366^{d}	57^{c}	55^{bcd}
T_7	40% RHC + 50% soil + 10% VC	7000^{a}	892^{a}	264^{a}	82^{ab}
T_8	20% RHC + 70% soil + 10% VC	7031^{a}	556^{b}	35^{defg}	83^{ab}
T_9	80% RHC + 20% CC	723^{g}	214^{l}	39^{de}	17^{e}
T_{10}	60% RHC + 20% soil + 20% CC	6272^{c}	239^{k}	25^{efghi}	29^{de}
T_{11}	40% RHC + 40% soil + 20% CC	6598^{b}	187^{m}	14^{ghi}	32^{de}
T_{12}	20% RHC + 60% soil + 20% CC	4842^{d}	249^{k}	17^{fghi}	94^{a}
T_{13}	80% RHC + 10% soil + 10% CC	4826^{d}	272^{i}	15^{fghij}	84^{ab}
T_{14}	60% RHC + 30% soil + 10% CC	6664^{b}	301^{g}	42^{de}	60^{abcd}
T_{15}	40% RHC + 50% soil + 10% CC	6644^{b}	286^{h}	12^{i}	49^{bcde}
T_{16}	20% RHC + 70% soil + 10% CC	6511^{b}	134^{op}	13^{hi}	34^{cde}
T_{17}	80% RHC + 20% soil	769^{g}	165^{n}	14^{ghi}	26^{de}
T_{18}	Control	55^{h}	24^{q}	14^{ghi}	17^{e}

* The means followed by common alphabets do not differ significantly at 5% level in DMRT

4.1.7 Nutrient content of seedlings

4.1.7.1 Nitrogen

The nitrogen content of seedlings at the time of transplanting is presented in Table 4.16. The highest N content of 3.62% was observed in 80% RHC + 10% soil + 10% VC (T_5) and it was followed by the media comprised of 60% RHC + 20% soil + 20% CC (T_{10}). The N content of seedlings was the lowest (2.43%) in the soil media (T_{18}).

4.1.7.2 Phosphorus

The phosphorus content of seedlings analysed at the time of transplanting is shown in Table 4.16. The highest P content of 0.4% was observed in control media (T_{18}) and it was on par with the media comprised of 20% RHC + 60% soil + 20% VC (T_4). The lowest (0.19%) P content of seedlings was recorded in T_{10} (60% RHC + 20% soil + 20% CC).

4.1.7.3 Potassium

The potassium content of the seedlings at the time of transplanting is presented in Table 4.16. The highest (3.21%) K content of seedlings was recorded in the media comprised of 80% RHC + 10% soil + 10% VC (T_5). The media T_{17} (80% RHC + 20% soil) recorded the lowest (1.05%) K content in seedlings.

4.1.7.4 Calcium

The data on calcium content of seedlings are given in Table 4.17. The highest Ca content of 4571.75 mg kg^{-1} was observed in control media (T_{18}) which was superior to all other media. It was followed by the media comprised of 80% RHC + 20% soil (T_{17}). The Ca content of seedlings was the lowest (700.75 mg kg^{-1}) in T_2 (60% RHC + 20% soil + 20% VC).

Table 4.16 N, P and K contents of seedlings (%) at 15 DAS as influenced by variation in growing media

Treatment		Nitrogen (%)	Phosphorus (%)	Potassium (%)
T_1	80% RHC + 20% VC	3.03^{def}	0.29^{cde}	3.07^{b}
T_2	60% RHC + 20% soil + 20% VC	2.80^{fg}	0.25^{def}	2.63^{d}
T_3	40% RHC + 40% soil + 20% VC	2.92^{efg}	0.27^{cde}	2.80^{c}
T_4	20% RHC + 60% soil + 20% VC	2.98^{defg}	0.37^{ab}	1.22^{m}
T_5	80% RHC + 10% soil + 10% VC	3.62^{a}	0.31^{bcd}	3.21^{a}
T_6	60% RHC + 30% soil + 10% VC	3.15^{cd}	0.23^{ef}	2.33^{g}
T_7	40% RHC + 50% soil + 10% VC	2.98^{defg}	0.31^{bcd}	2.37^{fg}
T_8	20% RHC + 70% soil + 10% VC	3.15^{cd}	0.24^{def}	1.55^{j}
T_9	80% RHC + 20% CC	3.09^{de}	0.27^{cde}	2.47^{ef}
T_{10}	60%RHC + 20% soil + 20% CC	3.38^{b}	0.19^{f}	2.66^{d}
T_{11}	40% RHC + 40% soil + 20% CC	3.09^{de}	0.23^{ef}	1.42^{kl}
T_{12}	20% RHC + 60% soil + 20% CC	3.15^{cd}	0.28^{cde}	2.20^{h}
T_{13}	80% RHC + 10% soil + 10% CC	2.92^{efg}	0.29^{cde}	1.52^{ijk}
T_{14}	60% RHC + 30% soil + 10% CC	2.86^{fg}	0.23^{ef}	2.03^{i}
T_{15}	40% RHC + 50% soil + 10% CC	3.15^{cd}	0.31^{bcd}	1.37^{l}
T_{16}	20% RHC + 70% soil + 10% CC	3.03^{def}	0.27^{cde}	2.50^{e}
T_{17}	80% RHC + 20% soil	3.33^{bc}	0.32^{bc}	1.05^{n}
T_{18}	Control	2.43^{g}	0.40^{a}	2.40^{efg}

* The means followed by common alphabets do not differ significantly at 5% level in DMRT

4.1.7.5 Magnesium

The magnesium content of seedlings as influenced by variation in growing media is presented in Table 4.17. The higher Mg content was recorded in T_2 (60% RHC + 20% soil + 20% VC), T_7 (40% RHC + 50% soil + 10% VC) and T_9 (80% RHC + 20% CC). These media were on par with T_1 (80% RHC + 20% VC), T_3 (40% RHC + 40% soil + 20% VC), T_5 (80% RHC + 10% soil + 10% VC), T_6 (60% RHC + 30% soil + 10% VC), T_{10} (60% RHC + 20% soil + 20% CC), T_{14} (60% RHC + 30% soil + 10% CC), T_{16} (20% RHC + 70% soil + 10% CC) and T_{17} (80% RHC + 20% soil).

4.1.7.6 Sulphur

The sulphur content of seedlings as influenced by variation in growing media is shown in Table 4.17. The highest S content of 3600 mg kg^{-1} was recorded in T_2 (60% RHC + 20% soil + 20% VC) and it was followed by T_1 (80% RHC + 20% VC) and T_4 (20% RHC + 60% soil + 20% VC). The S content of seedlings was the lowest (1266.67 mg kg^{-1}) in T_5 (80% RHC + 10% soil + 10% VC).

4.1.7.7 Iron

The data pertaining to iron content of seedlings are given in Table 4.18. The highest Fe content of 497.33 mg kg^{-1} was recorded in T_2 (60% RHC + 20% soil + 20% VC) and it was followed by control media (T_{18}). The Fe content of seedlings was the lowest (208.75 mg kg^{-1}) in T_1 (80% RHC + 20% VC).

4.1.7.8 Manganese

The manganese content of seedlings is presented in Table 4.18. The highest (615.5 mg kg^{-1}) Mn content was recorded in T_9 (80% RHC + 20% CC).

Table 4.17 Ca, Mg and S content of seedlings (mg kg^{-1}) as influenced by variation in growing media

Treatments		Calcium (mg kg^{-1})	Magnesium (mg kg^{-1})	Sulphur (mg kg^{-1})
T_1	80% RHC + 20% VC	758.50^{r}	1577.67^{ab}	3166.67^{b}
T_2	60% RHC + 20% soil + 20% VC	700.75^{s}	1620.17^{a}	3600.00^{a}
T_3	40% RHC + 40% soil + 20% VC	1284.50^{k}	1579.75^{ab}	1533.33^{gh}
T_4	20% RHC + 60% soil + 20% VC	1324.50^{j}	1543.67^{b}	3200.00^{b}
T_5	80% RHC + 10% soil + 10% VC	1791.50^{g}	1584.25^{ab}	1266.67^{h}
T_6	60% RHC + 30% soil + 10% VC	1079.25^{m}	1587.67^{ab}	2766.67^{cd}
T_7	40% RHC + 50% soil + 10% VC	864.50^{q}	1627.50^{a}	2266.67^{ef}
T_8	20% RHC + 70% soil + 10% VC	1784.00^{h}	1559.50^{b}	2400.00^{de}
T_9	80% RHC + 20% CC	931.50^{op}	1627.50^{a}	3133.33^{bc}
T_{10}	60% RHC + 20% soil + 20% CC	3580.50^{c}	1587.00^{ab}	1566.67^{gh}
T_{11}	40% RHC + 40% soil + 20% CC	966.50^{n}	1548.67^{b}	1566.67^{gh}
T_{12}	20% RHC + 60% soil + 20% CC	1649.50^{i}	1543.25^{b}	1600.00^{gh}
T_{13}	80% RHC + 10% soil + 10% CC	3249.75^{d}	1553.00^{b}	2366.67^{e}
T_{14}	60% RHC + 30% soil + 10% CC	1185.50^{l}	1581.42^{ab}	2900.00^{bc}
T_{15}	40% RHC + 50% soil + 10% CC	2020.00^{e}	1528.58^{b}	2866.67^{bc}
T_{16}	20% RHC + 70% soil + 10% CC	1891.25^{f}	1579.58^{ab}	1900.00^{fg}
T_{17}	80% RHC + 20% soil	4076.00^{b}	1586.50^{ab}	2966.67^{bc}
T_{18}	Control	4571.75^{a}	1532.58^{b}	1866.67^{g}

* The means followed by common alphabets do not differ significantly at 5% level in DMRT

It was followed by T_{12} (20% RHC + 60% soil + 20% CC) and T_{16} (20% RHC + 70% soil + 10% CC). The lowest (57.92 mg kg^{-1}) Mn content was recorded in T_5 (80% RHC + 10% soil + 10% VC).

4.1.7.9 Copper

The copper content of seedlings is presented in Table 4.18. The highest (24.58 mg kg^{-1}) Cu content was recorded in control media (T_{18}) and it was followed by T_{15} (40% RHC + 50% soil + 10% CC). The media T_9 (80% RHC + 20% CC) recorded the lowest (0.83 mg kg^{-1}) Cu content in rice seedlings.

4.1.7.10 Zinc

The data regarding the zinc content of seedlings are given in Table 4.18. The highest (106.17 mg kg^{-1}) Zn content was observed in control media (T_{18}). All other media except T_{10} (60% RHC + 20% soil + 20% CC) recorded comparable Zn content in seedlings whereas T_{10} recorded the lowest Zn content of 51.83 mg kg^{-1} in seedlings.

4.1.7.11 Boron

The boron content of seedlings as influenced by variation in growing media is presented in Table 4.19. The highest B content of 17.72 mg kg^{-1} was recorded in T_8 (20% RHC + 70% soil + 10% VC) and it was followed by T_2 (60% RHC + 20% soil + 20% VC). The B content of seedlings was the lowest (3.77 mg kg^{-1}) in T_4 (20% RHC + 60% soil + 20% VC).

4.1.7.12 Silicon

The data pertaining to silicon content in seedlings are shown in Table 4.19. The highest (2.56%) Si content of seedlings was recorded in T_{17} (80% RHC + 20% soil) and it was followed by T_1 (80% RHC + 20% VC). The Si content of seedlings was the lowest (0.90%) in T_4 (20% RHC + 60% soil + 20% VC).

Table 4.18 Fe, Mn, Zn and Cu content of seedlings (mg kg^{-1}) as influenced by variation in growing media

Treatments		F (mg/ kg)	Mn (mg/ kg)	Cu (mg/ kg)	Zn (mg/ kg)
T_1	80% RHC + 20% VC	208.75^{q}	78.50^{gh}	6.83^{g}	67.50^{bc}
T_2	60% RHC + 20% soil + 20% VC	497.33^{a}	71.00^{gh}	14.33^{d}	65.08^{bc}
T_3	40% RHC + 40% soil + 20% VC	397.75^{d}	120.25^{fg}	15.33^{c}	80.00^{b}
T_4	20% RHC + 60% soil + 20% VC	343.50^{e}	105.50^{fgh}	8.83^{f}	72.25^{bc}
T_5	80% RHC + 10% soil + 10% VC	285.17^{fgh}	57.92^{h}	5.58^{j}	59.17^{bc}
T_6	60% RHC + 30% soil + 10% VC	400.58^{d}	100.83^{fgh}	1.33^{m}	60.00^{bc}
T_7	40% RHC + 50% soil + 10% VC	270.83^{gh}	153.58^{ef}	5.83^{i}	74.17^{b}
T_8	20% RHC + 70% soil + 10% VC	282.33^{fgh}	199.67^{e}	8.83^{f}	60.25^{bc}
T_9	80% RHC + 20% CC	263.67^{h}	615.50^{a}	0.83^{n}	69.33^{bc}
T_{10}	60% RHC + 20% soil + 20% CC	264.00^{h}	203.17^{e}	4.08^{l}	51.83^{c}
T_{11}	40% RHC + 40% soil + 20% CC	324.50^{e}	330.58^{c}	6.08^{h}	78.75^{b}
T_{12}	20% RHC + 60% soil + 20% CC	321.33^{e}	451.67^{b}	6.83^{g}	77.25^{b}
T_{13}	80% RHC + 10% soil + 10% CC	434.92^{c}	313.92^{cd}	5.58^{j}	70.08^{bc}
T_{14}	60% RHC + 30% soil + 10% CC	419.92^{cd}	281.42^{cd}	12.33^{e}	73.58^{b}
T_{15}	40% RHC + 50% soil + 10% CC	332.17^{e}	324.00^{c}	15.58^{b}	71.75^{bc}
T_{16}	20% RHC + 70% soil + 10% CC	289.17^{fg}	459.00^{b}	4.58^{k}	64.83^{bc}
T_{17}	80% RHC + 20% soil	298.33^{f}	310.67^{cd}	5.83^{i}	74.08^{b}
T_{18}	Control	465.33^{b}	265.75^{d}	24.58^{a}	106.17^{a}

* The means followed by common alphabets do not differ significantly at 5% level in DMRT

Table 4.19 Boron (mg kg^{-1}) and silicon contents (%) of seedlings as influenced by variation in growing media

Treatments		Boron (mg kg^{-1})	Silicon (%)
T_1	80% RHC + 20% VC	12.82^{f}	1.93^{b}
T_2	60% RHC + 20% soil + 20% VC	15.46^{b}	1.91^{c}
T_3	40% RHC + 40% soil + 20% VC	13.23^{e}	1.09^{q}
T_4	20% RHC + 60% soil + 20% VC	3.77^{op}	0.90^{r}
T_5	80% RHC + 10% soil + 10% VC	13.57^{d}	1.66^{e}
T_6	60% RHC + 30% soil + 10% VC	11.73^{g}	1.53^{h}
T_7	40% RHC + 50% soil + 10% VC	13.57^{d}	1.27^{n}
T_8	20% RHC + 70% soil + 10% VC	17.72^{a}	1.19^{op}
T_9	80% RHC + 20% CC	14.33^{c}	1.27^{n}
T_{10}	60% RHC + 20% soil + 20% CC	6.42^{n}	1.89^{d}
T_{11}	40% RHC + 40% soil + 20% CC	11.31^{h}	1.34^{k}
T_{12}	20% RHC + 60% soil + 20% CC	10.18^{i}	1.32^{l}
T_{13}	80% RHC + 10% soil + 10% CC	11.31^{h}	1.39^{j}
T_{14}	60% RHC + 30% soil + 10% CC	7.16^{m}	1.28^{m}
T_{15}	40% RHC + 50% soil + 10% CC	6.41^{n}	1.50^{i}
T_{16}	20% RHC + 70% soil + 10% CC	8.33^{l}	1.54^{g}
T_{17}	80% RHC + 20% soil	8.67^{k}	2.56^{a}
T_{18}	Control	9.43^{j}	1.60^{f}

* The means followed by common alphabets do not differ significantly at 5% level in DMRT

4.1.8 Nutrient uptake of seedlings

4.1.8.1 Nitrogen

The N uptake by the seedlings as influenced by variation in growing media is presented in Table 4.20. The media T_1 (80% RHC + 20% VC) recorded the highest N uptake by the seedlings (2.36 g tray-1). It was followed by T_{17} (80% RHC + 20% soil). The lowest (1.2 g tray^{-1}) N uptake by the seedlings was recorded in T_{10} (60% RHC + 20% soil + 20% CC).

4.1.8.2 Phosphorus

The data on phosphorus uptake by the seedlings are given in Table 4.20. The P uptake was significantly higher (0.22 g tray^{-1}) in the media T_1 (80% RHC + 20% VC), T_4 (20% RHC + 60% soil + 20% VC) and T_{18} (control). The growing media of T_{10} (0.1 g tray^{-1}) recorded the lowest P uptake by seedlings.

4.1.8.3 Potassium

The uptake of potassium by the seedlings is shown in Table 4.20. The media comprised of 80% RHC + 20% VC (T_1) recorded significantly higher K uptake of 2.4 g tray^{-1} and it was followed by T_2 (60% RHC + 20% soil + 20% VC) and T_3 (40% RHC + 40% soil + 20% VC). The lowest (0.64 g tray^{-1}) K uptake by the seedlings was recorded in T_{17} (80% RHC + 20% soil).

4.1.8.4 Calcium

The data regarding calcium uptake by the seedlings are given in Table 4.21. The Ca uptake was significantly higher (0.25 g tray^{-1}) in control media (T_{18}) and it was followed by T_{17} (80% RHC + 20% soil). The lowest Ca uptake of 0.04 g tray^{-1} in seedlings was recorded in T_{10} (60% RHC + 20% soil + 20% CC).

Table 4.20 N, P and K uptake by seedlings (g tray^{-1}) as influenced by variation in growing media

Treatments		Nitrogen (g tray^{-1})	Phosphorus (g tray^{-1})	Potassium (g tray^{-1})
T_1	80% RHC + 20% VC	2.36^{a}	0.22^{a}	2.40^{a}
T_2	60% RHC + 20% soil + 20% VC	1.99^{bc}	0.18^{bcd}	1.87^{b}
T_3	40% RHC + 40% soil + 20% VC	1.89^{bcd}	0.17^{bcde}	1.81^{b}
T_4	20% RHC + 60% soil + 20% VC	1.77^{defgh}	0.22^{a}	0.72^{j}
T_5	80% RHC + 10% soil + 10% VC	1.82^{def}	0.15^{def}	1.62^{c}
T_6	60% RHC + 30% soil + 10% VC	1.75^{fgh}	0.11^{gh}	1.37^{ef}
T_7	40% RHC + 50% soil + 10% VC	1.88^{cde}	0.19^{ab}	1.50^{d}
T_8	20% RHC + 70% soil + 10% VC	1.81^{def}	0.14^{def}	0.89^{h}
T_9	80% RHC + 20% CC	1.76^{efgh}	0.16^{cdef}	1.41^{e}
T_{10}	60% RHC + 20% soil + 20% CC	1.20^{j}	0.10^{g}	0.89^{h}
T_{11}	40% RHC + 40% soil + 20% CC	1.65^{hi}	0.12^{fg}	0.76^{ij}
T_{12}	20% RHC + 60% soil + 20% CC	1.66^{ghi}	0.15^{def}	1.16^{g}
T_{13}	80% RHC + 10% soil + 10% CC	1.58^{i}	0.16^{bcdef}	0.83^{hi}
T_{14}	60% RHC + 30% soil + 10% CC	1.71^{fghi}	0.14^{ef}	1.21^{g}
T_{15}	40% RHC + 50% soil + 10% CC	1.78^{defg}	0.18^{bcde}	0.78^{ij}
T_{16}	20% RHC + 70% soil + 10% CC	1.71^{fghi}	0.15^{def}	1.40^{ef}
T_{17}	80% RHC + 20% soil	2.01^{b}	0.19^{abc}	0.64^{k}
T_{18}	Control	1.35^{ij}	0.22^{a}	1.33^{f}

* The means followed by common alphabets do not differ significantly at 5% level in DMRT

4.1.8.5 Magnesium

The magnesium uptake by the seedlings is as influenced by variation in growing media presented in Table 4.21. The media comprised of 80% RHC + 20% VC (T_1) recorded significantly higher (0.12 g tray^{-1}) Mg uptake and it was followed by T_2 (60% RHC + 20% soil + 20% VC). The lowest (0.06 g tray^{-1}) Mg uptake by the seedlings was observed in T_{10} (60% RHC + 20% soil + 20% CC).

