EVALUATION OF THERMOCHEMICAL DIGEST OF DEGRADABLE WASTE FOR CONTAINER CULTIVATION OF CHILLI

by

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DECLARATION

I, hereby declare that this thesis entitled **"EVALUATION OF THERMOCHEMICAL DIGEST OF DEGRADABLE WASTE FOR CONTAINER CULTIVATION OF CHILLI "** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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Certified that this thesis entitled " **EVALUATION OF THERMOCHEMICAL DIGEST OF DEGRADABLE WASTE FOR CONTAINER CULTIVATION OF CHILLI** " is a record of research work done independently by Ms. Jayakrishna, J. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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ACKNOLEDGEMENT

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Jayakrishna, J.

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LIST OF ABBREVATIONS AND SYMBOLS USED

@	At the rate of
B	Boron
B:C	Benefit : Cost
Ca	Calcium
CC	Coirpith compost
cm	Centimeter
cm^3	Cubic centimeter
C:N	Carbon nitrogen ratio
CP	Coco peat
CRD	Completely randomized design
Cu	Copper
DAP	Days after planting
EC	Electrical conductivity
EM	Effective micro organism
et al	And other co workers
Fe	Iron
FYM	Farmyard manure
g	Gram
K	Potassium
LAI	Leaf area index
Mg	Magnesium
mg kg^{-1}	milli gram per kilogram
Mn	Manganese
MRP	Mussoorie rock phosphate
N	Nitrogen
OC	Organic Carbon
P	Phosphorous

%	Per cent
RP	Rock phosphate
S	Sulphur
t ha^{-1}	Tons per hectare
TD	Thermochemical digest
viz.	Namely
Zn	Zinc

Introduction

INTRODUCTION

For a developing country like India, the ever rising population coupled with rapid diminution of natural resources has become a major challenge for attaining food security. The galloping urbanization in recent times has paved the way for increased consumerism and consequent market over dependence even to meet the basic food demands of the society. Kerala state stands second in terms of urbanization rate in India. Having a consumer driven economy in place, any minor fluctuation in the market economy and supply chain of the State will have a tremendous impact on the availability of food materials and goods to the society at large. Promotion of urban and peri-urban agriculture would be a viable alternative to surmount this indomitable situation. More recently there is an upswing in urban farming involving container cultivation and terrace farming in residences and other buildings which is gaining wide popularity and acclaim. Kerala, where the rural urban divide is a bare minimal, such a technology has immense scope and relevance capable of making our households self-sufficient especially in vegetable production which has otherwise been subjected to excessive pesticide contamination. This practice would also ensure supply of uncontaminated and pesticide residue free, nutritious farm fresh green produce. In order to facilitate adoption of this farming approach as part and parcel of the urban lifestyle in metros and cities where land is much scarce, good quality ready to use planting / growth media are to be made available at an affordable cost. The success of container cultivation largely depends on the selection of the appropriate growth medium components and proper fertilizer application. Most of such material inputs currently available are of high cost, inferior quality and poor performance especially during later stages of crop growth arising mainly due to insufficient drainage and poor aeration.

Another vexing problem of urbanization is the enormous quantity of solid waste generation and its safe disposal. Several technologies are available for conversion of solid waste to organic manure which can be utilized for urban agriculture. But most of these technologies have their own limitations such as they need larger area, long periods for the completion of the waste treatment process, emission of foul smell etc. A technology that could process the solid waste within the shortest time span available in an environment friendly manner is the need of the hour.

The Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vellayani has developed a patent pending environment friendly technology for disposal and conversion of degradable solid waste to organic manure rapidly. Adopting this rapid technology, the degradable waste can be processed to value added organic manure by thermochemical processing within a day which can be further fortified as per the requirement of the crops. The trials carried out at the department had shown promising results for its use in pot culture as a nutrient carrier / soil enricher / growth medium component. But for its use in urban or peri-urban agriculture, as a nutrient carrier / growth medium component, it needs further evaluation and standardization.

The container cultivation of vegetables especially in terraces of residential buildings and other establishments is gaining widespread acceptance and adoption all over Kerala particularly in urban and peri-urban areas. The increased awareness and social sensitization on the ill effects of pesticide residues in agricultural produce from unknown commercial sources has prompted urban population to resort toterrace farming and container cultivation. A costeffective, fertile growth medium with good drainage characteristics and sufficient aeration alone can provide substantialyield from such cultivation methods. The thermochemically processed manure from degradable solid waste which contains all the essential nutrients and with excellent drainage characteristics would serve as an ideal growth medium component for container cultivation. With a view to achieving this end, the present project envisages the development and standardization of a ready to use plant growth medium, utilizing the thermochemically converted manure from degradable waste. Chilli, a crop that is widely used as a vegetable, spice, condiment, sauce and pickle was selected for the study with the following objective.

To develop and standardize plant growth medium based on custom blended thermochemical digest of degradable waste for container cultivation of chilli.

Review of literature

2. REVIEW OF LITERATURE

The escalating food prices are the confronting cause of the food insecurity, which is more apparent in urban population. Poor urban dwellers are the most vulnerable group being affected largely by the food price hikes. Urban agriculture is the apt solution that is being perceived throughout the world to meet the demand of food for urban population. The urban agriculture had an impact on urban food security. At the household level, urban agriculture can be a source of income; can provide direct access to a larger number of nutritionally rich foods. The most striking feature of urban agriculture, which distinguishes it from rural agriculture, is that it is integrated into the urban economic and ecological system where the urban resources like organic waste and waste water are used for urban agriculture. Thus it plays an important role for making a city more resilient by utilizing the solid waste generated in urban areas for agriculture there itself.