4.1.8.6 Sulphur

The sulphur uptake by the seedlings is shown in Table 4.21. The S uptake was significantly higher in the media T_1 (0.25 g tray^{-1}) and T_2 (0.26 g tray^{-1}). The lowest S uptake of 0.06 g tray^{-1} in seedlings was recorded T_5 (80% RHC + 10% soil + 10% VC).

4.1.8.7 Iron

The data pertaining to iron uptake by the seedlings are given in Table 4.22. The media comprised of 60% RHC + 20% soil + 20% VC (T_2) recorded significantly higher (35.3 mg tray^{-1}) Fe uptake and it was followed by T_3 (40% RHC + 40% soil + 20% VC), T_{14} (60% RHC + 30% soil + 10% CC) and T_{18} (control). The lowest (13.62 mg tray^{-1}) Fe uptake by the seedlings was recorded in T_{10} (60% RHC + 20% soil + 20% CC).

4.1.8.8 Manganese

The uptake of manganese by the seedlings as influenced by variation in growing media is presented in Table 4.22. The Mn uptake was significantly higher (35.09 mg tray^{-1}) in T_9 (80% RHC + 20% CC) and it was followed by T_{12} (20% RHC + 60% soil + 20% CC) and T_{16} (20% RHC + 70% soil + 10% CC). The lowest (2.92 mg tray^{-1}) Mn uptake by the seedlings was recorded in T_5 (80% RHC + 10% soil + 10% VC).

Table 4.21 Ca, Mg and S uptake by seedlings (g $tray^{-1}$) as influenced by variation in growing media

Treatments		Calcium (g $tray^{-1}$)	Magnesium (g $tray^{-1}$)	Sulphur (g $tray^{-1}$)
T_1	80% RHC + 20% VC	0.06^{m}	0.12^{a}	0.25^{a}
T_2	60% RHC + 20% soil + 20% VC	0.05^{r}	0.11^{b}	0.26^{a}
T_3	40% RHC + 40% soil + 20% VC	0.08^{j}	0.10^{c}	0.09^{gh}
T_4	20% RHC + 60% soil + 20% VC	0.08^{k}	0.09^{ef}	0.19^{b}
T_5	80% RHC + 10% soil + 10% VC	0.09^{h}	0.08^{k}	0.06^{i}
T_6	60% RHC + 30% soil + 10% VC	0.19^{c}	0.08^{jk}	0.11^{fgh}
T_7	40% RHC + 50% soil + 10% VC	0.06^{n}	0.10^{c}	0.14^{de}
T_8	20% RHC + 70% soil + 10% VC	0.10^{g}	0.09^{fg}	0.14^{de}
T_9	80% RHC + 20% CC	0.05^{op}	0.09^{e}	0.18^{bc}
T_{10}	60% RHC + 20% soil + 20% CC	0.04^{s}	0.06^{l}	0.08^{hi}
T_{11}	40% RHC + 40% soil + 20% CC	0.05^{q}	0.08^{ij}	0.08^{ghi}
T_{12}	20% RHC + 60% soil + 20% CC	0.09^{i}	0.08^{jk}	0.08^{ghi}
T_{13}	80% RHC + 10% soil + 10% CC	0.18^{d}	0.08^{hij}	0.13^{ef}
T_{14}	60% RHC + 30% soil + 10% CC	0.07^{l}	0.09^{de}	0.17^{bc}
T_{15}	40% RHC + 50% soil + 10% CC	0.11^{e}	0.09^{gh}	0.16^{cd}
T_{16}	20% RHC + 70% soil + 10% CC	0.11^{f}	0.09^{fg}	0.11^{fg}
T_{17}	80% RHC + 20% soil	0.24^{b}	0.10^{d}	0.18^{bc}
T_{18}	Control	0.25^{a}	0.09^{hi}	0.10^{fgh}

* The means followed by common alphabets do not differ significantly at 5% level in DMRT

4.1.8.9 Copper

The uptake of copper by the seedlings is shown in Table 4.22. The control media (T_{18}) recorded significantly higher (1.36 mg tray^{-1}) Cu uptake in the seedlings and it was followed by T_2 (60% RHC + 20% soil + 20% VC). The lower (0.05 mg tray^{-1}) Cu uptake by the seedlings was recorded in T_6 (60% RHC + 30% soil + 10% VC) and T_9 (80% RHC + 20% CC).

4.1.8.10 Zinc

The data on zinc uptake by the seedlings are given in Table 4.22. The control media (T_{18}) recorded significantly higher (5.89 mg tray^{-1}) Zn uptake which was on par with T_1 (80% RHC + 20% VC), T_3 (40% RHC + 40% soil + 20% VC) and T_7 (40% RHC + 50% soil + 10% VC). The lowest (2.28 mg tray^{-1}) Zn uptake by the seedlings was recorded in T_{10} (60% RHC + 20% soil + 20% CC).

4.1.8.11 Boron

The boron uptake by the seedlings as influenced by variation in growing media is presented in Table 4.23. The B uptake was significantly higher (1.1 mg tray^{-1}) in T_2 (60% RHC + 20% soil + 20% VC) and it was followed by T_8 (20% RHC + 70% soil + 10% VC). The lowest (0.22 mg tray^{-1}) B uptake by the seedlings was recorded in T_4 (20% RHC + 60% soil + 20% VC).

4.1.8.12 Silicon

The data pertaining to silicon uptake by the seedlings are shown in Table 4.23. The media comprised of 80% RHC + 20% soil (T_{17}) recorded significantly higher (1.55 g tray^{-1}) Si uptake and it was followed by T_1 (80% RHC + 20% VC). The lowest (0.53 g tray^{-1}) Si uptake by the seedlings was recorded in T_4 (20% RHC + 60% soil + 20% VC).

Table 4.22 Fe, Mn, Zn and Cu uptake by seedlings (mg tray^{-1}) as influenced by variation in growing media

Treatments		Iron (mg tray^{-1})	Manganese (mg tray^{-1})	Copper (mg tray^{-1})	Zinc (mg tray^{-1})
T_1	80% RHC + 20% VC	16.27^{h}	6.12^{gh}	0.53^{f}	5.26^{ab}
T_2	60% RHC + 20% soil + 20% VC	35.30^{a}	5.04^{ghi}	1.02^{b}	4.62^{bcd}
T_3	40% RHC + 40% soil + 20% VC	25.76^{b}	7.79^{fg}	0.99^{c}	5.18^{abc}
T_4	20% RHC + 60% soil + 20% VC	20.38^{d}	6.26^{gh}	0.52^{f}	4.29^{bcd}
T_5	80% RHC + 10% soil + 10% VC	14.38^{jk}	2.92^{i}	0.28^{l}	2.98^{efg}
T_6	60% RHC + 30% soil + 10% VC	15.23^{ij}	3.83^{hi}	0.05^{o}	2.67^{fg}
T_7	40% RHC + 50% soil + 10% VC	17.12^{fgh}	9.71^{ef}	0.37^{h}	4.69^{abcd}
T_8	20% RHC + 70% soil + 10% VC	16.21^{hi}	11.46^{e}	0.51^{g}	3.46^{defg}
T_9	80% RHC + 20% CC	15.03^{j}	35.09^{a}	0.05^{o}	3.95^{cde}
T_{10}	60% RHC + 20% soil + 20% CC	13.62^{k}	10.48^{ef}	0.21^{n}	2.28^{g}
T_{11}	40% RHC + 40% soil + 20% CC	17.37^{fg}	17.69^{cd}	0.33^{j}	4.21^{bcde}
T_{12}	20% RHC + 60% soil + 20% CC	16.95^{gh}	23.82^{b}	0.36^{hi}	4.07^{bcde}
T_{13}	80% RHC + 10% soil + 10% CC	23.62^{c}	17.05^{cd}	0.30^{k}	3.81^{def}
T_{14}	60% RHC + 30% soil + 10% CC	25.08^{b}	16.81^{cd}	0.74^{e}	4.40^{bcd}
T_{15}	40% RHC + 50% soil + 10% CC	18.81^{e}	18.35^{c}	0.88^{d}	4.06^{bcde}
T_{16}	20% RHC + 70% soil + 10% CC	16.26^{h}	25.81^{b}	0.26^{m}	3.64^{def}
T_{17}	80% RHC + 20% soil	18.05^{ef}	18.80^{c}	0.35^{i}	4.48^{bcd}
T_{18}	Control	25.81^{b}	14.74^{d}	1.36^{a}	5.89^{a}

* The means followed by common alphabets do not differ significantly at 5% level in DMRT

Table 4.23 Boron (mg tray^{-1}) and silicon (g tray^{-1}) uptake by seedlings as influence by variation in growing media

Treatments		Boron (mg tray^{-1})	Silicon (g tray^{-1})
T_1	80% RHC + 20% VC	1.00^{c}	1.50^{b}
T_2	60% RHC + 20% soil + 20% VC	1.10^{a}	1.35^{c}
T_3	40% RHC + 40% soil + 20% VC	0.86^{d}	0.71^{n}
T_4	20% RHC + 60% soil + 20% VC	0.22^{q}	0.53^{s}
T_5	80% RHC + 10% soil + 10% VC	0.68^{f}	0.84^{g}
T_6	60% RHC + 30% soil + 10% VC	0.45^{l}	0.58^{r}
T_7	40% RHC + 50% soil + 10% VC	0.86^{d}	0.80^{i}
T_8	20% RHC + 70% soil + 10% VC	1.02^{b}	0.68^{q}
T_9	80% RHC + 20% CC	0.82^{e}	0.73^{l}
T_{10}	60% RHC + 20% soil + 20% CC	0.33^{op}	0.98^{d}
T_{11}	40% RHC + 40% soil + 20% CC	0.61^{h}	0.72^{m}
T_{12}	20% RHC + 60% soil + 20% CC	0.54^{i}	0.69^{op}
T_{13}	80% RHC + 10% soil + 10% CC	0.61^{g}	0.75^{k}
T_{14}	60% RHC + 30% soil + 10% CC	0.43^{m}	0.76^{j}
T_{15}	40% RHC + 50% soil + 10% CC	0.36^{n}	0.83^{h}
T_{16}	20% RHC + 70% soil + 10% CC	0.47^{k}	0.87^{f}
T_{17}	80% RHC + 20% soil	0.52^{j}	1.55^{a}
T_{18}	Control	0.52^{j}	0.89^{e}

* The means followed by common alphabets do not differ significantly at 5% level i: DMRT

4.1.9 Economics of nursery

The economics of nursery as influenced by variation in growing media is presented in Table 4.24. The highest (Rs. 5312) cost of nursery was recorded in the control media (T_{18}). The cost of nursery was lowest (Rs. 4918) in media comprised of 80% RHC + 20% CC (T_9).

4.2 SELECTION OF BEST PERFORMING MEDIA FOR FIELD EVALUATION

Best performing media (10 No's) were selected from Experiment I for evaluation under field conditions (Experiment II). The growing media were selected based on the important characters that contribute to the production of a robust mat. The important characters of seedlings and mat that contributed to the preferred mat in terms of growth of seedlings, mat characteristics and nutrient content of seedlings were selected for scoring. The characters selected for scoring were seedling height, biomass production, root length, mat thickness, mat weight, mat strength, number of normal seedlings and NPK contents of seedlings at the time of transplanting. Each parameter studied was classified into three categories as high, medium and low. Scores of 5, 3 and 2 were given classes high, medium and low respectively for scoring. Based on the aggregate scores obtained for each growing media, the ranking was done. The best performing ten media combinations in terms of aggregate scores were selected for the field evaluation.

The high seedling height, biomass production, root length, mat thickness, mat strength, number of normal seedlings and nutrient contents of seedlings and low mat weight were considered as favourable characters for selection of growing media. Based on the scores obtained for individual characters of seedlings and mat nursery, aggregate scores were calculated for each growing media and are presented in Table 4.25. The aggregate scores obtained for each media were selected as the criteria for ranking the growing media.

Table 4.24 Economics of nursery (Rs/ ha) as influenced by variation in growing media

Treatments		Cost of nursery required for 1 ha (Rs)
T_1	80% RHC + 20% VC	4947/-
T_2	60% RHC + 20% soil + 20% VC	5043/-
T_3	40% RHC + 40% soil + 20% VC	5138/-
T_4	20% RHC + 60% soil + 20% VC	5234/-
T_5	80% RHC + 10% soil + 10% VC	4939/-
T_6	60% RHC + 30% soil + 10% VC	5034/-
T_7	40% RHC + 50% soil + 10% VC	5130/-
T_8	20% RHC + 70% soil + 10% VC	5225/-
T_9	80% RHC + 20% CC	4918/-
T_{10}	60% RHC + 20% soil + 20% CC	5013/-
T_{11}	40% RHC + 40% soil + 20% CC	5109/-
T_{12}	20% RHC + 60% soil + 20% CC	5205/-
T_{13}	80% RHC + 10% soil + 10% CC	4924/-
T_{14}	60% RHC + 30% soil + 10% CC	5034/-
T_{15}	40% RHC + 50% soil + 10% CC	5115/-
T_{16}	20% RHC + 70% soil + 10% CC	5211/-
T_{17}	80% RHC + 20% soil	4930/-
T_{18}	Control	5312/-

The growing media with rank numbers from 1 to 10 out of 18 media were selected as the best performing media from Experiment I and these ten high ranking media were used for Experiment II.

4.3 FIELD EVALUATION OF BEST PERFORING MEDIA SELECTED FROM EXPERIMENT I

Best performing ten growing media based on aggregate scores and ranking were selected for field evaluation.

4.3.1 Performance of transplanter

4.3.1.1 Number of hills planted per metre run

The number of hills at planting by transplanter as influenced by nursery media is presented in Table 4.26. The mean number of hills planted per metre run of transplanter was 5.44. The number of hills planted per metre run in all the nursery media *viz.* N_1 (80% RHC + 20% VC), N_3 (40% RHC + 40% soil + 20% VC), N_4 (20% RHC + 60% soil + 20% VC), N_5 (60% RHC + 30% soil + 10% VC), N_6 (40% RHC + 50% soil + 10% VC), N_7 (20% RHC + 70% soil + 10% VC), N_8 (80% RHC + 20% CC), N_9 (60% RHC + 20% soil + 20% CC) and N_{10} (60% RHC + 30% soil + 10% CC) except N_2 (60% RHC + 20% soil + 20% VC) was comparable. The nursery media N_2 recorded 4.4 hills per metre run.

4.3.1.2 Number of seedlings planted per hill

The data on number of seedlings planted per hill by transplanter are shown in Table 4.26. The mean number of seedlings planted per hill by transplanter was 3.36. The highest (5.13) number of seedlings per hill was planted by the transplanter with respect to the nursery media of 60% RHC + 30% soil + 10% CC (N_{10}). The lowest (1.9) number of seedlings per hill was observed in the nursery media of 40% RHC + 40% soil + 20% VC (N_3).

Table 4.25 Aggregate scores and ranks given to different growing media

Treatment		Total score	Rank
T_1	80% RHC + 20% VC	39	2
T_2	60% RHC + 20% soil + 20% VC	43	1
T_3	40% RHC + 40% soil + 20% VC	39	3
T_4	20% RHC + 60% soil + 20% VC	34	7
T_5	80% RHC + 10% soil + 10% VC	32	11
T_6	60% RHC + 30% soil + 10% VC	38	4
T_7	40% RHC + 50% soil + 10% VC	36	5
T_8	20% RHC + 70% soil + 10% VC	34	8
T_9	80% RHC + 20% CC	36	6
T_{10}	60% RHC + 20% soil + 20% CC	34	9
T_{11}	40% RHC + 40% soil + 20% CC	27	15
T_{12}	20% RHC + 60% soil + 20% CC	28	14
T_{13}	80% RHC + 10% soil + 10% CC	32	12
T_{14}	60% RHC + 30% soil + 10% CC	33	10
T_{15}	40% RHC + 50% soil + 10% CC	27	16
T_{16}	20% RHC + 70% soil + 10% CC	22	18
T_{17}	80% RHC + 20% soil	30	13
T_{18}	Control	26	17

4.3.1.3 Number of missing hills per m^2

The number of missing hills per m^2 is given in Table 4.26. The mean number of missing hills per m^2 was 2.54. The highest (5.8 m^{-2}) number of missing hills was recorded with respect to the nursery media comprised of 60% RHC + 20% soil + 20% VC (N_2). The media N_{10} (60% RHC+ 30% soil + 10% CC) recorded the lowest (0.93 m^{-2}) number of missing hills per m^2.

4.3.1.4 Plant population per m^2 at planting

The plant population (number of hills) per m^2 at planting by the various nursery media is presented in Table 4.27. The overall mean plant population per m^2 at planting was 27.28 m^{-2}. The plant population per m^2 at planting was observed superior in the media N_1 (80% RHC + 20% VC), N_4 (20% RHC + 60% soil + 20% VC), N_5 (60% THC + 30% soil + 10% VC), N_8 (80% RHC + 20% CC) and N_{10} (60% RHC + 30% soil + 10% CC). These nursery media were comparable with the plant population per m^2 at planting with respect to N_3 (40% RHC + 40% soil + 20% VC), N_6 (40% RHC + 50% soil + 10% VC), N_7 (20% RHC + 70% soil + 10% VC) and N_9 (60% RHC + 20% soil + 20% CC). The lowest (24.2 m^{-2}) plant population per m^2 at planting was recorded in the media N_2 (60% RHC + 20% soil + 20% VC).

4.3.2 Biometric characters

4.3.2.1 Plant population per m^2 at maximum tillering and harvest stages

The plant population per m^2 at maximum tillering stage and at harvest are given in Table 4.27. The plant population per m^2 at maximum tillering stage and at harvest for all the ten media under consideration were statistically comparable. The mean plant population per m^2 at maximum tillering stage and at harvest stage were 26.32 m^{-2} and 25.25 m^{-2} respectively.

Table 4.26 Performance of transplanter as influenced by nursery media

Treatments		Number of hills planted per metre run	Number of seedlings per hill	Number of missing hills per m^2
N_1	80% RHC + 20% VC	6.00^{a}	4.00^{b}	1.50^{bc}
N_2	60% RHC + 20% Soil + 20% VC	4.40^{b}	2.37^{cd}	5.80^{a}
N_3	40% RHC + 40% Soil + 20% VC	5.33^{a}	1.90^{d}	3.60^{ab}
N_4	20% RHC + 60% Soil + 20% VC	5.47^{a}	3.87^{b}	1.27^{bc}
N_5	60% RHC + 30% Soil + 10% VC	5.33^{a}	3.43^{bc}	2.27^{bc}
N_6	40% RHC + 50% Soil + 10% VC	5.27^{a}	3.43^{bc}	3.47^{abc}
N_7	20% RHC ÷ 70% Soil + 10% VC	5.40^{a}	3.30^{bc}	3.33^{abc}
N_8	80% RHC + 20% CC	5.73^{a}	3.40^{bc}	2.20^{bc}
N_9	60% RHC + 20% Soil + 20% CC	5.73^{a}	2.73^{cd}	3.27^{abc}
N_{10}	60% RHC + 30% Soil + 10% CC	5.73^{a}	5.13^{a}	0.93^{c}
Mean		**5.44**	**3.36**	**2.54**

* The means followed by common alphabets do not differ significantly at 5% level in DMRT

Table 4.27 Plant population per m^2 at planting, maximum tillering and harvest stages

Treatments		At planting	At maximum tillering	At harvest
N_1	80% RHC + 20% VC	29.00[a]	27.93	26.80
N_2	60% RHC + 20% Soil + 20% VC	24.20[b]	24.07	23.73
N_3	40% RHC + 40% Soil + 20% VC	26.40[ab]	25.67	25.00
N_4	20% RHC + 60% Soil + 20% VC	28.67[a]	27.40	26.13
N_5	60% RHC + 30% Soil + 10% VC	27.73[a]	26.43	25.53
N_6	40% RHC + 50% Soil + 10% VC	26.53[ab]	25.73	24.93
N_7	20% RHC + 70% Soil + 10% VC	26.67[ab]	25.80	25.00
N_8	80% RHC + 20% CC	27.80[a]	26.80	25.73
N_9	60% RHC + 20% Soil + 20% CC	26.73[ab]	25.73	25.13
N_{10}	60% RHC + 30% Soil + 10% CC	29.07[a]	27.60	24.47
Mean		**27.28**	**NS**	

* The means followed by common alphabets do not differ significantly at 5% level in DMRT

4.3.2.2 Height of plant

The data on plant height observed at 30 days interval are shown in Table 4.28. The mean plant height at 30 DAT was 58.93 cm. The superior plants with respect to plant height at 30 DAT were observed in N_3 (40% RHC + 40% soil + 20% VC) and N_6 (40% RHC + 50% soil + 10% VC) which were on par with N_1 (80% RHC + 20% VC), N_2 (60% RHC + 20% soil + 20% VC), N_4 (20% RHC + 60% soil + 20% VC), N_7 (20% RHC + 70% soil + 10% VC) and N_9 (60% RHC + 20% soil + 20% CC). The shortest (56.69 cm) plants at 30 DAT was recorded in N_8 (80% RHC + 20% CC).

At 60 DAT, the mean plant height was 104.23 cm. The tallest (108.72 cm) plants were observed in the nursery media of 60% RHC + 30% soil + 10% CC (N_{10}) and it was comparable with N_3 (40% RHC + 40% soil + 20% VC). The media comprised of 80% RHC + 20% CC (N_8) recorded the shortest (100.55 cm) plants at 60 DAT. The plant height observed was superior with respect to N_7 (20% RHC + 70%.soil + 10% VC) and N_9 (60% RHC + 20% soil + 20% CC) at harvest. These were comparable with N_1 (80% RHC + 20% VC), N_2 (60% RHC + 20% soil + 20% VC), N_3 (40% RHC + 40% soil + 20% VC), N_4 (20% RHC + 60% soil + 20% VC), N_5 (60% RHC + 30% soil + 10% VC) and N_{10} (60% RHC + 30% soil + 10% CC). The shortest plants were observed in N_8 (80% RHC + 20% CC). The mean plant height at harvest was 114.36 cm.

4.3.2.3 Number of tillers per m^2

The data on number of tillers per m^2 at 30 and 60 DAT and at harvest are presented in Table 4.29. The number of tillers per m^2 at 30 DAT was the highest (324.33 m^{-2}) in the nursery media of 60% RHC + 30% soil + 10% CC (N_{10}) which was comparable with N_1 (80% RHC + 20% VC) and N_4 (20% RHC + 60% soil + 20% VC). The nursery media comprised of 60% RHC + 20% soil + 20% VC (N_2) recorded the lowest (247.67 m^{-2}) number of tillers at 30 DAT.

Table 4.28 Plant height (cm) of rice as influenced by nursery media

Treatments		30 DAT	60 DAT	At harvest
N_1	80% RHC + 20% VC	57.79^{ab}	103.20^{c}	114.76^{ab}
N_2	60% RHC + 20% Soil + 20% VC	59.22^{abc}	106.32^{b}	115.01^{ab}
N_3	40% RHC + 40% Soil + 20% VC	61.61^{a}	107.20^{ab}	115.67^{ab}
N_4	20% RHC + 60% Soil + 20% VC	59.62^{ab}	104.00^{c}	115.03^{ab}
N_5	60% RHC + 30% Soil + 10% VC	56.80^{bc}	102.32^{cd}	115.32^{ab}
N_6	40% RHC + 50% Soil + 10% VC	61.28^{a}	103.90^{c}	111.63^{bc}
N_7	20% RHC + 70% Soil + 10% VC	59.43^{abc}	102.38^{cd}	115.95^{a}
N_8	80% RHC + 20% CC	56.69^{c}	100.55^{d}	108.61^{c}
N_9	60% RHC + 20% Soil + 20% CC	59.26^{abc}	103.70^{c}	116.11^{a}
N_{10}	60% RHC + 30% Soil + 10% CC	57.64^{bc}	108.72^{a}	115.50^{ab}
Mean		**58.93**	**104.23**	**114.36**

* The means followed by common alphabets do not differ significantly at 5% level in DMRT

The tiller count per m^2 at 60 DAT and at harvest stage was found to be comparable in all the nursery media and did not cause any significant difference. The mean number of tillers at 60 DAT and at harvest stages was 417.06 m^{-2} and 319.41 m^{-2} respectively.

4.3.2.4 Weed count per m^2

The weed count per m^2 recorded was zero at 20 DAT. The weed count recorded from one square metre area at 40 DAT (Table 4.30) indicated that weed population was not influenced by different nursery media. The mean weed count per m^2 at 40 days DAT was 39.53 m^{-2}.

4.3.3 Yield attributes

4.3.3.1 Number of panicles per m^2

The data recorded on yield attributes as influenced by the different nursery media are given in Table 4.31. The total number of panicles per m^2 formed was not influenced by various nursery media. The crop produced 319.41 panicles per m^2 on an average of all the nursery media with a variation from 302.67 to 338 panicles per m^2.

4.3.3.2 Number of spikelets per panicle

On an average, 141.3 spikelets were formed per panicle (Table 4.31) with a variation from 129.37 to 160.33 spikelets per panicle. The number of spikelets per panicle recorded in different nursery media was comparable.

4.3.3.3 Number of filled grains per panicle

The number of filled grains as influenced by nursery media is shown in Table 4.31. The mean number of filled grains per panicle was 107.5. Even though the number of filled grains per panicle showed a variation from 95.27 to 124.03 per panicle, all the nursery media were statistically comparable.

Table 4.29 Number of tillers per m^2 as influenced by nursery media

Treatments		30 DAT	60 DAT	At harvest
N_1	80% RHC + 20% VC	314.67[ab]	428.30	315.70
N_2	60% RHC + 20% Soil + 20% VC	247.67[c]	401.33	302.67
N_3	40% RHC + 40% Soil + 20% VC	305.33[b]	422.33	332.00
N_4	20% RHC + 60% Soil + 20% VC	312.67[ab]	417.67	320.70
N_5	60% RHC + 30% Soil + 10% VC	303.00[b]	420.00	338.00
N_6	40% RHC + 50% Soil + 10% VC	305.67[b]	416.00	315.70
N_7	20% RHC + 70% Soil + 10% VC	305.00[b]	408.67	310.30
N_8	80% RHC + 20% CC	303.33[b]	414.33	319.00
N_9	60% RHC + 20% Soil + 20% CC	306.00[b]	415.67	321.00
N_{10}	60% RHC + 30% Soil + 10% CC	324.33[a]	426.33	319.00
Mean		**302.77**	**NS**	**NS**

* The means followed by common alphabets do not differ significantly at 5% level in DMRT

Table 4.30 Weed count per m^2 as influenced by nursery media

Treatments		40 DAT
N_1	80% RHC + 20% VC	42.67
N_2	60% RHC + 20% Soil + 20% VC	44.67
N_3	40% RHC + 40% Soil + 20% VC	30.00
N_4	20% RHC + 60% Soil + 20% VC	46.33
N_5	60% RHC + 30% Soil + 10% VC	34.33
N_6	40% RHC + 50% Soil + 10% VC	32.00
N_7	20% RHC + 70% Soil + 10% VC	57.00
N_8	80% RHC + 20% CC	32.00
N_9	60% RHC + 20% Soil + 20% CC	36.67
N_{10}	60% RHC + 30% Soil + 10% CC	39.67
CD (0.05)		**NS**

4.3.3.4 Thousand grain weight

The data on thousand grain weight are shown in Table 4.31. The thousand grain weight was not influenced by different nursery media. The mean thousand grain weight was 28.68 g and it was ranged from 28.03 g to 29.57 g.

4.3.3.5 Spikelet sterility (%)

The spikelet sterility as influenced by nursery media is presented in Table 4.31. The observations on spikelet sterility revealed that the spikelet sterility remained unaffected by the different nursery media. The spikelet sterility ranged from 20.89% with respect to N_8 (80% RHC + 20% CC) to 28.47% in N_3 (40% RHC + 40% soil + 20% VC) with an overall mean of 23.94%.

4.3.4 Yield

4.3.4.1 Grain yield

The data on grain yield ha^{-1} are given in Table 4.32. The data showed that the ultimate grain output of the crop was not at all influenced by different nursery media used for raising tray nursery.

4.3.3.4 Thousand grain weight

The data on thousand grain weight are shown in Table 4.31. The thousand grain weight was not influenced by different nursery media. The mean thousand grain weight was 28.68 g and it was ranged from 28.03 g to 29.57 g. The overall mean yield of the crop was 4.7 t ha^{-1}. The grain yield of the crop was ranged from 4.37 t ha^{-1} in N_1 (80% RHC + 20% VC) to 5.28 t ha^{-1} in N_6 (40% RHC + 50% soil + 10% VC).

Table 4.31 Yield attributes of rice as influenced by nursery media

Treatments		Panicles/ m^2	Spikelets/ panicle	Filled grains/ panicle	1000 grain weight (g)	Spikelet sterility (%)
N_1	80% RHC + 20% VC	315.70	136.17	104.83	28.03	22.69
N_2	60% RHC + 20% Soil + 20% VC	302.67	160.33	124.03	29.00	22.64
N_3	40% RHC + 40% Soil + 20% VC	332.00	145.69	104.06	29.57	28.47
N_4	20% RHC + 60% Soil + 20% VC	320.70	132.52	104.37	28.03	22.12
N_5	60% RHC + 30% Soil + 10% VC	338.00	136.18	98.90	28.53	26.86
N_6	40% RHC + 50% Soil + 10% VC	315.70	135.82	101.12	28.47	25.43
N_7	20% RHC + 70% Soil + 10% VC	310.30	143.58	112.63	29.23	21.65
N_8	80% RHC + 20% CC	319.00	149.42	119.90	29.37	20.89
N_9	60% RHC + 20% Soil + 20% CC	321.00	143.88	109.93	27.87	23.15
N_{10}	60% RHC + 30% Soil + 10% CC	319.00	129.37	95.27	28.73	25.50
CD (0.05)		**NS**	**NS**	**NS**	**NS**	**NS**

4.3.4.2 Straw yield

The data pertaining to the yield of straw are given in Table 4.32. The straw yield of different nursery media was comparable. The mean production of straw by the crop under various nursery media was 5.7 t ha^{-1} and it was ranged from 4.8 t ha^{-1} (N_9) to 6.5 t ha^{-1} (N_6).

4.3.5 Harvest index

The harvest index as influenced by nursery media is presented in Table 4.32. The harvest index remained unaltered due to various nursery media. The mean harvest index was 0.45 and the values were ranged from 0.43 to 0.48.

4.3.6 Nutrient content of grain and straw at harvest

4.3.6.1 Nitrogen content of grain and straw

The data on nitrogen content of grain and straw are presented in Table 4.29. Even though the various nursery media did not influence the N content of grain and straw, the N content of grain varied from 1.11% to 1.46% and that of straw was varied from 0.64% to 0.76% with a mean value of 1.26 % in grain and 0.7% in straw.

Table 4.32 Grain and straw yield (t ha^{-1}) and harvest index (HI) as influenced by nursery media

No.	Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest Index
N_1	80% RHC + 20% VC	4.37	5.74	0.43
N_2	60% RHC + 20% Soil + 20% VC	4.54	5.78	0.44
N_3	40% RHC + 40% Soil + 20% VC	4.88	5.46	0.47
N_4	20% RHC + 60% Soil + 20% VC	4.87	6.17	0.44
N_5	60% RHC + 30% Soil + 10% VC	4.61	5.99	0.43
N_6	40% RHC + 50% Soil + 10% VC	5.28	6.49	0.45
N_7	20% RHC + 70% Soil + 10% VC	4.59	5.70	0.45
N_8	80% RHC + 20% CC	4.59	5.41	0.46
N_9	60% RHC + 20% Soil + 20% CC	4.39	4.81	0.48
N_{10}	60% RHC + 30% Soil + 10% CC	4.83	5.55	0.47
CD (0.05)		**NS**	**NS**	**NS**

Table 4.33 Nitrogen content of grain and straw (%) as influenced by nursery media

Treatments		Grain	Straw
N_1	80% RHC + 20% VC	1.11	0.64
N_2	60% RHC + 20% soil + 20% VC	1.40	0.70
N_3	40% RHC + 40% soil + 20% VC	1.28	0.70
N_4	20% RHC + 60% soil + 20% VC	1.17	0.70
N_5	60% RHC + 30% soil + 10% VC	1.23	0.64
N_6	40% RHC + 50% soil + 10% VC	1.11	0.76
N_7	20% RHC + 70% soil + 10% VC	1.46	0.70
N_8	80% RHC + 20% CC	1.46	0.70
N_9	60% RHC + 20% soil + 20% CC	1.17	0.76
N_{10}	60% RHC + 30% soil + 10% CC	1.23	0.70
CD (0.05)		NS	NS

4.3.6.2 Phosphorus content of grain and straw

The phosphorus content of grain and straw as influenced by nursery media is presented in Table 4.30. The various growing media did not influence the P content of grain and straw. The P content of grain varied from 0.30% to 0.36% and that of straw was varied from 0.14% to 0.22% with a mean value of 0.33% in grain and 0.17% in straw.

4.3.6.3 Potassium content of grain and straw

The data pertaining to potassium content of grain and straw are presented in Table 4.35. The K content of crop remained unaltered without any significant variation due to various nursery media. The K content of grain varied from 0.26% to 0.27% and that of straw was varied from 1.37% to 1.56% with a mean value of 0.26% in grain and 1.48% in straw.

4.3.7 Nutrient uptake of plants

4.3.7.1 Nitrogen uptake

The data on nitrogen uptake by the crop are presented in Table 4.36. The N uptake by the crop remained unaltered without any significant variation due to various nursery media. The mean uptake of nitrogen by grain and straw were 59.21 kg ha^{-1} and 32.12 kg ha^{-1} respectively. The mean total uptake of N by the crop was 91.43 kg ha^{-1}

4.3.7.2 Phosphorus uptake

The effect of different nursery media on phosphorus uptake by the crop is presented in Table 4.37. The various growing media did not influence the P uptake by the crop. The mean uptake of phosphorus by grain and straw were 15.32 kg ha^{-1} and 7.75 kg ha^{-1} respectively. The mean total uptake of P by the crop was 23.07 kg ha^{-1}.

Table 4.34 Phosphorus content of grain and straw (%) as influenced by nursery media

Treatments		Grain	Straw
N_1	80% RHC + 20% VC	0.31	0.22
N_2	60% RHC + 20% soil + 20% VC	0.32	0.15
N_3	40% RHC + 40% soil + 20% VC	0.30	0.18
N_4	20% RHC + 60% soil + 20% VC	0.34	0.15
N_5	60% RHC + 30% soil + 10% VC	0.35	0.16
N_6	40% RHC + 50% soil + 10% VC	0.34	0.17
N_7	20% RHC + 70% soil + 10% VC	0.32	0.22
N_8	80% RHC + 20% CC	0.36	0.14
N_9	60% RHC + 20% soil + 20% CC	0.31	0.15
N_{10}	60% RHC + 30% soil + 10% CC	0.33	0.17
CD (0.05)		**NS**	**NS**

Table 4.35 Potassium content of grain and straw (%) as influenced by nursery media

Treatments		Grain	Straw
N_1	80% RHC + 20% VC	0.26	1.37
N_2	60% RHC + 20% soil + 20% VC	0.27	1.51
N_3	40% RHC + 40% soil + 20% VC	0.27	1.56
N_4	20% RHC + 60% soil + 20% VC	0.26	1.41
N_5	60% RHC + 30% soil + 10% VC	0.26	1.49
N_6	40% RHC + 50% soil + 10% VC	0.27	1.47
N_7	20% RHC + 70% soil + 10% VC	0.26	1.56
N_8	80% RHC + 20% CC	0.26	1.52
N_9	60% RHC + 20% soil + 20% CC	0.26	1.53
N_{10}	60% RHC + 30% soil + 10% CC	0.26	1.39
CD (0.05)		**NS**	**NS**

Table 4.36 N uptake by grain and straw (kg ha^{-1}) as influenced by nursery media

Treatments		Grain	Straw	Total
N_1	80% RHC + 20% VC	48.81	29.40	78.21
N_2	60% RHC + 20% soil + 20% VC	63.83	32.28	96.11
N_3	40% RHC + 40% soil + 20% VC	62.03	30.56	92.59
N_4	20% RHC + 60% soil + 20% VC	58.24	34.93	93.17
N_5	60% RHC + 30% soil + 10% VC	56.71	30.55	87.26
N_6	40% RHC + 50% soil + 10% VC	58.99	40.36	99.35
N_7	20% RHC + 70% soil + 10% VC	66.98	31.90	98.88
N_8	80% RHC + 20% CC	66.15	30.23	97.38
N_9	60% RHC + 20% soil + 20% CC	50.12	28.34	78.46
N_{10}	60% RHC + 30% soil + 10% CC	60.20	32.66	92.86
CD (0.05)		NS	NS	NS

Table 4.37 P uptake by grain and straw (kg ha^{-1}) as influenced by nursery media

Treatments		Grain	Straw	Total
N_1	80% RHC + 20% VC	13.50	9.91	23.41
N_2	60% RHC + 20% soil + 20% VC	14.34	6.70	21.00
N_3	40% RHC + 40% soil + 20% VC	14.63	8.27	22.90
N_4	20% RHC + 60% soil + 20% VC	16.48	7.27	23.75
N_5	60% RHC + 30% soil + 10% VC	16.14	7.47	23.61
N_6	40% RHC + 50% soil + 10% VC	17.76	8.64	26.40
N_7	20% RHC + 70% soil + 10% VC	14.77	9.80	24.57
N_8	80% RHC + 20% CC	16.41	6.14	22.55
N_9	60% RHC + 20% soil + 20% CC	13.48	5.99	19.47
N_{10}	60% RHC + 30% soil + 10% CC	15.72	7.32	23.04
CD (0.05)		NS	NS	NS

4.3.7.3 Potassium uptake

The data on potassium uptake by the crop are presented in Table 4.34. The various nursery media did not influence the K uptake by the crop. The mean uptake of potassium by grain and straw were 12.31 kg ha^{-1} and 67.63 kg ha^{-1} respectively. The mean total uptake of K by the crop was 79.95 kg ha^{-1}.

4.2.6 Soil analysis after harvest of the crop

The data on soil analysis after the harvest crop are given in Table 4.39. The pH of the soil and the electrical conductivity (EC) after the harvest of the crop was 5.33 and 0.09 dS m^{-1} respectively. An organic carbon content of 0.48% was recorded in the soil after harvest of the crop. The contents of nitrogen, phosphorus and potassium after cultivation of the crop were 163.07 kg ha^{-1}, 32.59 kg ha^{-1} and 221.18 kg ha^{-1} respectively.

4.2.7 Economics of cultivation

The effect of different nursery media on the economics of cultivation is presented in Table 4.40. The cost of cultivation was comparable in all the nursery media. The highest return of Rs. 1,23,000 was manifested by media of 40% RHC + 50% soil + 10% VC (N_6) followed by the media of 20% RHC + 60% soil + 20% VC (Rs.1,14,118). The highest BC ratio of 1.67 was recorded in the media comprised of 40% RHC + 50% soil + 10% VC (N_6) followed by the media of 20% RHC + 60% soil + 20% VC (N_4). The lowest ratio of 1.36 was recorded in the media comprised of 60% RHC + 20% soil + 20% CC (N_9).