Urban agriculture is most easily practiced by resorting to container cultivation. The container cultivation needs a fertile growth medium with proper aeration and drainage to yield profusely. Several growth mediums both organic / inorganic ones are available. Hence the available literature on different components for growth media, their effects on plant growth, quality and yield of produce and their nutrient composition are reviewed here.

2.1 Urbanization and solid waste management in India

Accounting for nearly 18% of world's human population, India become the second most populous country in world, without having resources and adequate system in place to treat the solid waste. Solid waste management is one such service where India has an enormous gap to fill.

Varma (2004) reported that rapid urbanization and constant changes in food consumption pattern in Kerala had increased the rate of generation of municipal solid waste beyond the assimilative capacity of the environment and management capacity of the existing waste management systems. Aalok *et al.* (2008) also reported that the booming population and rapid urbanization resulted encroachment of fertile land area and leads to massive generation of waste.

Improper solid waste management leads to severe problems like deterioration of public health, degradation of natural resources, climatic changes and created great impacts on the quality of life of citizens. It also leads to severe environmental pollution. But the proper processing and recycling of organic wastes as resources for agriculture can greatly reduce the environmental pollution. Additional benefits include improved public health, conservation of resources and better appearance of both urban and rural communities (Annepu, 2012).

2.2 Solid waste for urban agriculture

Several studies on the effect of urban agriculture reviewed that; through urban vegetation air temperature can be reduced by the cooling effect of evapotranspiration, shading and absorption (Katayama *et al.,* 1993; Mc Pherson *et al.,* 1994; Avissar, 1996; Dimoudi and Nikolopoulou, 2003; Wong *et al.,* 2003; Shashua *et al.,* 2009).

Saiz *et al.* (2006) reported that the various forms of urban farming like roof garden, balcony garden, community garden etc. helps in the reduction of air temperature and thus mitigating the urban heat. The city areas were facing so many issues like environmental challenges which include air and water quality issues, lack of insufficient green space, excess heat capture, polluted water runoff and lack of ecological biodiversity. Urban agriculture presents a unique opportunity to utilize vacant or idle land and rooftops throughout cities for the production of healthy, pesticide-free food. It also helps in adding green spaces to a neighborhood, including community gardens and urban farms, is known to provide a number of social, health, economic and environmental benefits (Heather, 2012).

The urban agriculture played an important role in the reduction of urban energy footprint and pressure on agricultural land (Oberndorfer *et al.,* 2007; De Zeeuw, 2011) and as well as it can act as an excellent solution for climate change adaptation (Specht *et al.,* 2013). The container cultivation is a suitable option for landless city residents. It provides direct access to nutritionally rich vegetables and a more varied diet. The availability of nutritionally rich ready to grow medium at cheap rate can boost up the urban agriculture sector (Awasthi, 2013).

Several studies reported that the urban farming helps in maintaining eco-effective architecture and urban landscapes, reduces the food miles and transportation emissions, use and recycling of water resources, energy consumption and production, recycling of organic waste, new landscape opportunities, improving food security, provision of educational facilities, helps in linking consumers to food production, act as an inspiration to designers and planners, as an economic advantage for urban areas and provide potential products and yields. (Specht *et al.,* 2013; Vazhacharickal and Gangopadhyay, 2014).

2.3 Growth media and their suitability for container cultivation

Olympios (1995) reported that the selection of best growth medium had a positive effect on the productivity of the crop. It should provide sufficient anchorage or support, nutrients and water reserves, good exchange of gases between roots and atmosphere outside the root substrate (Bilderback *et al.*, 2005; Grunert *et al.*, 2008). The growth medium used in container culture must be rich in nutrients, have good water holding capacity and provide amble aeration to the root system (Ahemed *et al.*, 2014).

Growing medium is the material used in sufficient containers to grow a plant, the substrate includes various composted materials which have been routinely used as component and rooting medium (Blok and Verhagen, 2009; Schroeder and Sell, 2009; Vaughn *et al*., 2011). It includes various substrates of different properties and structure which could have directly or indirectly affect the plant growth and development. These substrates can be used alone or as mixture of substrate viz., as peat and perlite; coir and clay, peat and compost (Nair *et al*., 2011; Bhat *et al*., 2013).

Mphaphuli *et al*. (2006) reported that the suitability of growth medium depends on several quality parameters such as particle size, air filled porosity, water holding capacity, pH and EC. Awang *et al*. (2009) observed that cocopeat have an acceptable pH, electrical conductivity and other chemical attributes so can be utilized as a component of growing media. But the high water holding capacity of cocopeat causes poor air-water relationship, leading to low aeration within the medium and affecting the oxygen diffusion to the roots which can be overcome by the incorporation of coarser materials in the medium.

Composted pine bark can be utilized as an excellent substrate for the raising of horticultural and forestry seedlings (Smith, 1992). Nurzynski (2006) and Grunert *et al*. (2008) reported that growth medium substrate includes peat, pine bark, sawdust, coco-fiber and cacao shell performed well. The different growth medium includes the organic materials such as peat, compost, tree bark, coconut (*Cocos nucifera L*.) coir, poultry feathers, and inorganic materials such as clay, perlite, vermiculite, and mineral wool (Vaughn *et al*., 2011). A mixture of substrates likes peat and perlite; coir and clay, peat and compost can be used for vegetable cultivation. The mineral soil or sand has also can be utilized for vegetable cultivation (Nair *et al*., 2011).

Schoor *et al*. (1990) reported that one of the important factor which affects the suitability of growth medium was the polyphenol content of the medium having a threshold limit of 2 per cent, beyond which phytoxicity may occur. Harborne (1997) observed that the excess content of these polyphenols in growing medium retarded the release of N for plant use. But through composting these contents can be easily broken down and could be leached due to high solubility in water.

Sullivan and Miller (2001) reported that the intrinsic physical and chemical qualities of the medium viz. pH, EC, CEC, C/N ratio, polyphenol and the basic nutrient contents determines the suitability of a growing medium for horticultural crops. The organic amendments added to the growth media influenced the physical, chemical and biological properties of growth media and its effect depends on chemical properties of soil and compost material itself (Loper *et al*., 2010).

Hanlon *et al*. (2002) observed that the electrical conductivity of the medium could be attributed due to the components in composting. A good growth medium should possess EC beyond an optimum range between 200 - 350 mS m^{-1}. Fatunbi (2009) reported that the addition of single super phosphate and rock phosphate in growth medium GM6 (pine bark + lawn clippings + human urine + MgO) and GM7 (lawn clippings + human urine + MgO + rock phosphate) recorded higher pH and N content also.

An experiment conducted by Forster *et al.* (1993) reported that the acceptable optimum range of C:N ratios for good growing medium suitable for horticultural purposes was between12 and 32. Grunert *et al*. (2008) also observed that the yield and quality of the vegetables were determined by the physicochemical characteristics of the growing medium along with growing techniques like fertigation.

2.4 Impact of container cultivation on yield and quality of produce

Several scientific studies were conducted on the effects of different growth medium on yield character of the vegetables. Verdonck *et al*. (1982) reported that the various organic and inorganic substrates helped the plants for best nutrient uptake, adequate growth and development to optimize water and oxygen holding. Similar studies conduted by Shinohara *et al.* (1999); Carrijo *et al.* (2004); Hallman and Kobryn (2014) reported that tomatoes showed a better yield when they were grown in coconut fiber substrates than any other substrates.

Use of cocopeat as a substrate in container cultivation for horticultural crops is quite popular. The selection of a particular material for substrate use depends on its availability, cost and local experience on its use. Use of suitable growing media or substrate is essential for production of quality horticultural crops since it directly affects the development and later maintenance of the extensive functional rooting system (Yahya *et al.,* 2009). The studies conducted by Alifar *et al.* (2010) in five growing media including pure cocopeat, perlite-cocopeat (50–50 v/v), perlite-cocopeat-peatmoss (50-20-30 v/v and 50-30-20) and Perlite-peat moss, revealed that the best performer was cocopeat alone and recorded the highest fruit yield for cucumber. The lowest performance was recorded by perlite-cocopeat mixture. Mazahreh *et al.* (2015) reported that perlite recorded the maximum yield and highest quality (class A) for cucumber compared with the other substrates like cocopeat and peatmoss. Cocopeat alone recorded the lowest yield but when it was combined perlite in 1:1 ratio, the cucumber yield increased by 82 per cent.

Alan *et al.* (1994) reported that the tomato plants grown with a mixture of 80 per cent pumice + 10 per cent perlite + 10 per cent peat medium, provided a 30 per cent increase in fruit production in comparison to the soil. Another study conducted by Djedidi *et al.* (1997) in five growth substrates like rockwool, perlite, and mixtures of perlite to zeolite 1:1, 1:2 and 2:1 ratios in soilless culture with an open system on tomato plants reported that the mixture of perlite and zeolite with 1:1 ratio had the best performance in yield. The highest flowering percentage was obtained for perlite substrate. But the medium containing perlite and zeolite in 2:1 ratio had the best distribution of fruit size, total soluble solids and sensorial quality and highest dry matter of fruit. Similarly Tzortzakis and Economakis (2008) observed that among the different subtrates in growth medium for tomato *viz*. pumice, perlite and maize substrate, the highest yield was obtained for maize substrate and the lowest for pumice and perlite substrates. Therefore one of the most important factors affecting plant growth and development in the greenhouse and influencing vegetable quality is substrate selection. Nair *et al*. (2011) also reported that the plants that grown in amended medium showed a better stem diameter, height, leaf chlorophyll content, and plant dry weight compared to plants grown in media without any amendments. Cuckoorani (2013) observed that the growth medium with substrates coirpith compost and FYM in ratio 2:1 on weight basis recorded highest values for growth characters like LAI, number of leaves and shortest crop duration in bindi.

Cucumber plant that grown in perlite or rockwool showed a faster development and the higher yield in comparison to the plants that were grown in coconut fibre (Böhme *et al*., 2001). In a similar study Shaw *et al*. (2004) observed that the cucumber plants grown in three different media (coarse-grade perlite, medium-grade perlite, and pine bark) have the same average fruit yield of 6 kg per plant.

Atiyeh *et al*. (2002) reported that when all necessary nutrients are available, even at substitution rates as low as 5-30% into the soilless bedding plant potting mixture, if little amount of vermicomposts are substituted, it has resulted in significant increase in the germination and growth of marigold, tomato and pepper, in greenhouse trials. In different experiments Bilderback *et al*. (2005) and Mastouri *et al*. (2005) observed that the lettuce plant that grown in tea waste compost had the highest head weight and the lowest for plants that grown in tree bark compost. Similarly Tzortzakis and Economakis (2008) found that the addition of shredded maize stems in perlite and pumice improved their properties over inorganic media and could lead to better plant development and yield for greenhouse tomato.