Table 4.38 K uptake by grain and straw (kg ha^{-1}) as influenced by nursery media

Treatments		Grain	Straw	Total
N_1	80% RHC + 20% VC	11.51	63.75	75.26
N_2	60% RHC + 20% soil + 20% VC	12.25	71.07	83.32
N_3	40% RHC + 40% soil + 20% VC	13.16	68.22	81.38
N_4	20% RHC + 60% soil + 20% VC	12.68	70.13	82.81
N_5	60% RHC + 30% soil + 10% VC	11.91	71.74	83.65
N_6	40% RHC + 50% soil + 10% VC	13.94	74.72	88.66
N_7	20% RHC + 70% soil + 10% VC	11.83	70.68	82.51
N_8	80% RHC + 20% CC	11.88	65.72	77.60
N_9	60% RHC + 20% soil + 20% CC	11.51	58.90	70.41
N_{10}	60% RHC + 30% soil + 10% CC	12.51	61.39	73.90
CD (0.05)		**NS**	**NS**	**NS**

Table 4.39 Soil analysis after cultivation of crop

No.	Physico - chemical properties	Value
1	Soil reaction (pH)	5.33
2	Electrical conductivity (dS m^{-1})	0.09
3	Organic Carbon (%)	0.48
4	Available N (kg ha^{-1})	163.07
5	Available P_2O_5 (kg ha^{-1})	32.59
6	Available K_2O (kg ha^{-1})	221.18

Table 4.40 Economics of cultivation (Rs/ ha) as influenced by nursery media

Treatments		Cost of cultivation	Gross return	BC Ratio
N_1	80% RHC + 20% VC	73,362/-	1,03,106/-	1.41
N_2	60% RHC + 20% soil + 20% VC	73,457/-	1,06,462/-	1.45
N_3	40% RHC + 40% soil + 20% VC	73,553/-	1,11,830/-	1.52
N_4	20% RHC + 60% soil + 20% VC	73,649/-	1,14,118/-	1.55
N_5	60% RHC + 30% soil + 10% VC	73,449/-	1,08,548/-	1.48
N_6	40% RHC + 50% soil + 10% VC	73,544/-	1,23,000/-	1.67
N_7	20% RHC + 70% soil + 10% VC	73,640/-	1,07,160/-	1.46
N_8	80% RHC + 20% CC	73,332/-	1,06,110/-	1.45
N_9	60% RHC + 20% soil + 20% CC	73,428/-	1,00,210/-	1.36
N_{10}	60% RHC + 30% soil + 10% CC	73,449/-	1,11,174/-	1.51

Discussion

V. DISCUSSION

The experiment on standardization of media for tray nursery technique in rice was conducted at Agricultural Research Station, Mannuthy. Rice is the principal food crop of Kerala. But the cultivated area of rice in Kerala is drastically decreasing year after year. The major reason for this reduction is the high cost of cultivation due to increased wage rate prevailing in the state. Mechanization of rice cultivation has become imperative to sustain and make it economically viable as well as ecologically harmonious (Jaikumaran *et al.,* 1999). Since manual transplanting of rice increases the cost of cultivation, mechanical transplanting using tray nursery will be a great help to farmers. The soil media used for raising tray nursery is very costly and substitution of the growing media with low cost and easily available materials will lead to cost reduction in rice cultivation and wider acceptance of the technology. This will also help to pave way for the commercial production of paddy mat nursery with light weight for easy transportation.

Based on these facts, the different growing media were tested and the growth characters and nutrient status of seedlings, mat characteristics, performance of growing media under field condition with respect to growth and yield of rice, performance of transplanter and nutrient status of crop and soil were studied.

5.1 EXPERIMENT I: STANDARDIZATION OF MEDIA FOR TRAY NURSERY TECHNIQUE IN RICE

Raising mat nursery using low cost and easily available materials with the help of automatic paddy mat nursery sowing machine was found to be successful in cost reduction of rice cultivation. Experiment I was designed to find out the best performing growing media with respect to growth characters of seedlings, mat characteristics and nutrient contents of seedlings.

5.1.1 Effect of growing media on growth characters of seedlings

The time required for germinating 50% of the seedlings in mat nursery was five days which was unaltered by different growing media. It could be observed that the establishment of the seedlings of mat occurred at 15 days after sowing (DAS) which is regarded as the appropriate time for transplanting the seedlings.

The data on seedling characters revealed that the growing media comprised of high proportion of rice husk charcoal had a significant role in seedling vigour especially with respect to seedling height, shoot dry weight and root length of rice seedlings. Higher proportion (60% or above) of rice husk charcoal in the media produced taller seedlings (Fig. 5.1) at 15 DAS. As regards the different media, the media comprised of 80% RHC + 20% VC contributed to the maximum height and had maintained the same temperament right from the germination of seedlings as the observations were taken at five days interval. The same media of 80% RHC + 20% VC produced higher biomass also. Dhananchezhiyan *et al.* (2013) suggested that the nursery height can be considered as an indicator of the health of the nursery that was grown. According to Mamun *et al.* (2013), the suitable seedling height of 12 cm could be achieved from 12-16 days old seedlings for mechanical transplanting in rice. This is in confirmation with the present study.

The seedlings attained a relatively good biomass only after 15 DAS (Fig. 5.2). The media comprised of vermicompost at a proportion of 20% with 60% rice husk charcoal and 20% soil had the highest biomass production. Vermicompost even at a proportion of 20% contributed to the higher biomass production of rice seedlings. Edwards *et al.* (2004) proved that the vermicompost produced significant positive effects on plant growth and yield at relatively low proportions (up to 20% of the growing media).

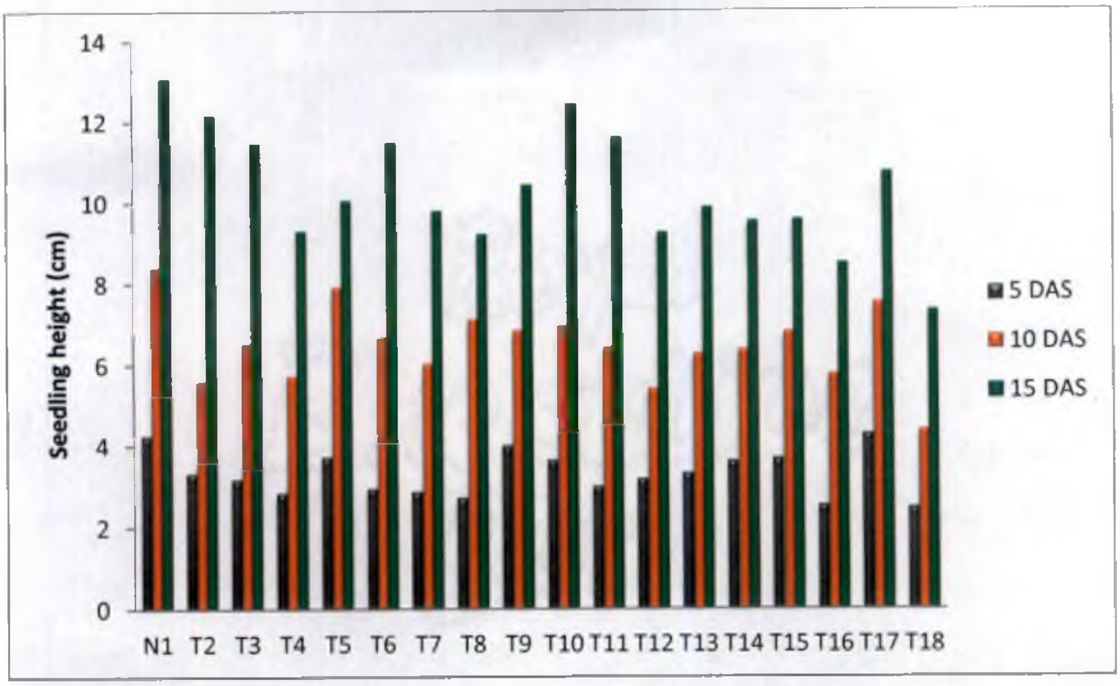

Fig. 5.1 Seedling height of seedlings as influenced by variation in growing media

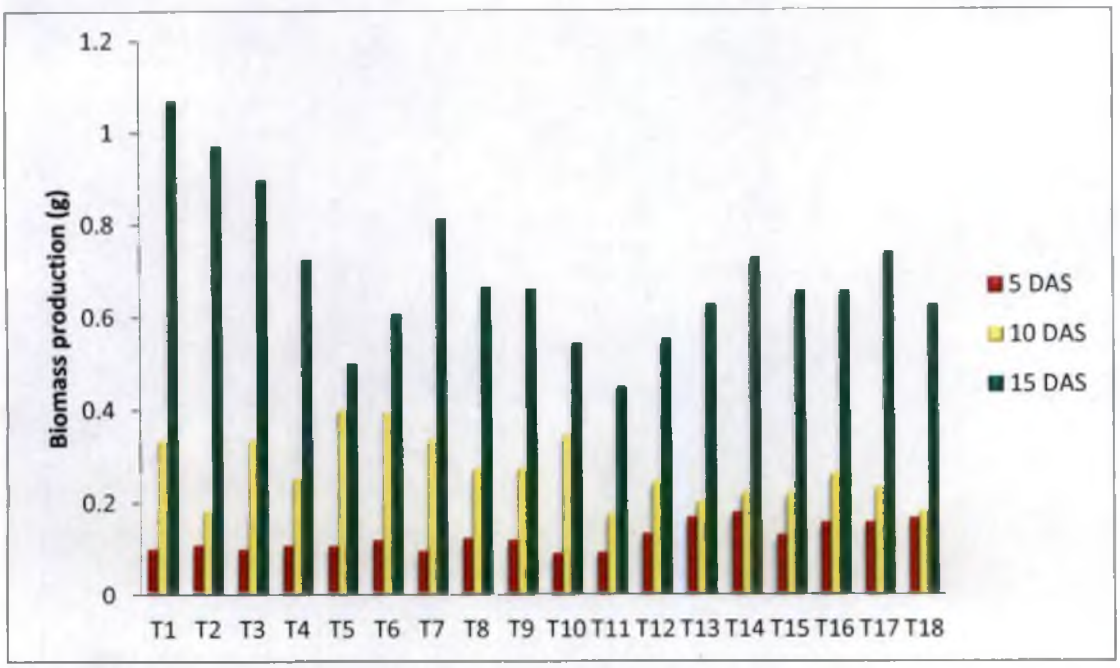

Fig. 5.2 Biomass production of seedlings as influenced by variation in growing media

In vermicompost, the nutrients are present in readily available form for plant uptake (Edwards and Burrows, 1988) and moreover, it contains large amounts of humic substances, some of the effects of which on plant growth are similar to those of soil applied plant growth regulators (Muscolo *et al.,* 1999). All these effects of vermicompost had contributed positively for the increased growth of rice seedlings in their respective media. Though the seedlings showed a better growth with higher biomass at 5 DAS in the soil media, further overall growth was poor at 10 and 15 DAS. However, higher biomass and dry matter production (Fig. 5.3) of seedlings were obtained in media with higher proportion of rice husk charcoal at 15 DAS. Milla *et al.* (2013) observed a greater increase in biomass production in water spinach with the application of fertilizer and rice husk charcoal. The rice husk charcoal was found to increase the final biomass of potted lettuce (*Lactuca sativa*) in comparison to no rice husk charcoal treatments (Carter *et al.,* 2013).

The seedlings with high root dry weight were produced in the media with higher proportion of soil (Fig. 5.4). The highest root dry weight bearing seedlings at 15 DAS was produced in the control media with soil alone. This may be due to the production of more number of roots by the seedlings in the soil media. Seedlings with high shoot dry weight (Fig 5.5) and root length (Fig 5.6) at 15 DAS were also produced by the media comprised of higher proportion of rice husk charcoal. It was observed that the proportion of rice husk charcoal had a prominent role in the seedling growth of rice. The taller seedlings with relatively high biomass and dry matter production were produced by the media comprised of 80% and 60% rice husk charcoal. Rice husk charcoal is a byproduct in rice mills and it could act as a soil conditioner by supplying and retaining nutrients and thus improving the physical and biological properties of soil (Milla *et al.,* 2013). It also has high aeration properties and good moisture retentiveness due to its porosity (Ikeura *et al.,* 2012). Islam (2008) focused the good aeration and light weight properties of rice husk charcoal and found to be a suitable medium for soilless culture.

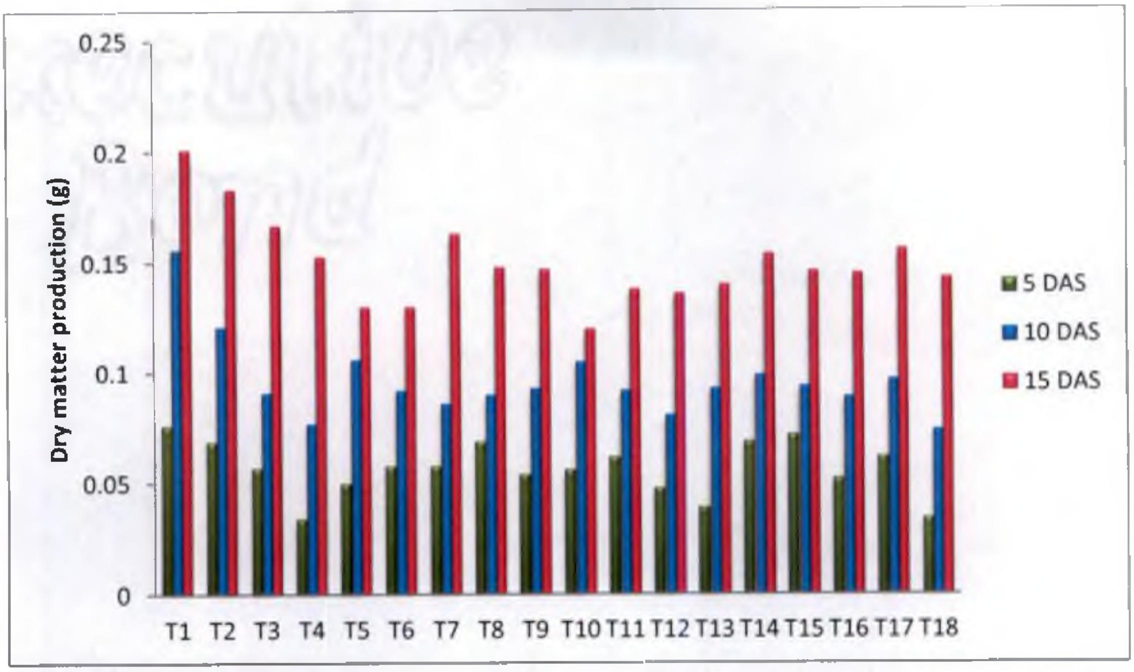

Fig. 5.3 Dry matter production of seedlings as influenced by variation in growing media

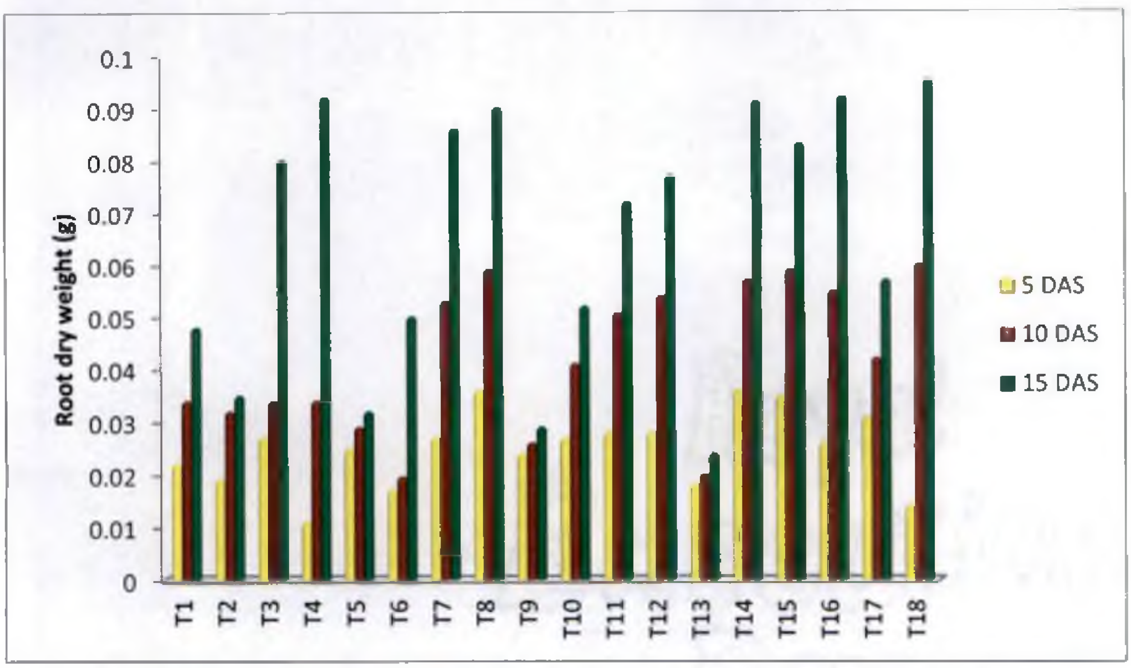

Fig. 5.4 Root dry weight of seedlings as influenced by variation in growing media

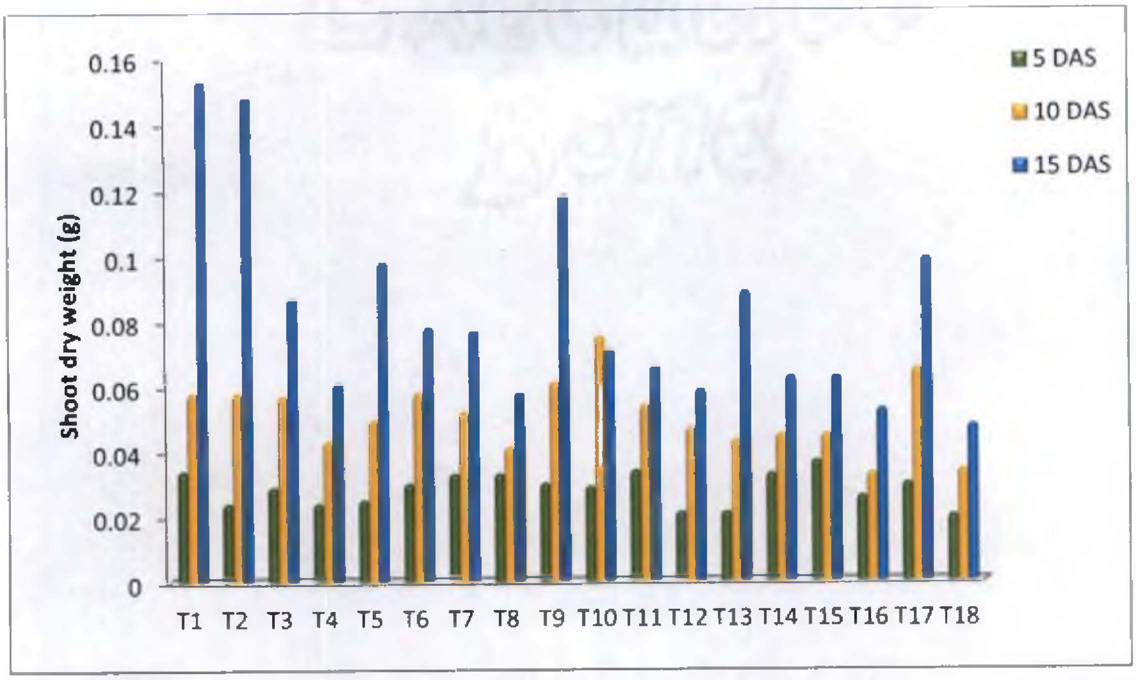

Fig. 5.5 Shoot dry weight of seedlings as influenced by variation in growing media

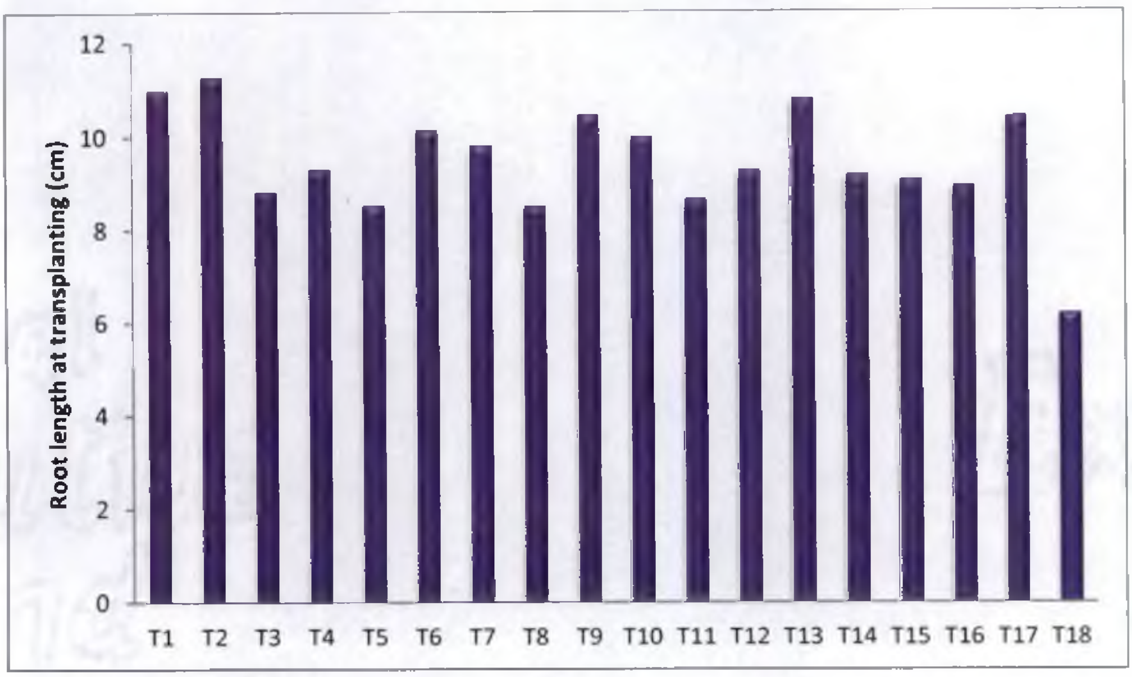

Fig. 5.6 Root length of seedlings as influenced by variation in growing media

Chien *et al.* (2011) reported that the addition of rice husk charcoal can increase the soil's concentration of Ca, Mg, K and S as well as its pH value by lowering acidity in acid soils. So the increased nutrient supplying capacity and improved physical properties of rice husk charcoal had helped it to act as a good growing medium for seedlings and this had also reflected in improved growth of rice seedlings grown in higher proportion of rice husk charcoal in the study. It was also noticed that the rice husk charcoal mixed well with vermicompost or coir pith compost which is evident from higher biomass and dry matter production with combinations of rice husk charcoal and vermicompost or coir pith compost.