2.5 Impact of container cultivation on quality of produce

Lee *et al*. (1999) reported that the tomato harvested from plants grown in peat were redder, softer and tastier than other medium. But the fruits harvested from medium contain rice hull alone resulted in increased sugar content in tomato fruit to 6.0° Brix when compared with that of perlite grown plants. Nurzynski (2006) observed that the tomato plants grown on straw or rockwool recorded the highest dry weight, ascorbic acid content and sugars. Grunert *et al*. (2008) reported that the tomato plants grown on peat substrate produced more tasty fruits than perlite under certain conditions.

Cros *et al*. (2007) carried out three experiments using peat, vermiculite, coir, perlite, and mixtures of peat and perlite (3:1 and 1:1 v/v) for cultivating common purslane. The highest fatty acid content, alpha-linolenic acid and linoleic acid contents were recorded by the plants grown in peat substrate. But the highest proportion of alpha-linolenic acid to total fatty acids was obtained for plants grown either in coir or perlite. In another experiment conducted by Gao *et al*. (2010) observed that the cucumber plants grown in mixture of peat to vermiculite 1:1 showed higher cucumber fruit quality than that of peat vermiculite media in 3:1 ratio.

2.6 Effect of fortified or enriched manures in crop yield of field crops

Gowda *et al*. (1995) reported that rice yield increased with the application of single superphosphate with green manure and P solubilising fungi when comparable to muriate of potash along with green leaf manure. Incubating rock phosphate with coirpith resulted 28 per cent increase in grain yield of rice over the sole application of rockphosphate Savithri *et al*. (1995). In an experiment, Sunilkumar *et al*. (1995) observed that 1:1 mixture of MRP and single superphosphate with greenleaf manure in rice resulted higher straw yield. But there was no significant difference in grain yield between those treatments. On comparing the compost enriched with rock phosphate with that of single superphosphate, Singh and Amberger (1995) observed that the yield in rice can be increased with the application of enriched compost. In a pot culture experiment Devarajan and Krishnamoorthy (1996) observed that Zn enriched organic manures increased the grain and straw yield of rice than the recommended levels of organic manure alone. With the combined application of Zn and biogas slurry enhanced the grain yield in rice than that of single application (Singh *et al*., 1998). Similarly Sahai *et al*. (2006) reported that the application of organic manures enriched with Zn increased the yield of rice and wheat.

A significant improvement in the soil nutrient status, availability of nutrients and crop yield in green gram were noticed with the application of Zn enriched organic manure (Deverajan, 1987; Gupta, 1988; Singh and Rakipov, 1990; Thennarasu, 1994). Sudhirkumar *et al*. (1997) reported that rock phosphate applied along with organic amendments had increased the yield in chickpea. Similarly Deepa (2005) observed that enriched vermicompost application has increased the number of pods and flowers.

Becker (1995) found that the application of granite, basalt, glacial silt along with compost increased the grain yield of maize. Sharanppa (2002) also observed an increase in maize yield by the application of FYM enriched with 10 percent by weight each of rock phosphate and gypsum.

A study conducted by Kumar *et al*. (2004) in turmeric reported that the application of farmyard manure + zinc solublising bacteria and farmyard manure addition alone as well as with Zn and Fe increased the rhizome yield, total dry matter production and curcumin content. This might be due to the enhanced supply of nutrient favoured by complexation and chelation reaction resulting in increase of availability of native soil nutrients, besides the applied Zn and Fe. Similarly

Rajamoni *et al.* (2006) observed that the application of enriched organic manures increased the plant height, LAI and yield also in turmeric.

Compost enriched with *Trichoderma viride* (500 g t^{-1}), 2 per cent RP and 1 per cent pyrite leads to better plant growth and yield (Sreenivas and Narayanasamy, 2003). Also the application of enriched poultry manure with microbial innoculant followed by *Trichoderma viride* banana pseudostem compost @ 750 kg ha^{-1} along with 75 percent of the recommended dose of fertilizer recorded the highest yield in banana (Thenmozhi and Pularaj, 2009).

Ushakumari *et al.* (1999) reported that application of vermicompost along with full recommended dose of NPK enhanced the growth and yield of okra. In another study conducted by Siddiqui *et al.* (2008) observed that the rice straw compost fortified with *Trichoderma harzianum* gave a significantly better growth performance and yield due to stimulation of growth by improving the nutrient efficiency of okra (*Abelmoschus esculentus).*

Srivasthava and Ahlawat (1995) reported a significant increase in nodulation of cowpea by seed inoculation with *Rhizobium* or P bacteria and phosphate fertilizer. There was overall improvement in growth of the crop also. Similarly in another study conducted by Manjaiah *et al.* (1995) it was observed that a significant increase in nodule number of cowpea when treated with combination of organic amendments and P solublizers plus muriate of potash. The application of enriched vemicompost with the rock phosphate had increased the plant height, number of branches, number of nodules and grain yield of cowpea and also increased the available N, P_2O_5 and K_2O status of soil (Sailajakumari, 1999). Zyed and Abdel- Motaal (2005) reported compost enriched with *Trichoderma viride* and *Aspergillus niger* @300g along with 1 per cent rock phosphate recorded the highest yield in cowpea. Application of vermicompost enriched with P and S increased the yield of coriander (Singh *et al.*, 2009).

Several experiments showed that the compost enriched with microbes had a positive impact on plant growth. Application of vermi compost inoculated with azosprillum and photosynthetic bacteria recorded the highest plant height, number of leaves and shoot ratio in chilli (Zachariah, 1995). Dinakaran and Savithri (1995) reported that the effect of vesicular arbuscular mycorrhizal fungi (VAM) in increasing dry matter production was positive and it was more pronounced at higher levels of P application in onion. Dubey (1996) recorded an improved growth and uptake of nutrients by the use of *Psuedomonas striata* either alone or in conjunction with single super phosphate and muriate of potash in soyabean. Banerjee and Das (1988) reported that the application of enriched compost improved the growth attributes of potato as compared to uninnoculated control. The compost enriched with *Azotobacter chroococcum* and phosphate solubilizing bacteria increased the number of leaves, height of plant and number of days for the emergence of spike in tuberose (Pandhare *et al*., 2009).

Bugbee (2002) reported increased plant growth of flowering annuals and herbaceous perennials when biosolids compost was added @ 50-100 per cent in a mix of biosolids compost, bark, peat and sand. Muriate of potash enriched sugarcane trash compost had increased the ratoon yield of sugarcane (Dahia *et al*., 2003). Leno *et al.* (2016) reported that the fortified manure produced by rapid conversion technology had superior effects on vine length, intermodal length, fruits per plant, fruit polar and equatorial diameter, fruit weight, fruit volume, flesh thickness, 100 seed weight and fruit yield of oriental pickling melon.

2.7 Effect of enriched manures in the growth and yield characters of chilli

One of the most important commercial spice crops grown on 0.95 million hectares land in our country is Chilli (*Capsicum annum)* having a total production of 0.82 million tons (Ingle *et al*., 2004). Capsaicin, having a significant physiological action, can be utilized in pharmaceutical and cosmetic preparations can be only extracted from (Hari *et al.*, 2006).

Sathyaseelan (2004) reported that the chilli yield and drymatter content of bhusa and fruit were highest for the treatment which received the latex sludge added along with rock phosphate. Similarly Kurumkar *et al.* (2005) observed that the enriched vermicompost application had improved length of shoot, number of leaves and fruit yield in chilli. The enriched vermicompost with triple 17- complex recorded significantly higher biometric characters *viz.* number of leaves, fruits and maximum shoot length over the other treatments (Densilin *et al.*, 2011). Lekshmi (2011) reported that the enriched application of organic manure (BM compost + panchagavya) had enhanced the biometric and yield characters of chilli.

2.8 Effect of enriched manures in the quality parameters chilli

In a study conducted by Densilin *et al.* (2011) the maximum lycopene and carotenoid content of 0.87 mg % and 174. 5μg g^{-1} was recorded by triple 17 complex + *Azospirillum* and *Phosphobacteria*.Vermicompost+ *Azosprillum* and *Phosphobacte ria* + *Azosprillum* and *Phosphobacteria* increased the starch content of fruit by 1.19% and 1.16% respectively. He also reported that the treatment which received triple 17 complex and vermicompost recorded the maximum content for starch, carbohydrates, reducing sugars, protein, total soluble sugars, ascorbic acid, total phenol, calcium and magnesium. Lekshmi (2011) found that the treatment received 75% N as EM compost + Panchagavya recorded the highest values for capsaicin, ascorbic acid and shelf life of fruits.

Sudharmaidevi *et al.* (2015) reported that the new fortified manure produced by rapid conversion technology (FMRCT) was evaluated in pot culture trials for the production of chilli revealed that there was a significant increase in the yield compared with the FYM, conventional compost and vermicompost.

2.9 Effect of enriched manures in the nutrient up take of chilli

A study conducted by Sathyaseelan (2004) reported that the application of latex sludge along with rock phosphate increased the uptake of N, P, K, Ca and Mg by chilli plant. Similarly Densilin (2011) reported that the phosphorus, which is an important essential nutrient in chilli had increased by the application of enriched manures. It also increased the uptake of N and enhanced the growth and yield of chilli.

2.10 Effect of enriched manures in the pest and disease incidence of chilli

Lekshmi (2011) reported that disease incidence percentage (*Colletotrichum* fruit rot) was found to be reduced by the treatments with organic enriched manures. Damping off disease in chilli can be effectively controlled with the application of *Trichoderma harizanum* enriched sugarcane bagasse (Subash, 2014).

Materials and methods

3. MATERIALS AND METHODS

The present study entitled "Evaluation of thermochemical digest of degradable waste for container cultivation of chilli" was carried out at the Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vellayani, during 2014 – 2016. The objective of the study was to develop and standardize plant growth medium based on custom blended thermochemical digest of degradable waste for container cultivation of chilli. The study consisted of two pot culture experiments using chilli as the test crop was conducted to standardize the best growth medium , rate and frequency of fertilizer application.