Adequate root length is required for good anchorage and establishment of seedlings after transplanting in the field. In the present investigation, media comprised of 60% RHC + 20% soil + 20% VC recorded longer roots (Fig. 5.6). The lowest root length was recorded in the soil media. The higher root length was observed with higher proportions of rice husk charcoal and it may be due to the presence of very light material with micro porous structure and low bulk density of rice husk charcoal (Haefele *et al.,* 2009). This might have helped the roots to penetrate to the lower layers of medium faster and hence more root length was observed. Islam (2008) observed that the rice husk charcoal has the potency as substrate due to its suitable physico-chemical characteristics, better performance on crop productivity, low price, ecological suitability and with no environmental pollution after its use. Vijayakumar *et al.* (2004), Ahmed *et al.* (2008) and Dhananchezhiyan *et al.* (2013) also reported the similar results.

According to Mamun *et al.* (2013), the recommended seedling height for mechanical transplanting is 12 cm. The seedlings with 10 cm or more than 10 cm height is considering as the normal seedlings for mechanical transplanting. The number of normal and abnormal seedlings was significantly influenced by different growing media. The number of normal seedlings (Fig. 5.7) was also more with higher proportions (60% or > 60%) of rice husk charcoal along with either vermicompost or coir pith compost. The improved vigour of the seedlings in the media contained higher proportion of rice husk charcoal resulted in reduction of number of abnormal seedlings in these media.

5.1.2 Effect of growing media on mat characteristics

The mat characteristics play prominent role in mechanical transplanting. Mat characteristics such as thickness, weight and strength of mat are important for efficient performance of the self propelled rice transplanter.

The optimum mat thickness is essential because the thinner mats will lead to slipping down of mat while placing in the seedling box of transplanter. This may cause high number of floating seedlings. A mat with thickness above 2.5 cm will interfere the performance of the transplanter by clogging the fingers of the transplanter (Rajesh, 2003). The thickness of the media (Fig. 5.8) varied with the different combinations of growing media and the highest mat thickness was recorded for media comprised of 20% RHC + 60% soil and 20% VC (1.7 cm). While studying the influence of mat characteristics on performance of self-propelled rice transplanter, Behera *et al.* (2007) observed that the energy required has initially decreased and then increased with the 2 cm size mat. Therefore, it should be better to keep the thickness of mat not more than 2 cm. In the study, the average mat thickness was 1.5 cm and the mat thickness was below 2 cm in all the treatments.

The mat weight (Fig. 5.9) was also significantly influenced by different combinations of growing media. It was observed that, as the proportion of rice husk charcoal increased, the weight of mat decreased. The heavier mats were produced in trays with soil medium and they were found to be difficult to handle during transportation. Hence, low mat weight is preferred for mechanized transplanting and easy transportation. The observations of mat weight in the study clearly indicated that the combinations with high proportions of rice husk charcoal and coir pith compost was lighter in weight compared to vermicompost and soil.

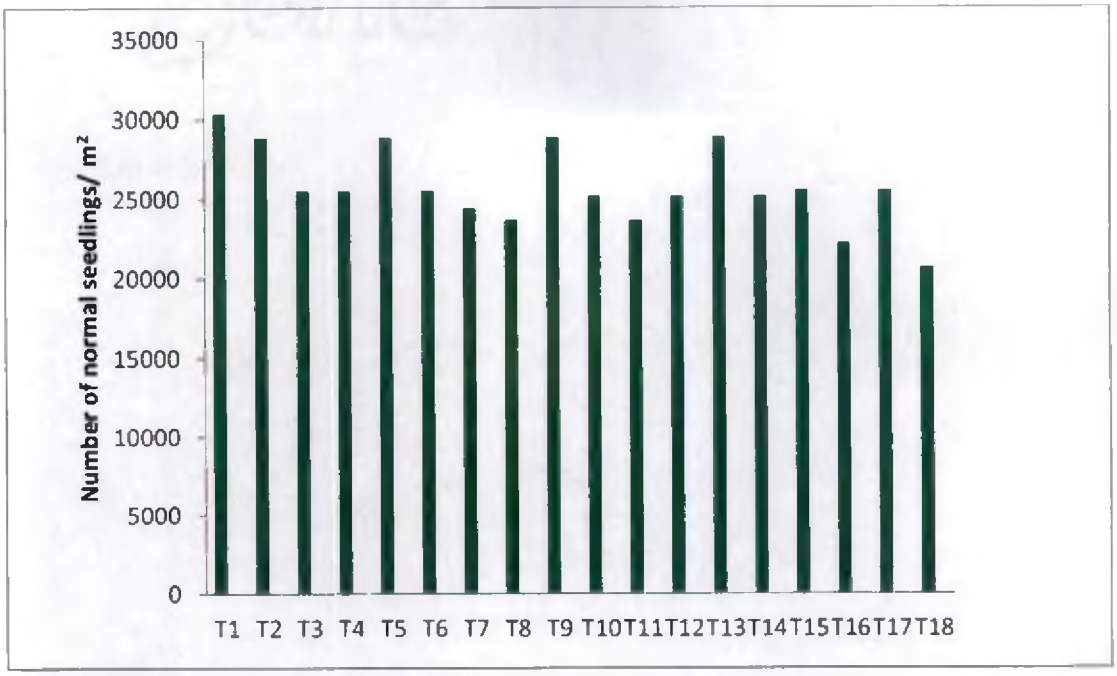

Fig. 5.7 Number of normal seedlings as influenced by variation in growing media

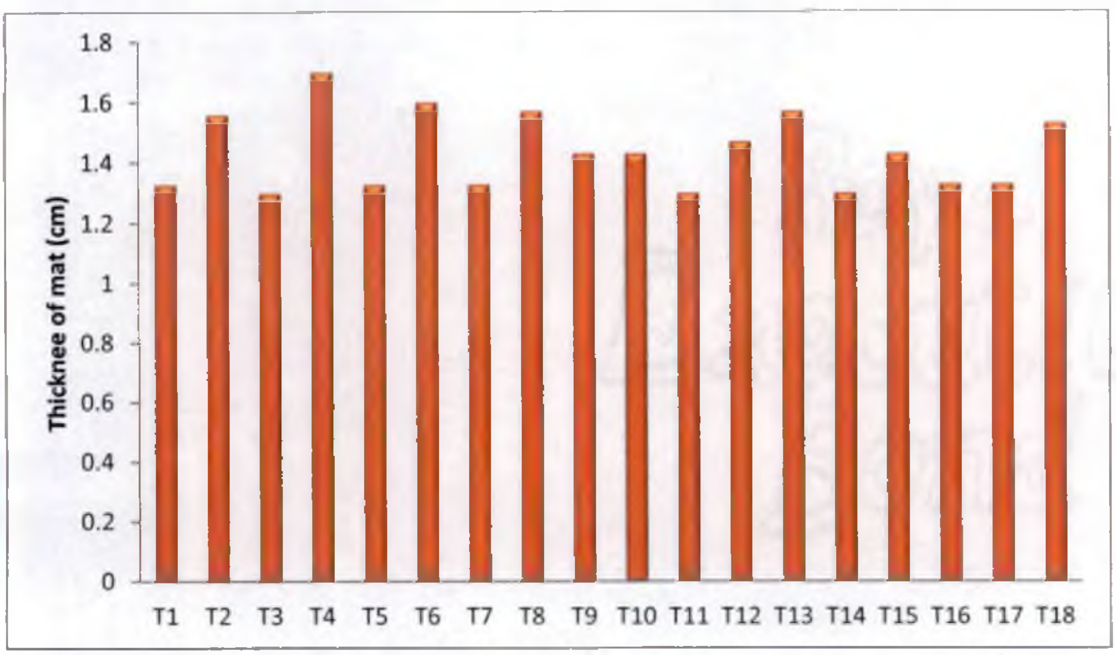

Fig. 5.8 Thickness of mat as influenced by variation in growing media

Kim *et al.* (2003) also noticed that the weight of rice seedling trays could be decreased by using rice husk charcoal as a seedling medium. The weight of rice husk charcoal is less compared with its volume. Because of less effort in handling the seedlings trays, labour can be saved by using rice husk charcoal. The light weight of the mat nursery is an important character in the context of commercial production of paddy mat nursery for the supply of ready to transplant mat nursery trays to the farmers. But with increasing the proportion of rice husk charcoal up to 90% with low proportion of soil and nutrient source showed the tendency of loosening the roots held in the mat at higher moisture condition with low cohesiveness. The medium was distorted in combinations of high proportion of rice husk charcoal and low proportion of soil due to non sticky nature of rice husk charcoal and low proportion of soil which had an aggregating property.

If the mats are not stiff enough to handle while taken out from the tray, the performance of transplanter will not be satisfactory. Insufficient root network was observed as the cause of such weak mat stiffness (Dhananchezhiyan *et al.*, 2013). Mat strength is a measure of stiffness of mat. In this study, the mat strength (Fig. 5.10) was higher in the media comprised of 80% RHC + 20% CC. Dhananchezhiyan *et al.* (2013) also observed that the mat strength was found to be maximum for a media mixture of field soil and coir pith at 1:1 and 2:1 ratios. The higher mat strength in the study may be due to the presence of more organic matter in the medium causing better binding and thereby better stiffness. Hence, an optimum combination of organic source and rice husk charcoal favouring low mat weight and high mat strength was noticed to be necessary for easy transportation of mat nursery and mechanical transplanting in rice cultivation.

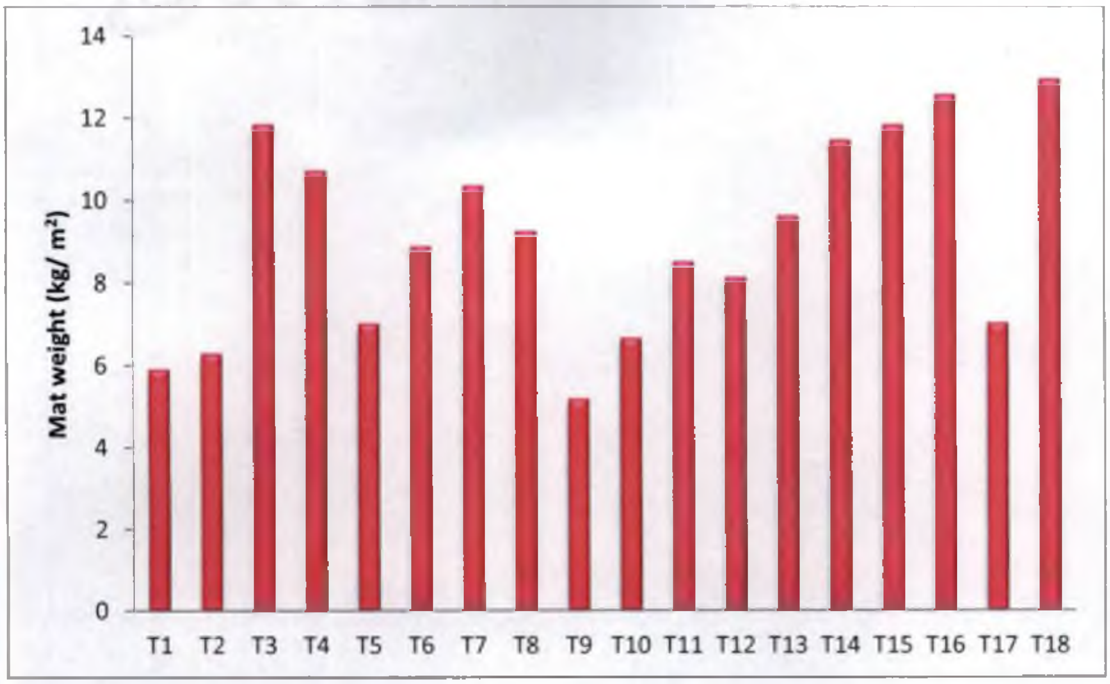

Fig. 5.9 Mat weight as influenced by variation in growing media

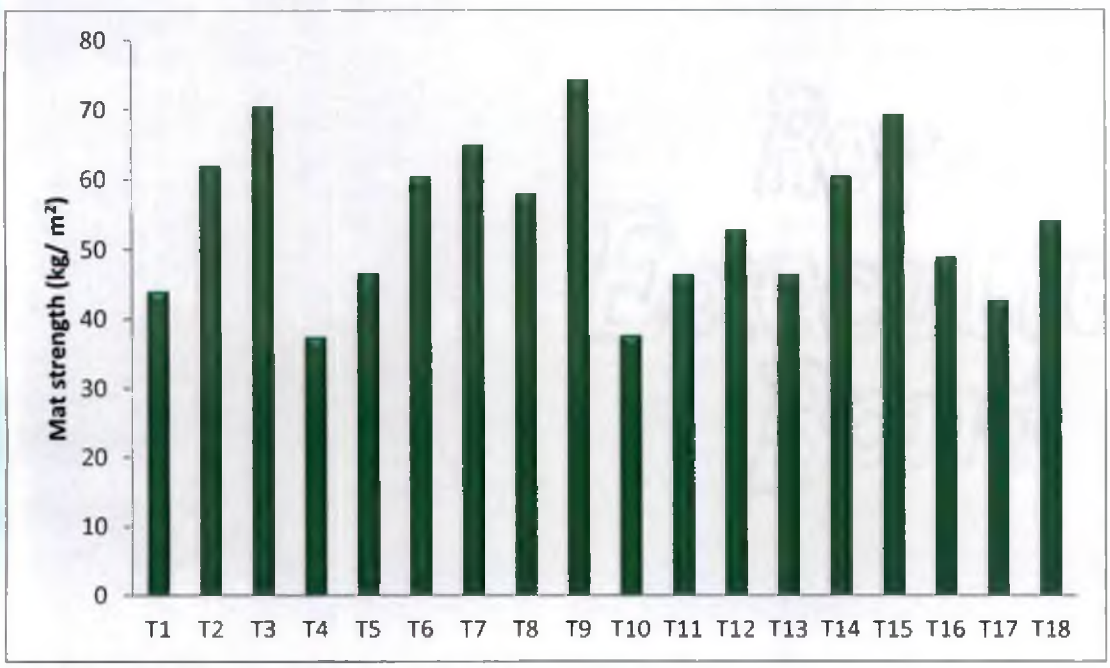

Fig. 5.10 Mat strength as influenced by variation in growing media

5.1.3 Effect of growing media on content and uptake of nutrients by seedlings

The water holding capacity of the media comprised of higher proportion of rice husk charcoal was significantly higher compared to other media whereas the bulk density of these media recorded a low value. Low bulk density of rice husk charcoal was also observed by Islam *et al.* (2002) and Haefele *et al.* (2009). The low bulk density of rice husk charcoal resulted in light weight of mats and will favour easy transportation. The carbonization process improves the water holding capacity of rice husks (Oshio *et al.,* 1981). The higher seedling vigour observed may be due to the higher water holding capacity of rice husk charcoal which supplied steady moisture content to the seedlings in the nursery resulting in more uptake of nutrients by seedlings during growth in nursery.

The highest organic carbon content was observed in the media of 80% RHC + 20% CC among the different media. The seedlings raised in the media comprised of higher proportion of rice husk charcoal showed high nitrogen content. The potassium content of seedlings was highest in the media comprised of 80% RHC + 10% soil + 10% VC due to higher contents of potassium in vermicompost and rice husk charcoal, while the contents of calcium, zinc and copper were highest in the media comprised of soil alone. But the media comprised of 60% RHC + 20% soil + 20% VC recorded the highest magnesium, sulphur and iron contents in seedlings. The addition of rice husk charcoal carbonized at 600 and 700°C to soil can increase the concentrations of calcium, magnesium, potassium and silicon as well as the pH value (lowers soil acidity) of the soil and it was identified as a great soil modifier (Chien et al., 2011). It was also reported that rice husk charcoal has a porous structure which contributes to aeration and water retention which in turn enhances water and nutrients (especially potassium and phosphorus) retention (Oshio *et al.,* 1981). These may be the reasons for higher nutrient contents of the seedlings grown in media with higher proportions of rice husk charcoal.