Part I: Standardisation of growth medium based on thermochemical digest of degradable waste (TD)

Part II: Standardisation and custom blending of TD with fertilizers for yield maximization in chillies

3. PART I - STANDARDISATION OF GROWTH MEDIUM BASED ON THERMOCHEMICAL DIGEST OF DEGRADABLE WASTE (TD)

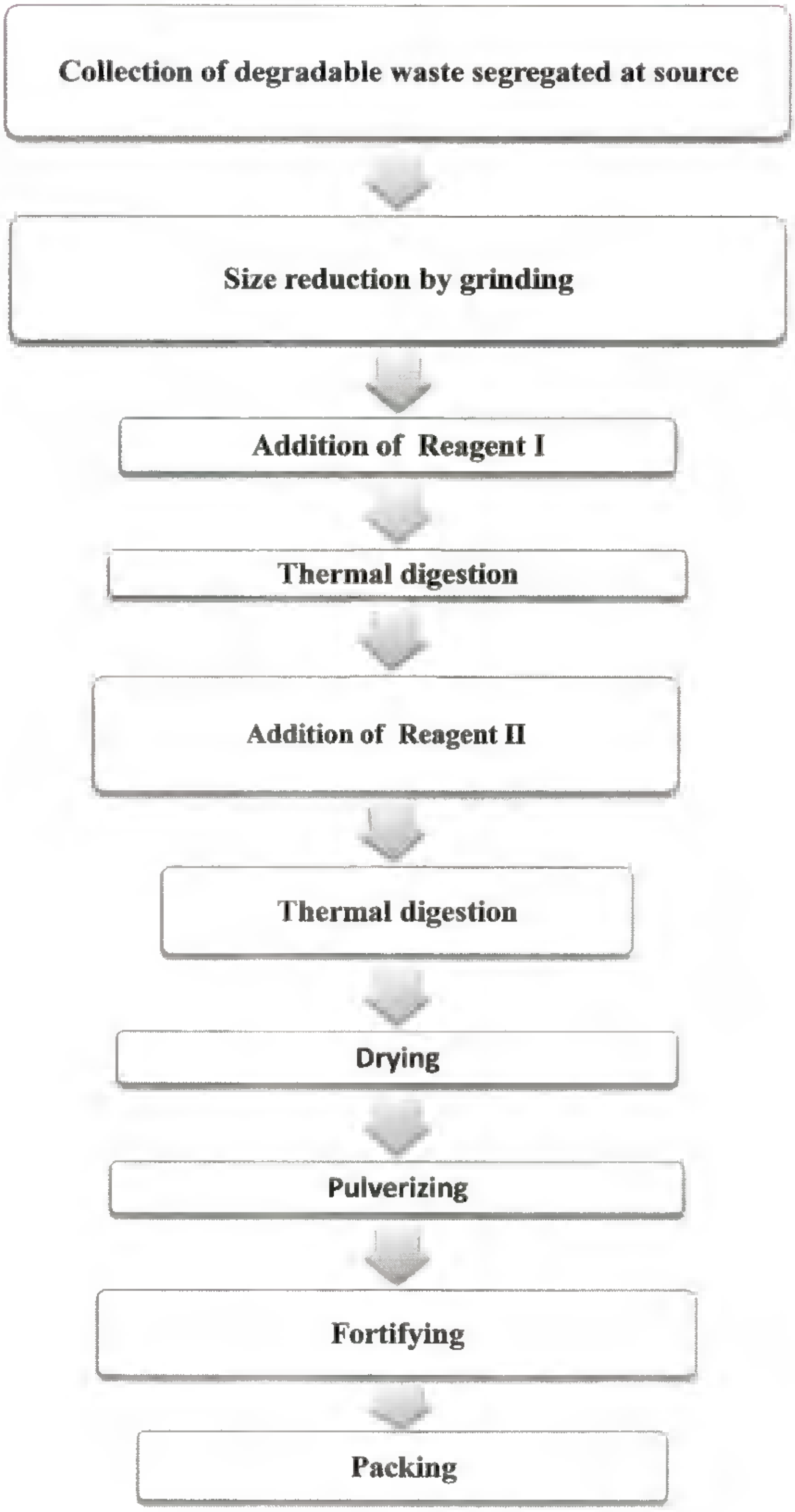
3.1. Growth medium

The growth medium comprising of thermochemical digest of degradable waste (TD), coirpith compost (CC) / coco peat (CP) and red soil (S) in different proportions was used to raise chilli plant. The treatments were compared with the normal potting medium which consisting of soil (S), sand (SS) and farm yard manure (FYM) in 2:1:1 ratio. The components were analysed for their chemical characteristics and are presented in Table 5 and 6.

Plate1. Machine for thermochemical digest preparation (Suchitha)

Plate 2. Thermochemical digest

FLOW CHART OF WASTE PROCESSING



3.1.1. Soil

Soil collected from the Model Organic Farm, College of Agriculture, Vellayani, was used for the preparation of growth medium. The growth media were prepared by mixing 5 kg soil with TD, CC/CP in different proportions on volume basis as per treatments and used for filling the grow bags.

3.1.2. Thermochemical digest of degradable waste

A patent pending technology had been developed at the Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vellayani, for rapid conversion of degradable waste to organic fertilizer. In this process the waste materials are first ground to a fine paste and boiled at 100 °C for one hour by adding two reagents at 30 minutes interval. The digested product is then mixed with drying agent viz, cocopeat @ 40 g per kg of fresh waste. The recovery of thermochemical digest from degradable waste is 35 percent. The processed material is further sun dried and fortified with essential minerals.

The thermochemical digest for the investigation was produced at the Department of Soil Science and Agricultural Chemistry using the waste collected from hostel and canteens of College of Agriculture, Vellayani as per the technology developed.

3.1.3. Coirpith compost

The compost produced from coirpith by inoculating with *Pleurotus sajor caju* has been widely used as a potting medium as well as an organic manure. Hence coirpith compost was selected as a component of growth medium. Coirpith compost was purchased from the Model Organic Farm, College of Agriculture, Vellayani.

3.1.4. Cocopeat

Sterilized cocopeat available in briquette form was purchased from Agrobazar, Thiruvananthapuram. These briquetts were produced from the left over coirpith after the extraction of coir fibre.

3.1.4. Farmyard manure

The farmyard manure was brought from the Department of Animal Husbandry, College of Agriculture, Vellayani.

3.2. Season

The crop was grown from 1st week of August to 2nd week of December 2015. The weather parameters viz., maximum and minimum temperature, relative humidity and average rainfall, at weekly intervals were collected from the Metereological Observatory of College of Agriculture, Vellayani and presented in Table 3.

3.3. Variety and planting material

The chilli variety used in the study was Vellayani Athulya, a high yielding, shade tolerant variety with medium pungency. The seeds were purchased from the Department of Olericulture, College of Agriculture, Vellayani.

3.4. Fertilizers

The sources of N, P and K were urea (46% N), factomphos (20 % N: 20 % P_2O_5) and muriate of potash (60% K_2O) respectively. The N requirement of the crop was met through factomphos and urea. The NPK for chillies as per Package of Practices Recommendations and secondary and micronutrients as per adhoc Package of Practice Recommendations of Kerala Agriculture University were applied to the crop.

3.5. Design and layout of experiment

Design : CRD

Treatments : 11

Replication : 3

Crop : Chilli

Variety : Vellayani Athulya

Treatments :

T1 - TD + coirpith compost + soil in 1:1:1 – (TD1:CC1:S1)

T2 - TD + coirpith compost + soil in 2:1:1 - (TD2:CC1:S1)

T3 - TD + coirpith compost + soil in 1:2:1 - (TD1:CC2:S1)

T4 - TD + coirpith compost + soil in 2:2:1 - (TD2:CC2:S1)

T5 - TD + cocopeat + soil in 1:1:1 - (TD1:CP1:S1)

T6 - TD + cocopeat + soil in 2:1:1 - (TD2:CP1:S1)

T7 - TD + cocopeat + soil in 1:2:1 - (TD1:CP2:S1)

T8 - TD + cocopeat + soil in 2:2:1 - (TD2:CP2:S1)

T9 - TD + soil in 1:1 - (TD1:S1)

T10 - TD + soil in 2:1 - (TD2:S1)

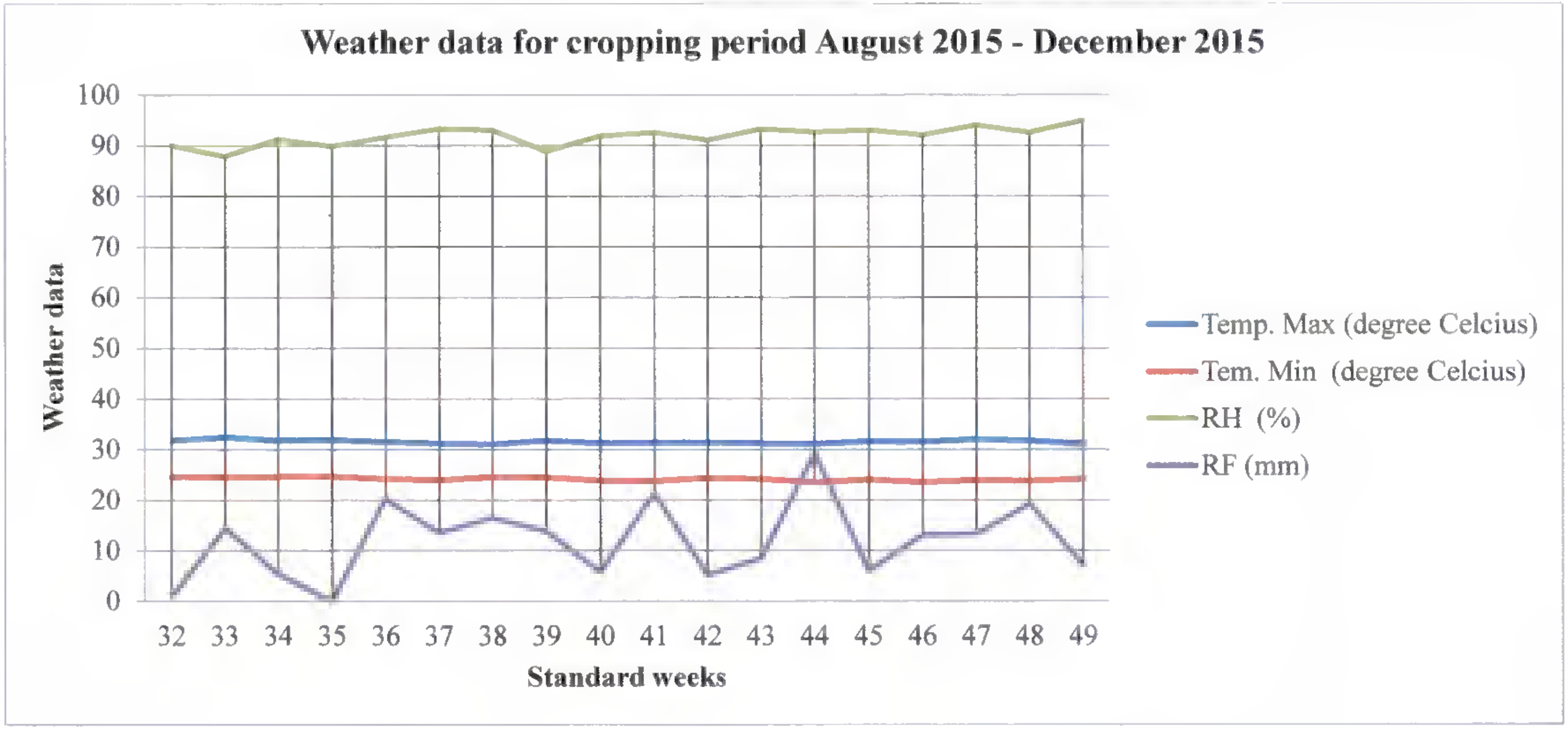
T11- Soil: sand: FYM- 2:1:1 - (S2:SS1:F1)