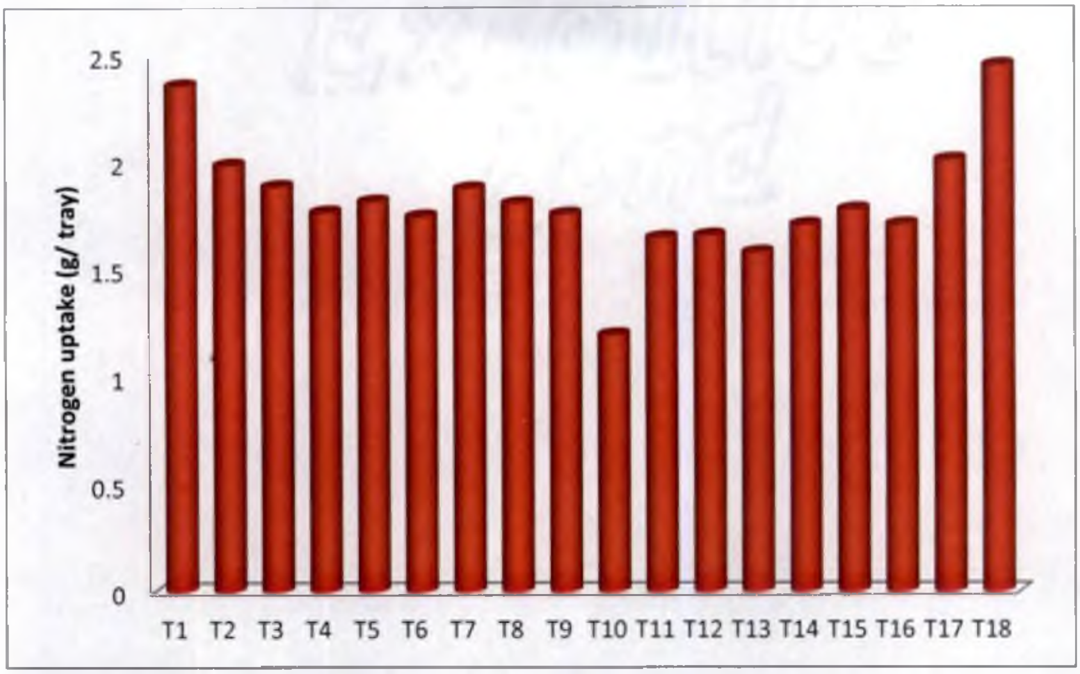

Fig. 5.11 N uptake by seedlings as influenced by variation in growing media

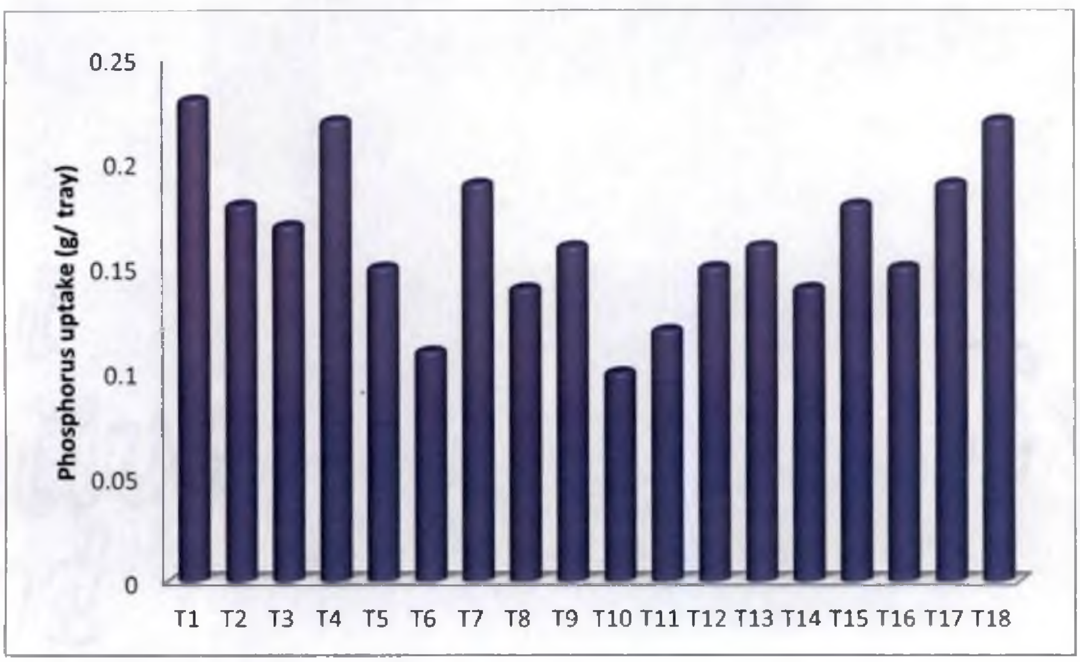

Fig. 5.12 P uptake by seedlings as influenced by variation in growing media

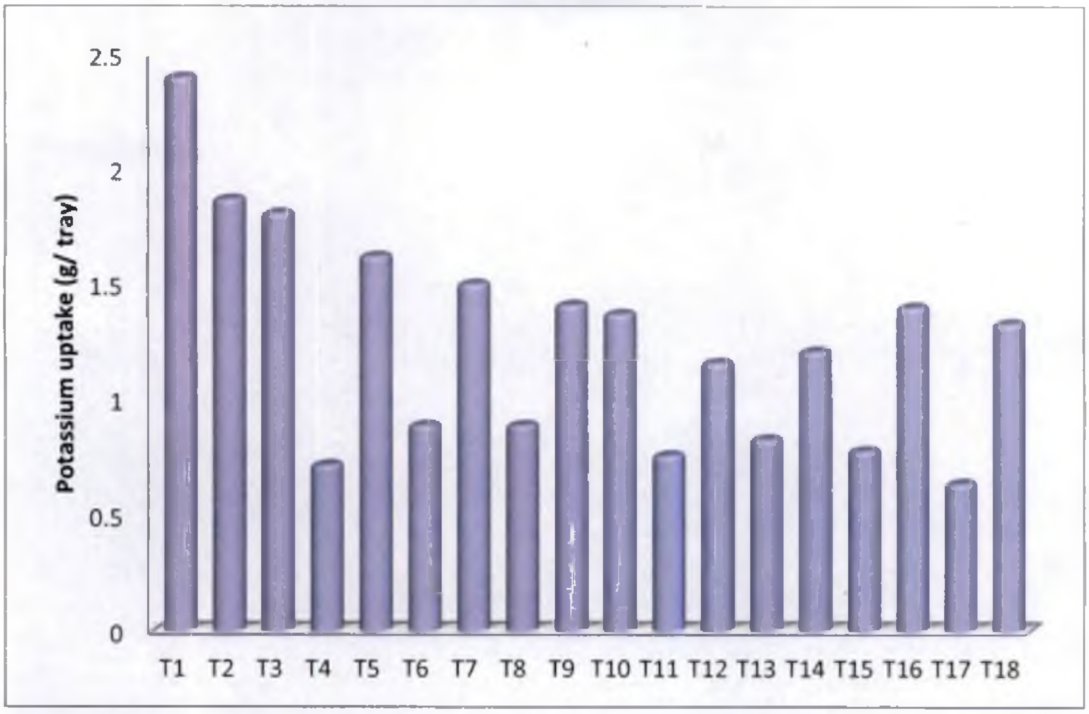

Fig. 5.13 K uptake by seedlings as influenced by variation in growing media

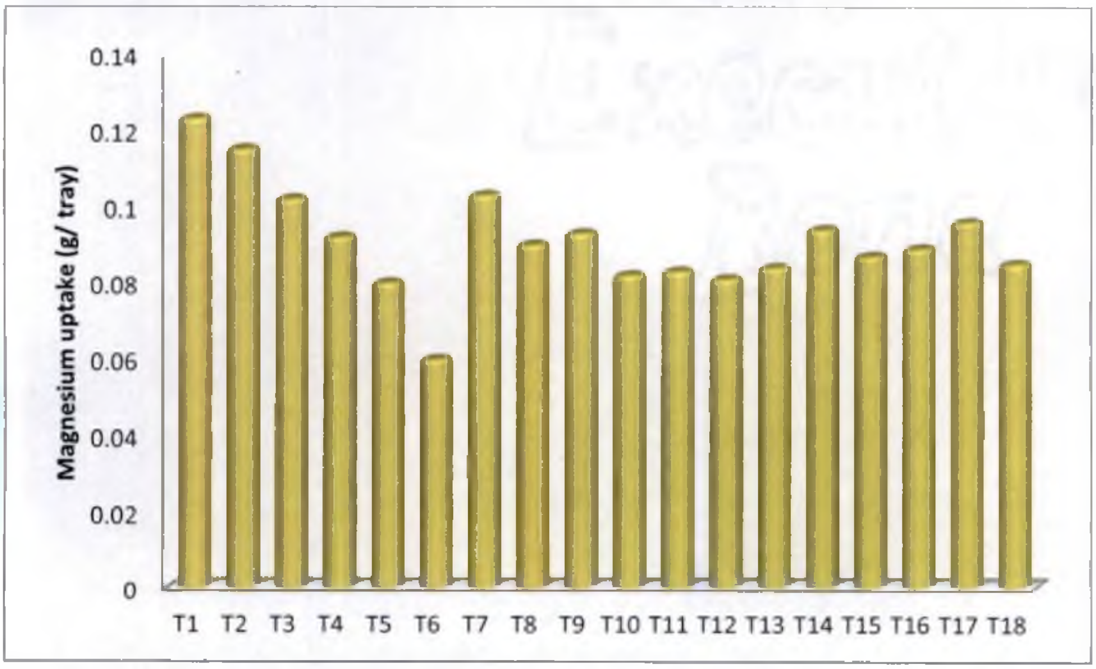

Fig. 5.14 Mg uptake by seedlings as influenced by variation in growing media

The increased biomass production and seedling growth with media comprised of 80% RHC + 20% VC and 60% RHC + 20% soil + 20% VC were also due to higher proportion of vermicompost in these media compared to other combinations. The uptake of nitrogen (Fig. 5.11), phosphorus (Fig. 5.12), potassium (Fig. 5.13), magnesium (Fig. 5.14) and silicon (Fig. 5.18) were higher in the media comprised of 80% RHC + 20% VC. The media of 60% RHC + 20% soil + 20% VC recorded the highest iron (Fig. 5.16), sulphur (Fig. 5.15) and boron (Fig. 5.17) uptake. Similar results were also recorded by Edwards and Burrows (1988), Sureshkumar and Ganesh (2012) and Milla *et al.* (2013). The nutrient analysis of individual components of the growing media revealed that vermicompost had higher nutrient contents compared to other components of the media *viz.* rice husk charcoal and coir pith compost. Rice husk charcoal also contains relatively higher contents of nutrients. Consequently, the nutrient contents of the media comprising of vermicompost and rice husk charcoal was high which resulted in improved growth of seedling and higher biomass production in these media. Moreover, the higher water holding capacity of these two components in the media favour increased uptake of nutrients in seedlings in these combinations of media as evident in the study.

Considering the economics of the nursery, the cost of nursery was comparable for all the growing media. However the cost of nursery was higher with soil media and the growing media comprised of higher proportion of soil recorded a slight increase in the cost of nursery. It was also noticed that the total cost of nursery for raising mat nursery using automatic paddy mat nursery sowing machine is less expensive than conventional nursery since the latter demands high labour. Garg *et al.* (1997) reported about the economic advantage of mechanical planting using mat nursery.

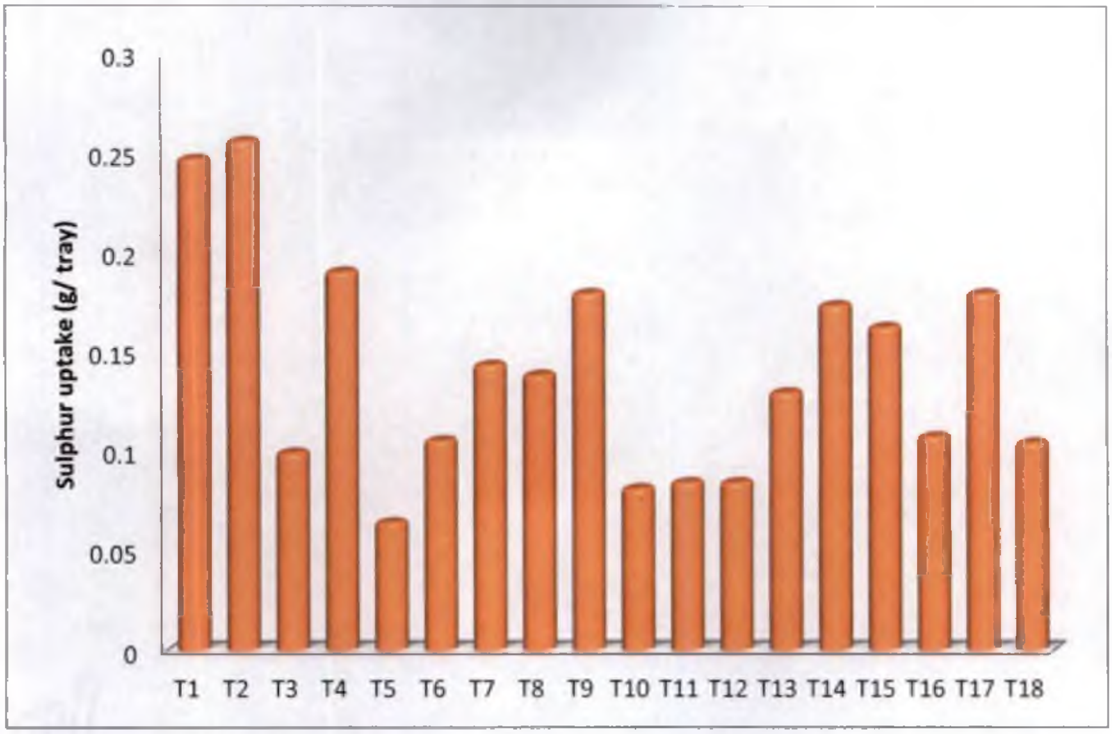

Fig. 5.15 S uptake by seedlings as influenced by variation in growing media

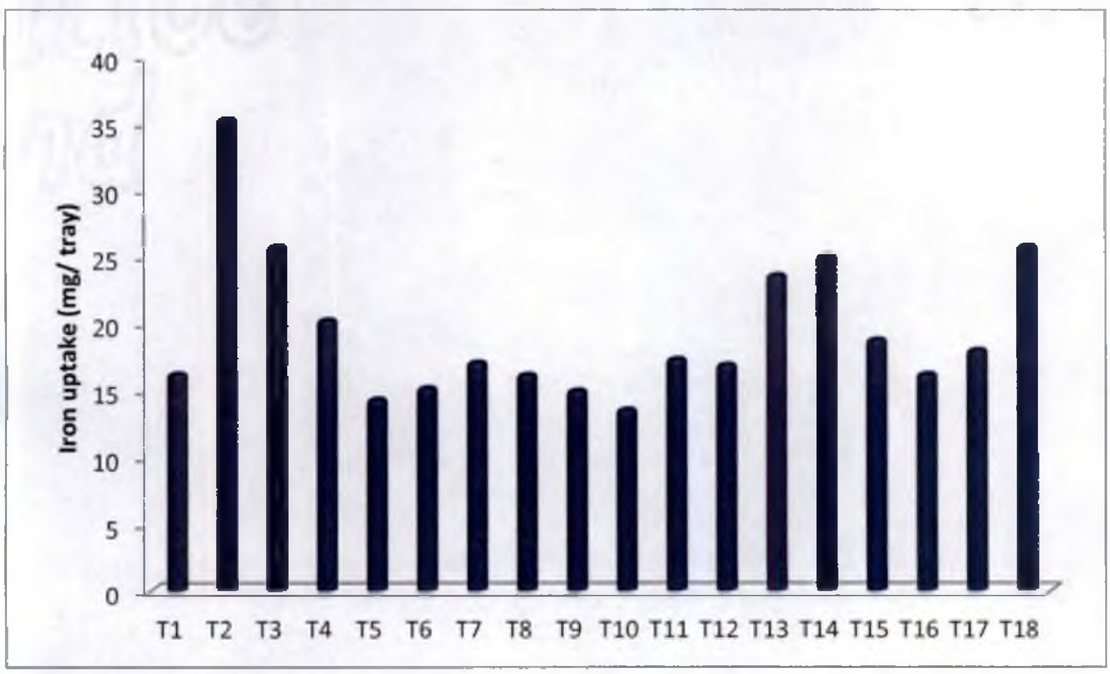

Fig. 5.16 Fe uptake by seedlings as influenced by variation in growing media

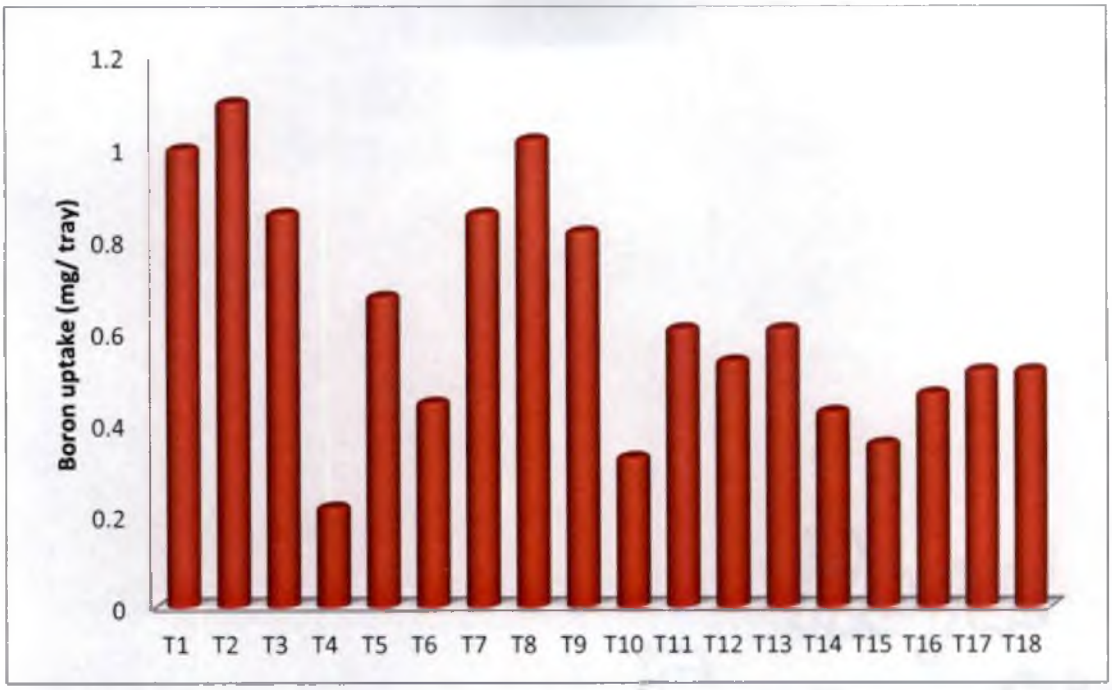

Fig. 5.17 B uptake by seedlings as influenced by variation in growing media

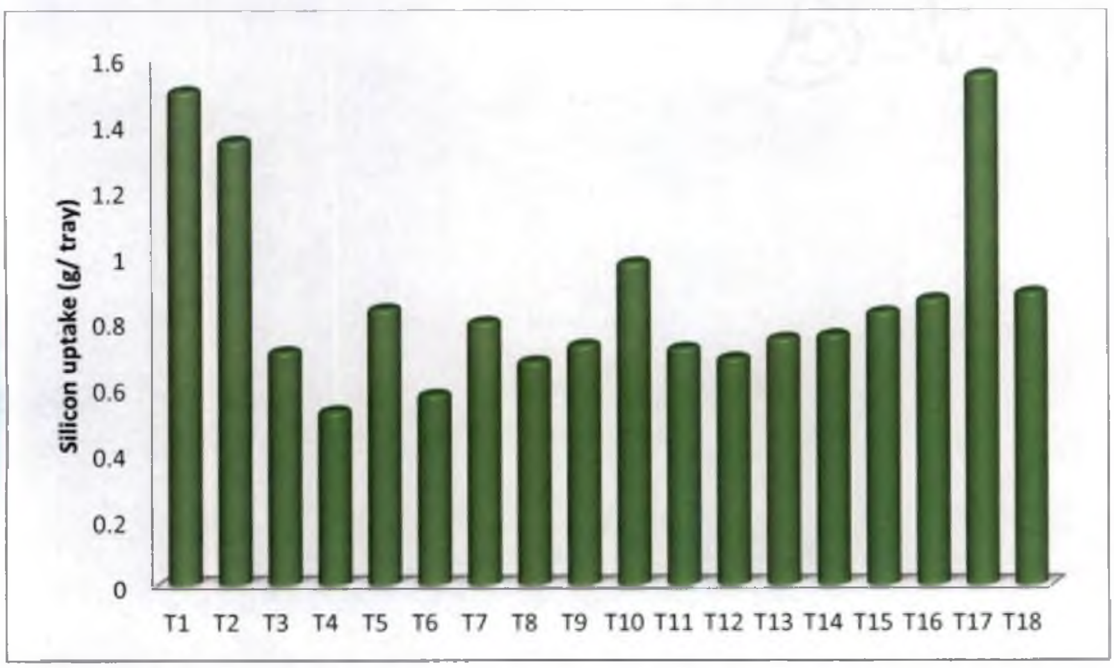

Fig. 5.18 Si uptake by seedlings as influenced by variation in growing media

The Experiment I revealed that the treatment combinations comprised of higher proportions of rice husk charcoal (80-60%) and vermicompost produced more vigorous seedlings compared to coir pith compost. Among the two nutrient sources studied, different combinations of vermicompost produced vigorous seedlings. Vermicompost has finer structure than ordinary compost and it has outstanding chemical and biological properties with plant growth regulators (lacking in other composts) and significantly larger and diverse microbial populations than the conventional thermophilic composts (Tomati and Galli, 1995). All these characters of vermicompost favoured positively as a nutrient rich source and also for increased seedling vigour. Considering the economics of nursery, media comprised of less soil was found to be less expensive than others. The media comprised of higher proportion of rice husk charcoal (80-60%) recorded higher contents of nutrients especially K, Mg, S, Mn and Si. The increased availability of nutrients in rice husk charcoal and vermicompost resulted in increased absorption of nutrients. This had also reflected in higher uptake of nutrients and growth of seedlings resulting in higher biomass production. The combination of media with higher proportion of rice husk charcoal and vermicompost or coir pith compost as nutrient source also resulted in favourable mat characters of light weight and stronger mats. Considering the above facts, the media with higher proportion of rice husk charcoal was favourable for tray nursery in rice. So combination of optimum proportion of rice husk charcoal (60-70%), soil (10-30%) and vermicompost (10-20%) was found to be performing better in terms of seedling vigour and mat characteristics as growing media for mat nursery.

Though there was improvement in seedling growth, biomass, mat characters and uptake of nutrients by seedlings due to different media, clear and steady trend in all the favourable characters for a quality mat nursery was not obtained from Experiment I. Hence a scoring technique was utilized to rank the media of Experiment I for further study. Scoring was done by classifying the media into three classes of high, medium and low for the important characters with respect to growth and nutrient contents of seedlings and mat characters. The scoring study revealed that the media of 80% RHC + 20% VC, 60% RHC + 20% soil + 20% VC, 40% RHC + 40% soil + 20% VC, 20% RHC + 60% soil + 20% VC, 60% RHC + 30% soil + 10% VC, 40% RHC + 50% soil + 10% VC, 20% RHC + 70% soil + 10% VC, 80% RHC + 20% CC, 60% RHC + 20% soil + 20% CC and 60% RHC + 30% soil + 10% CC were performed better and hence highest ten ranks were obtained in the scoring. The better performance of these media was also evident through improved growth characters of seedlings, efficient mat characteristics and nutrient contents of seedlings.

5.2 EXPERIMENT II: FIELD EVALUATION OF MEDIA SELECTED FROM EXPERIMENT I

The Experiment II was designed to evaluate the performance of the different media selected from Experiment I under field condition. From Experiment I, out of 18 combinations of media, ten media were selected based on the seedling and mat characters for field evaluation. The scoring system was adopted for selection and ten high ranking media were selected. These media were evaluated under field condition for performance of transplanter and growth and yield of crop.

5.2.1 Effect of nursery media on performance of transplanter

The success of mechanical transplanting depends on the mat nursery produced and the mat nursery should satisfy the conditions of transplanter in terms of number of hills planted per metre run, number of seedlings per hill, number of missing hills per m^2 and plant population at planting.

The number of hills planted per metre run (Fig. 5.19) by the transplanter was unaltered by different nursery media except the media comprised of 60% RHC + 20% soil + 20% VC which recorded significantly lower number of hills per metre run compared to all the other growing media. The aggregation power of mat of this media was poor especially under high moisture. This made the mat unsuitable for mechanical transplanting resulting in less number of hills per metre run. The average number of hills per metre run was 5.44.

The number of seedlings planted per hill (Fig. 5.20) was highest when the seedlings were raised in nursery media of 60% RHC + 30% soil + 10% CC. The media of 40% RHC + 40% soil + 20% VC recorded the lowest number of seedlings per hill. The nursery media of 60% RHC + 20% soil + 20% VC or CC also planted less number of seedlings per hill. The low number of seedlings per hill in these media may be due to the low cohesive strength of the media. While working with a 5-row paddy transplanter, Garg and Sharma (1984) observed that it covered 0.3 to 0.4 hectares per day and planted four seedlings per hill. But according to Dewangan *et al.* (2005), transplanters pick more than five seedlings per pick. However, 3-4 seedlings per hill were found to be optimum and that was satisfied by all the media except the media of 60% RHC + 20% soil + 20% VC, 40% RHC + 40% soil + 20% VC and 60% RHC +30% soil + 10% CC.

The highest number of missing hills per m^2 (Fig. 5.21) occurred when the nursery media of 60% RHC + 20% soil + 20% VC was used. The missing hills per m^2 were lower in the media of 80% RHC + 20% VC, 20% RHC + 60% soil + 20% VC and 60% RHC + 30% soil + 10% CC and consequently higher plant population per m^2 was noticed. The number of missing hills in media of nursery ranged from 0.93 to 5.80 hills per m^2. The cohesiveness of the media of 60% RHC + 20% soil + 20% VC or CC was very poor especially under moist condition. However, the spoilage of mat due to rain in the media of 60% RHC + 20% soil + 20% CC was less compared to the media of 60% RHC + 20% soil + 20% VC. In these media, the roots were exposed out of the media at high moisture content due to low aggregation of the components of the media and the mat became thinner and hence low quality.

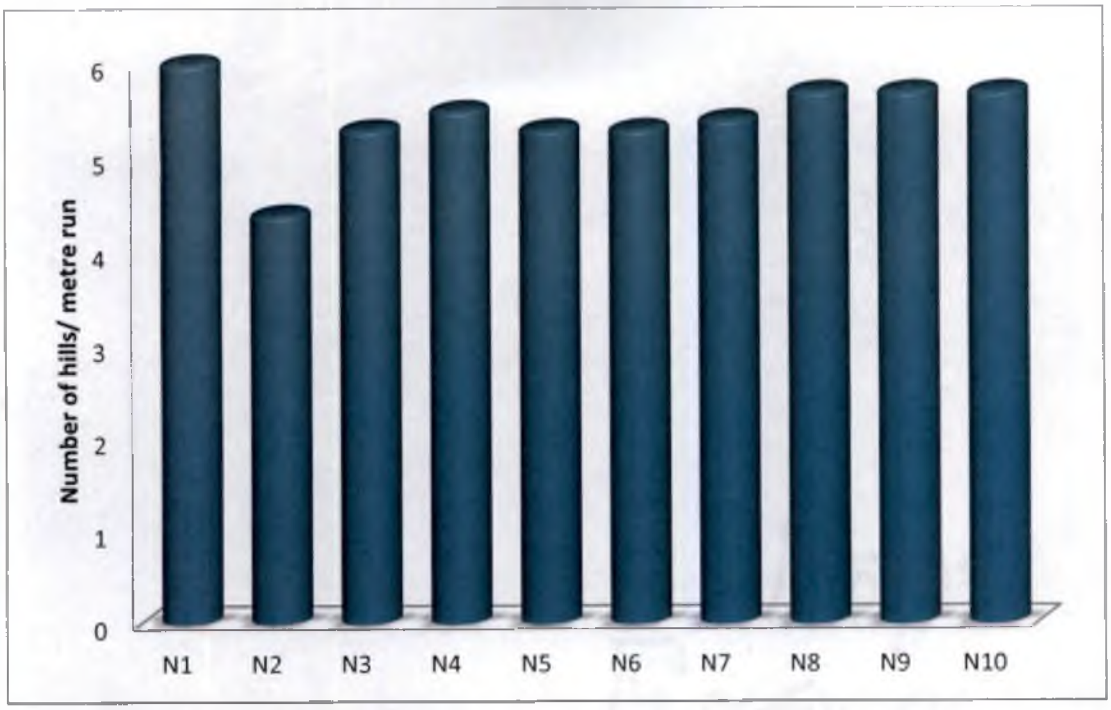

Fig. 5.19 Number of hills planted per metre run as influenced by nursery media

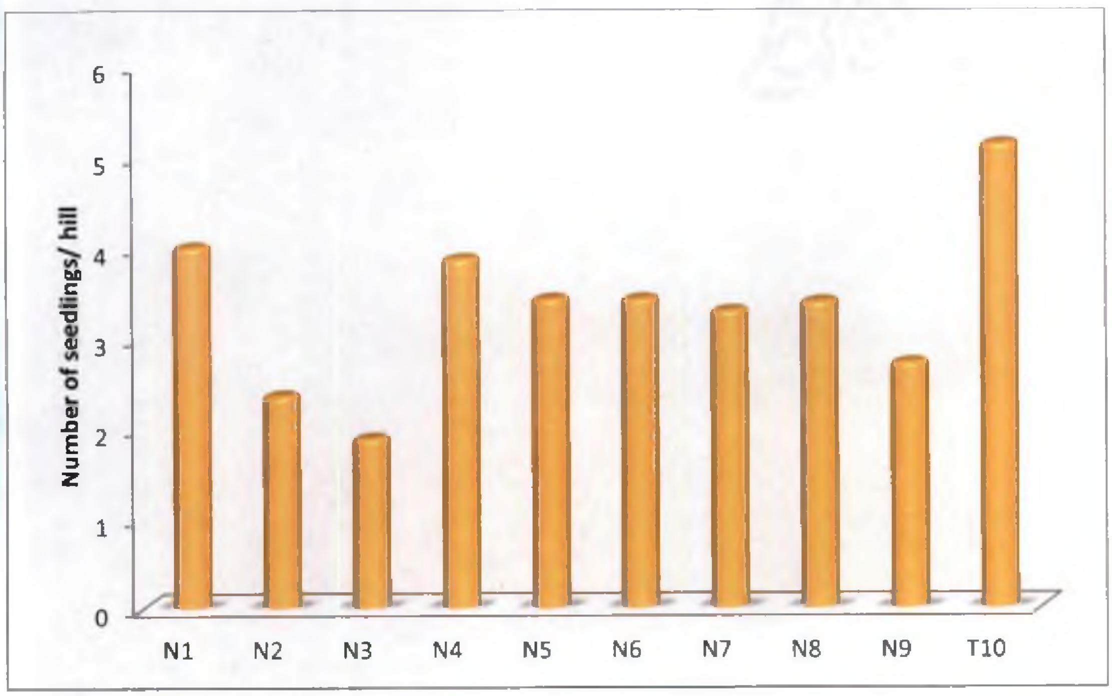

Fig. 5.20 Number of seedlings per hill as influenced by nursery media

Low quality and thinner mats will hinder the planting of seedlings by transplanter. This might be the reason for more number of missing hills with respect to these nursery media.

In this study, the lowest plant population (Fig. 5.22) was noticed in the nursery media of 60% RHC + 20% Soil + 20% VC and all the other media recorded comparable plant population at planting. The lowest plant population was due to the incomplete mat in the media under high moist condition by heavy rain occurred at the time of transplanting. Incomplete mats reduce the efficiency of the mechanical transplanter. The plant population at planting ranged from 24.2 to 29.07 hills per m^2 with an average of 27.28 hills per m^2. Rajesh (2003) also observed that the plant population was lower in mechanical transplanting compared to manual transplanting ranging from 23 to 32 with an average of 29 hills per m^2. The plant population at different stages showed a slight variation due to the fact that, at planting, even there was more number of seedlings, there is chance of deterioration in the number of seedlings in due course due to competition between the seedlings. Among the mat nursery produced by ten different media with respect to the performance of transplanter, media of 80% RHC + 20% VC, 20% RHC + 60% soil + 20% VC, 60% RHC + 30% soil + 10% VC and 80% RHC + 20% CC were found to be better. But the success of the mat nursery production especially in the context of commercial venture as ready to supply system to farmers depend on the low mat weight and higher strength since the mats are to be transported to longer distances. Under this situation, it was observed that the media of 80% RHC + 20% VC, 60% RHC + 30% soil + 10% VC and 80% RHC + 20% CC had low mat weight and higher mat strength. So these three media were found to be satisfying the conditions for the better performance of transplanter and at the same time easy to transport.

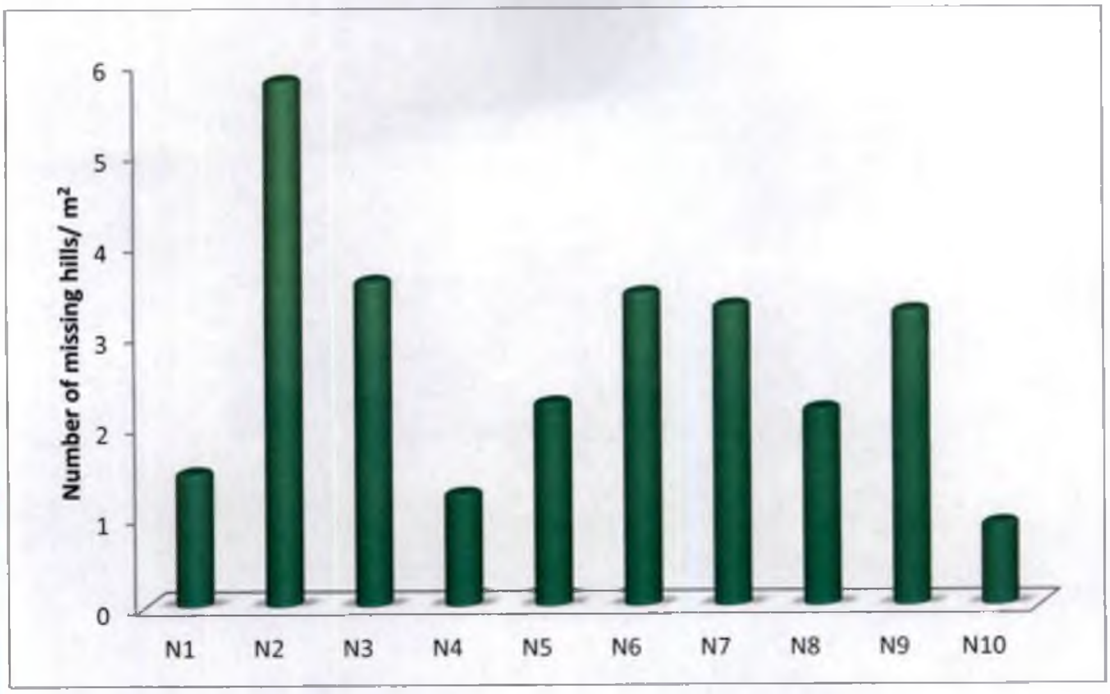

Fig. 5.21 Number of missing hills per m^2 as influenced by nursery media

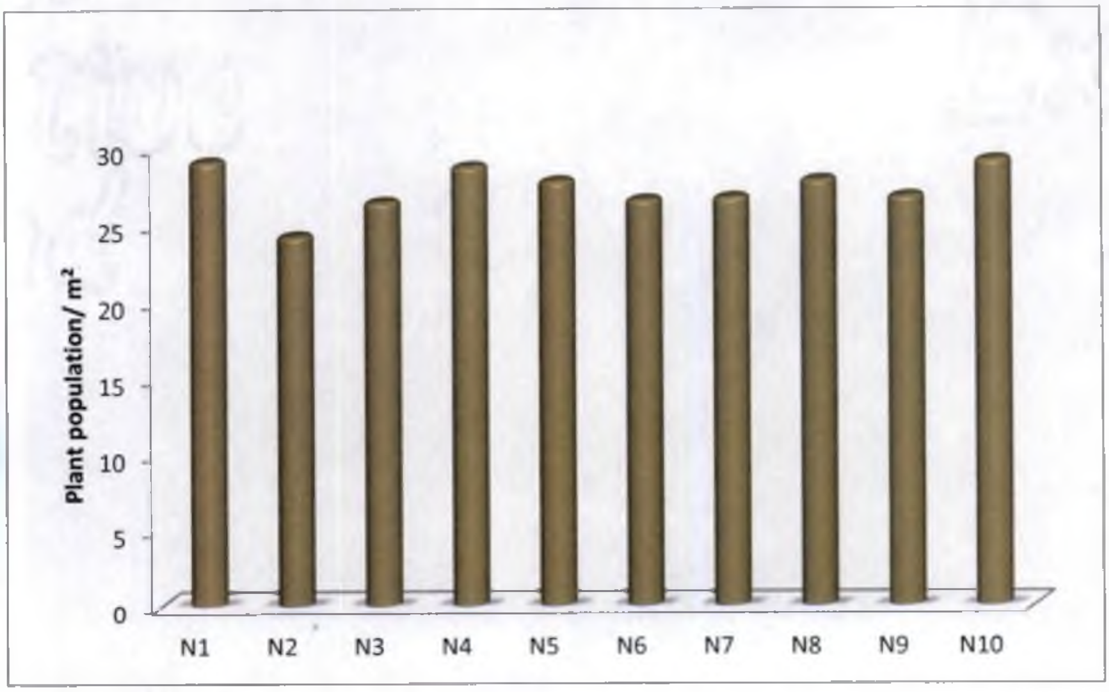

Fig. 5.22 Plant population per m^2 as influenced by nursery media

5.2.2 Effect of nursery media on growth and yield of rice

Little variation was noticed in the height of the plants at 30 and 60 DAT and at harvest stages (Fig. 5.23) due to different nursery media. The average height of plant at harvest was 114.36 cm.

The number tillers (Fig. 5.24) was lowest in plants which was raised in the nursery media of 60% RHC + 20% soil + 20% VC. This may be due to the lowest plant population and the more number of missing hills observed with respect to this media. However, the number of tillers per m^2 at 60 DAT and at harvest was not influenced by different nursery media. This may be due to the more number of tillers produced by the plants in the media of 60% RHC + 20% soil + 20% VC due to wider spacing by missing hills. According to Manian *et al.* (1987) missing hills up to 15 per cent did not affect the final output of the crop. This may be the reason for not having any variation in tiller number after 60 DAT and harvest. Garg and Sharma (1984) observed that the average number of tillers per hill with respect to mechanically planted crop (28) was higher than that in the manually transplanted crop (13).

The different nursery media did not affect the weed infestation and weed count in rice. The predominant weeds *Echinochloa crusgalli, Echinochloa colona, Echinochloa glabbrescens, Vallisneria sp.*, *Monochoria vaginalis, Schoenoplectus laterifolius* and *Spinochloea zeylanica* were found in the field irrespective of the nursery media. These weed species are usually found in rice during the crop season, as per the reports of Thomas and Abraham (1998). The weed count per m^2 was slightly high (39.53 per m^2) due to mechanical transplanting irrespective of the growing media of the nursery. Wider spacing adopted in mechanical transplanting might have favoured intensive weed growth in the field.

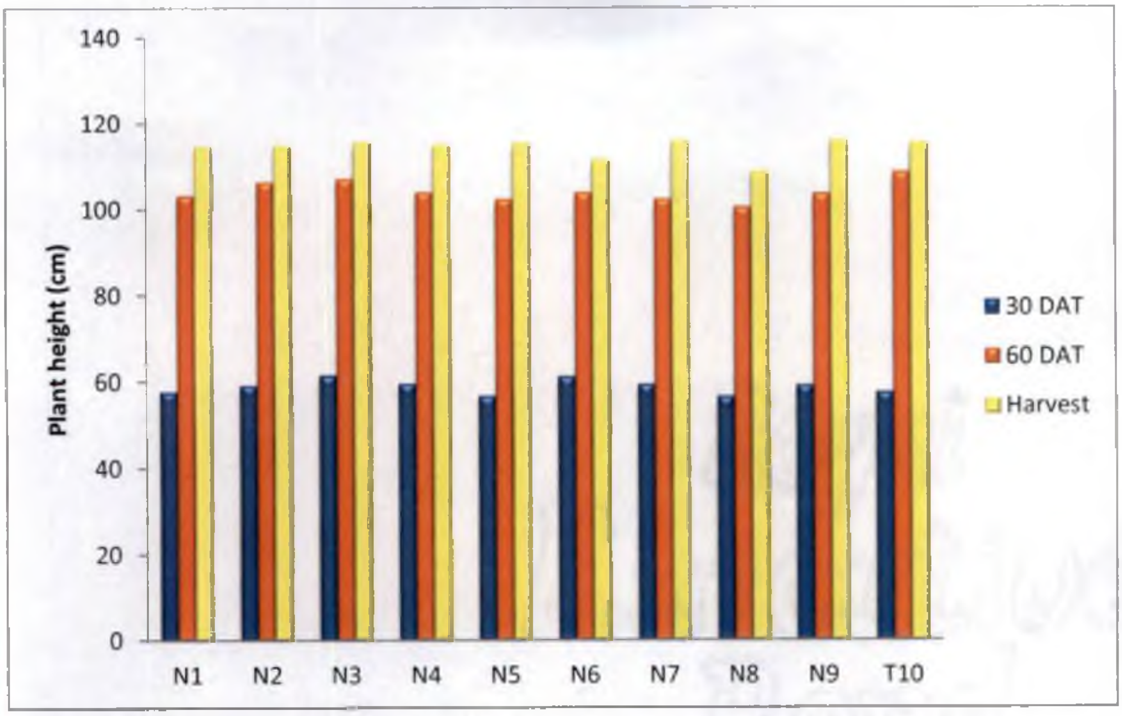

Fig. 5.23 Plant height as influenced by nursery media

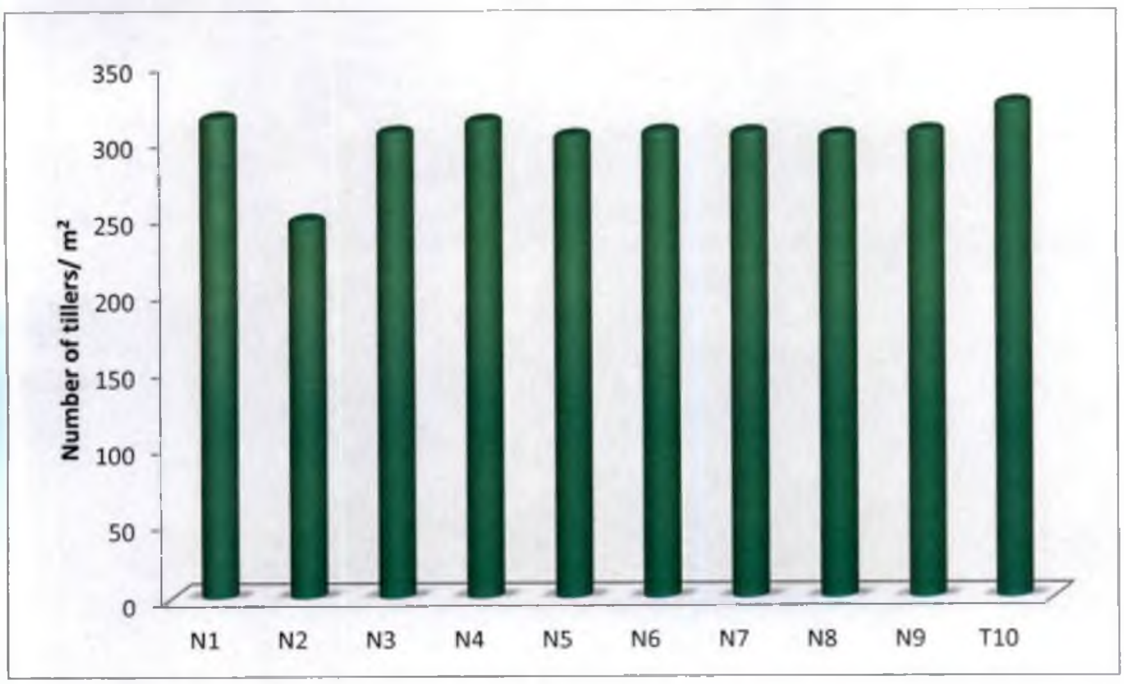

Fig. 5.24 Number of tillers per m^2 as influenced by nursery media

5.2.3 Effect of nursery media on content and uptake of nutrients by the crop

There was no significant variation in nutrient contents and uptake of nutrients by the crop due to the variation in nursery media. The mean nitrogen content of grain was 1.26 % and that of straw was 0.7%. The overall mean of phosphorus content in grain and straw were 0.33% and 0.17% respectively. The mean content of potassium in grain was 0.26% and that of straw was 1.48%. The various nursery media did not influence N, P and K uptake by the crop. The mean uptake of nitrogen by the crop was 91.43 kg ha^{-1}, phosphorus uptake was 23.07 kg ha^{-1} and that of potassium was 79.95 kg ha^{-1}.

The yield attributes *viz.* the number of panicles, number of spikelets per panicle, number of filled grains per panicle, thousand grain weight and spikelet sterility were remained unaffected due to various nursery media. The crop produced 319.14 panicles per m^2 on an average with a range of 302.67 to 338 panicles per m^2. The mean number of spikelets per panicle was 141.3 with a range of 129.37 to 160.33 and number of filled grains per panicle was 107.5 with a range of 95.27 to 124.03. The mean spikelet sterility recorded was 23.94% which indicated that 76.06% filling was noticed in the crop.

The grain and straw yield and the harvest index were also not influenced by the different nursery media. The mean production of grain and straw by the crop under various media was 4.7 t ha^{-1} and 5.7 t ha^{-1} respectively. The mean harvest index observed was 0.45. A higher number of productive tillers, a good number of spikelets and filled grains per panicle and a uniform test weight with effective partitioning of photosynthates were observed irrespective of nursery media which might have altogether contributed to the same production level of both grain and straw. Though the different media used for the mat nursery did not influence the uptake of nutrients by the crop, the uptake of N, P and K by the seedlings was higher when they were grown in the media of 80% RHC + 20% VC. Similar results of uptake of nutrients being uninterrupted by the nursery media in rice was also reported by Rajesh (2003). The treatments of Experiment II being unaltered due to the nursery media under field condition clearly indicated that the selection criteria utilized for the best ten growing media from Experiment I was perfectly sound.

5.2.4 Soil nutrient status

The pH of the soil decreased from 5.46 to 5.33 while the electrical conductivity (EC) of the soil increased from 0.08 dS/ m to 0.09 dS/ m due to cropping. This might be due to the application of fertilizers during the cropping period. Even though the organic carbon content was high in the initial stage of cropping, it was decreased after cropping due to the high temperature and rainfall prevailing in Kerala. The content of nitrogen (163.07 kg ha^{-1}) and potassium (221.18 kg ha^{-1}) were decreased after the cultivation of the crop due to the uptake of the nutrients by the crop. The phosphorus content of the soil showed an increase due to cropping. This might be due to the immobilization of phosphatic fertilizer applied in the field.

5.2.5 Effect of nursery media on cost of cultivation

In this study, there was no significant variation in the cost of cultivation due to different nursery media. But the gross return was found to be the maximum for the media of 40% RHC + 50% soil + 10% VC due to the higher yield obtained in this media. The variation in return in this media was to the tune of 20,000 rupees only. The benefit cost ratio of different nursery media ranged from 1.37 to 1.68. According to Ravi *et al.* (1994) mechanical transplanting has a benefit cost ratio in the range of 1.16 to 2.46. Ahamed and Sivaswamy (1994) observed that the medium and high mechanization packages produced a higher B: C ratio. Similar results were obtained by James *et al.* (1996) also. The components other than soil of the media being cheaper, the media comprised of higher proportion of rice husk charcoal, vermicompost and coir pith compost with lower proportion of soil was economically cheaper which is an important criteria for mat nursery as a commercial product.

The field level performance of the various nursery media did not produce significant yield variation due to combinations of components of media. So, the selection of the mat nursery for commercialisation depends mainly on the seedling performance, mat characteristics, the performance of the transplanter at planting, economics of nursery and easiness to transport. The higher proportion of rice husk charcoal which is the cheapest source among the different components of the media used for nursery may result in non binding nature of the mat due to low cohesiveness though light in weight. While higher proportion of soil found to produce firm mat for easy transplanting but costly and heavier in nature. So the different factors *viz.* characters for vigour seedling growth, light weight with stronger mats, efficient performance of transplanter with respect to number of hills per metre run, minimum number of missing hills, number of seedlings per hill, optimum plant population and cheaper in production are to be considered in view of commercialisation of mat nursery. The media comprised of 80% RHC + 20% VC, 60% RHC + 30% soil + 10% VC and 80% RHC + 20% CC were found to be satisfying the above mentioned characters for quality and cheap mat nursery production. These media were also noticed to be performing well and produced higher grain yield under field condition.

FUTURE LINE OF WORK

- Further studies on the evaluation of possible combinations of media with cheaper materials like straw, saw dust *etc.* are needed to confirm the results of the study.

- The mat nursery raised in the media of 80% RHC + 20% VC or 60% RHC + 30% soil + 10% VC or 80% RHC + 20% CC though produced average seedling growth, stronger mats and light weight, the seedling vigour was not satisfactory. Nutrient supplementation in these media either through medium or seed priming may improve the vigour of the seedlings. Hence, the studies in this line are to be explored.

- Several studies showed that there is widespread deficiency of micronutrients especially Zn, B and Cu in wet lands. So supplementation of micronutrients through seed priming may correct the deficiency of rice in the field of deficient areas. Seed priming of micronutrients in the mat nursery and its evaluation in nutrient deficient areas to be done to explore the possibility of correcting the micronutrient deficiency under field condition.

Summary

VI. SUMMARY

The present study entitled "Standardization of media for tray nursery technique in rice" was carried out at Agricultural Research Station during 2013-15 with the objectives of standardizing the media for tray nursery technique in rice and to evaluate the best performing media from Experiment I under field condition. The study was carried out in two experiments. The variety used was Jyothi.

The design of the Experiment I was CRD with 18 treatments replicated five times. Four levels of rice husk charcoal, seven levels of soil and two levels of vermicompost or coir pith compost were mixed together to get the desired combinations as per the treatments. The biometric observations on mean germination time, seedling height, shoot dry weight, root dry weight, biomass production, dry matter production, root length at transplanting, pest and disease incidence scoring and number of normal and abnormal seedlings and mat characteristics *viz.* thickness of media, mat weight and mat strength were recorded. Physical characteristics *viz.* water holding capacity (WHC) and bulk density and the chemical properties of the media were also determined. Nutrient contents of seedlings and uptake of nutrients were recorded. Economics of cost of nursery was also calculated for each growing media.

The Experiment II was designed to evaluate the ten best performing media selected from Experiment I under field condition. The design was RBD with three replications. Performance of transplanter was assessed based on number of hills per metre run, number seedlings per hill, number of missing hills and plant population at planting. Biometric characters *viz.* plant height, tiller count, weed count, yield attributes, grain and straw yield and harvest index were recorded. Soil and plant samples were analyzed for N, P and K after harvest of the crop. Uptake of nutrients *viz.* N, P and K by grain and straw and total uptake were computed. Economics of

cost of cultivation was also calculated for each treatment. The results of the study are summarized and listed here.

EXPERIMENT I: STANDARDIZATION OF MEDIA FOR TRAY NURSERY TECHNIQUE IN RICE

1. The media comprised of 80% RHC + 20% VC, 60% RHC + 20% soil + 20% VC and 60% RHC + 30% Soil + 10% VC were superior with respect to growth characteristics of seedlings *viz.* seedling height, biomass production, shoot dry weight, dry matter production, root length at the time of transplanting and number of normal seedlings.

2. With respect to mat characteristics, the mats with low weight were produced by the media of 80% RHC + 20% CC followed by 80% RHC + 20% VC. The mat strength was higher in the media of 80% RHC + 20% CC, 60% RHC + 30% Soil + 10% VC and 60% RHC + 30% Soil + 10% CC.

3. The water holding capacity was found to be higher with the growing media of higher proportion of rice husk charcoal whereas these media recorded a lower bulk density compared to other media.

4. The N and K content of the seedlings were higher in the media of 80% RHC + 10% soil + 10% VC whereas the soil media recorded the higher P, Ca, Cu and Zn contents of seedlings. The Mg, S and Fe contents were maximum in the media of 60% RHC + 20% soil + 20% VC. The media of 20% RHC + 70% soil + 10% VC recorded the highest B content whereas the Si content of seedlings was maximum in the media od 80% RHC + 20% soil.

5. N, P, K, Mg and S uptake by the seedlings were maximum in the media of 80% RHC + 20% VC whereas the soil media had higher P and Ca uptake by the

seedlings. The media 60% RHC + 20% soil + 20% VC recorded maximum S, Fe and B uptake whereas the Mn uptake was highest in the media of 80% RHC + 20% CC. The soil media recorded maximum Cu and Zn uptake by the seedlings. The highest Si uptake was recorded in the media of 80% RHC + 20% soil.

6. Even though the cost of nursery did not show significant variation due to different growing media, it was lower for 80% RHC + 20% VC, 60% RHC + 30% Soil + 10% VC, 80% RHC + 20% CC and 60% RHC + 30% Soil + 10% CC compared to other media.

EXPERIMENT II: FIELD EVALUATION OF BEST PERFORMING MEDIA FROM EXPERIMENT I

1. The number of hills planted per metre run was comparable in all the nursery media studied. The number of seedlings per hill varied from 3 to 4 in the media of 80% RHC + 20% VC, 60% RHC + 30% soil + 10% VC and 80% RHC + 20% CC. The number of missing hills per m^2 was lower in the nursery media of 80% RHC + 20% VC, 60% RHC + 30% soil + 10% VC, 80% RHC + 20% CC and 60% RHC + 30% Soil + 10% CC.

2. The plant population at planting was comparable in all the nursery media except the media of 60% RHC + 20% soil + 20% VC.

3. The number of tillers per m^2 at 30 DAT was comparable in all the nursery media except 60% RHC + 20% soil + 20% VC. The number of tillers per m^2 at 60 DAT and at harvest were comparable in all the nursery media.

4. The number of panicles per m^2, number of spikelets per panicle, number of filled grains per panicle, thousand grain weight and the spikelet sterility were remained unaltered due to different nursery media under field evaluation.

5. The grain and straw yield and harvest index were not influenced by the different nursery media evaluated. The content and uptake of nutrients *viz.* N, P and K by the crop also remained unaffected by different nursery media.

6. The cost of cultivation was comparable in all the nursery media.

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*Originals not seen

Appendix

APPENDIX-I

Monthly weather data during the cropping period at ARS, Mannuthy from July2014 to November 2014

(Latitude 12^{0}32'N, Longitude 74^{0}20' and Altitude 22.5 MSL)

Month	Temperature (^{0}C)		Relative Humidity (%)		Rainfall (mm)	Mean evaporation (mm/day)	Rainy days	Sunshine hours (hrs/day)	Mean wind speed (Km/hr)
	Maximum	Minimum	Morning	Evening					
July	29.5	23.1	95	80	768	2.5	26	1.6	2.1
August	29.5	23.2	97	76	599.8	2.9	22	2.6	1.9
September	31.3	23.3	95	69	215.1	3.1	13	5.8	2.2
October	31.9	23.7	93	68	224.6	2.8	15	4.4	2.2
November	31.6	23.2	84	60	85.3	3.2	5	5.1	3.7

APPENDIX-II

Details of cost of nursery

Sl. No.	Particulars	Men/ha (Rs.450/day)	women/ha (Rs.360/day)	Amount (Rs/ha)
Nursery operations				
1	Automatic paddy mat nursery sowing machine	-	-	1376/-
2	Water management	-	2	760/-

APPENDIX-III

Details of cost of cultivation

Sl. No.	Particulars	Men/ha (Rs.450/day)	women/ha (Rs.360/day)	Amount (Rs/ha)
	Field operations			
1	Ploughing (machine)	-	-	3750/-
2	Lime application	2	-	900/-
3	Bund formation	8	-	3600/-
4	Nursery preparation	-	-	4760/-
5	Transplanting	-	-	3500/-
6	Fertilizer application	1	1	810/-
7	Water management	3	-	1350/-
8	Weeding (Thrice)	-	60	21,600/-
9	Plant protection chemical spraying	4	-	1800/-
10	Harvesting (Combine harvester)	-	-	4500/-
11	Baling (Baler)	-	-	5600/-

APPENDIX-IV

Details of cost of inputs

Sl. No.	Particulars	Amount (Rs/kg)
1	Seed	39/-
2	FYM	2/-
3	Lime	10/-
4	Urea	6/-
5	Mussouriephos	11/-
6	MOP	17/-
7	Seedling tray	2/- (per tray)
8	Rice husk charcoal	0.5/-
9	Vermicompost	7/-
10	Coir pith compost	6/-
11	Soil	0.75/-

STANDARDIZATION OF MEDIA FOR TRAY NURSERY TECHNIQUE IN RICE

By

GREESHMA V. MATHEW

(2013-11-127)

ABSTRACT OF THE THESIS

Submitted in partial fulfillment of the requirement

for the degree of

Master of Science in Agriculture

(AGRONOMY)

Faculty of Agriculture

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2015

ABSTRACT

Rice is the principal food crop of Kerala. But the cultivated area of rice in Kerala is drastically decreasing year after year. The major reason for reduction in area is the high cost of cultivation due to increased wage rate prevailing in the state. Mechanization has become imperative to sustain and make rice cultivation economically viable as well as ecologically harmonious. Manual transplanting is labour intensive and mechanical transplanting using tray nursery which is a low cost technology can be adopted in rice cultivation. The success of mechanical transplanting depends on the success of nursery. The soil media used for raising tray nursery limits the easy transportation of the nursery and substitution of the growing media with light weight, cheap and easily available materials will lead to the commercial production of paddy mat nursery for easy transportation and wider acceptance of the technology.

The present study entitled "Standardization of media for tray nursery technique in rice" was conducted during 2013-2015 at Agricultural Research Station, Mannuthy with the objectives of standardizing the media for tray nursery technique in rice and to evaluate its efficiency under field condition. The study was carried out in two experiments. The variety used was Jyothi.

The design of the Experiment I was CRD with 18 treatments replicated five times. The components *viz.* four levels of rice husk charcoal, seven levels of soil and two levels of vermi compost or coir pith compost were mixed as per the treatments. Observations on mean germination time, growth characters of seedlings, mat characteristics, physico-chemical properties of media, nutrient contents and uptake by the seedlings were recorded. Economics of nursery was also calculated. The media comprised of 80% RHC + 20% VC, 60% RHC + 20% soil + 20% VC, 80% RHC + 10% soil + 10% VC and 80% RHC + 20% CC were found to be superior with respect

to biometric characters. The mats with light weight were produced by the media of 80% RHC + 20% CC and 80% RHC + 20% VC. The stronger mats were noticed in the media of 80% RHC + 20% CC and 40% RHC + 40% soil + 20% VC. Based on the growth characteristics, mat characters and nutrient uptake by the seedlings, ten high ranking media were selected among 18 media from Experiment I for evaluating under field condition.

The Experiment II was designed to evaluate the ten best performing media selected from Experiment I under field condition. The design was RBD with three replications. Observations on performance of transplanter, growth characters, yield attributes and yield were recorded. The nutrient contents of the crop were determined and uptake by the crop and economics of cultivation were computed. The performance of the transplanter with respect to the number of hills per metre run and the plant population per m^2 at planting were comparable in all the media except the media 60% RHC + 20% soil + 20% VC. The optimum number of seedlings per hill and less number of missing hills per m^2 were noticed in the media of 80% RHC + 20% VC, 60% RHC + 30% soil + 10% VC, 80% RHC + 20% CC and 20% RHC + 60% soil + 20% VC. The variation in biometric characters, yield attributes, yield, harvest index, nutrient contents of crop and uptake of nutrients by the crop did not produce significant variation under field condition.

From the study, it was revealed that the media comprised of 80% RHC + 20% VC, 60% RHC + 30% soil + 10% VC and 80% RHC + 20% CC were found to be better for cheap, good qualty and light tray nursery production in terms of seedling and mat characteristics and performance of transplanter. These media were also noticed to be performing well and produced higher grain yield under field condition also.

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