3.6. Details of cultivation

3.6.1. Raising of seedlings

Seedlings were raised in potting mixture containing soil, cocopeat and vermicompost in 1:1:1 proportion with adequate irrigation. Seed started germination from fifth day onwards.

Fig. 1 Weather data for cropping period of first pot culture experiment



3.6.2. Transplanting of seedlings

The seedlings were transplanted to the grow-bags filled with the growth medium as per treatments on 30th day after sowing.

3.6.3. Application of fertilizers

N, P and K as per Package of Practices Recommendations for chilli and secondary and micro nutrients as per adhoc Package of Practices Recommendations of Kerala Agricultural University (KAU, 2011) were applied. The N requirement was met through urea and factamphos, P through factamphos and K through muriate of potash. $CaSO_4$, $MgSO_4$, $ZnSO_4$ and borax met the requirement of Ca, Mg, Zn and B respectively. The required quantities of fertilizers were thoroughly mixed with thermochemical digest (TD), before application.

3.6.4. Irrigation and after cultivation activities

Daily irrigation was given except on rainy days. After cultivation activities like weeding, stalking etc. as per Package of Practices of Kerala Agricultural University (KAU, 2011) were done.

3.6.5. Plant protection

Nimbicidine @ 2 per cent was sprayed at weekly intervals to the crop. Mite infestation was noticed and Oberon @ 0.08% was sprayed as and when the infestation was noticed. No disease was noticed.

3.6.6. Harvesting

The matured fruits were harvested when the fruits turned slight yellowish in colour. Subsequent harvests were done at 10 days interval. Altogether five harvests were undertaken.

3.7. Chemical analysis

3.7.1 Growth medium component analysis

The components of growth medium viz. thermochemical digest, coirpith compost, cocopeat, FYM and soil were analysed as per standard procedures. The parameters viz. pH, EC, organic carbon, total N, P, K, Na, Ca, Mg, S, Fe, Mn, Zn, Cu and B were analysed. For soil, the available fractions of the above nutrients were estimated. The standard procedures adopted for analysis are shown in Table 4.

3.7.1 Growth medium analysis

Samples drawn from the growth medium initially ie., before planting and after final harvest were analysed. The samples collected were dried under shade and sieved through the 2 mm sieve. pH, EC, organic carbon and available N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu and B were estimated. The standard procedures for analysis are shown in the Table 5.

3.7.2. Plant analysis

Chemical analysis of both shoot and fruit samples were done and the procedures adopted for analysis are presented in Table 6.

3.7.2.1. Shoot analysis

Each plant was uprooted after final harvest, cleaned and the roots were removed. The shoot portion was chopped, air dried and oven dried at 70^0 C. The dried samples were powdered and subjected to analysis for N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, and B.

Table 1. Standard analytical methods followed for chemical analysis of growth medium components

Sl.No	Properties	Method	Reference
1	pH	pH meter (manure and water taken in a ratio of 1:2 w/v)	FCO (1985)
2	EC	Conductivity meter (manure and water taken in a ratio of 1:5 w/v)	FCO (1985)
4	OC	Loss on ignition method	FCO (1985)
5	Nitrogen	Micro Kjeldahl method	Jackson (1973)
6	Phosphorus	Nitric- perchloric acid (9:4) digestion and spectrophotometry using vanadomolybdophosphoric yellow colour method	Jackson (1973)
7	Potassium	Nitric- perchloric acid (9:4) digestion and flame photometry	Jackson (1973)
8	Calcium and magnesium	Nitric- perchloric acid (9:4) digestion and versanate titration	Piper (1966)
9	Sulphur	Nitric- perchloric acid (9:4) digestion and turbidimetry	Chesnin and Yien (1950)
10	Iron, manganese, zinc and copper	Nitric- perchloric acid (9:4) digestion and AAS	Jackson (1973)
9	Boron	Nitric- perchloric acid (9:4) digestion and Azomethine-H colorimetry	Wolf (1971)

Table 2. Standard analytical methods followed in soil and growth medium analysis

Sl.No	Properties	Method	Reference
1	pH	pH meter (soil and water taken in a ratio of 1:2.5 w/v)	Jackson (1973)
2	Electrical conductivity	Conductivity meter (soil and water taken in a ratio of 1:2.5 w/v)	Jackson (1973)
3	Organic carbon	Walkley and Black rapid titration method	Walkley and Black (1934)
4	Total organic carbon	Loss on ignition method	Jackson (1973)
4	Available nitrogen	Alkaline potassium permanganate method	Subbiah and Asija (1956)
5	Available phosphorus	Bray No.1 extraction and estimation using spectrophotometer.	Jackson (1973)
6	Available potassium	Neutral normal ammonium acetate extraction and estimation using flame photometer.	Jackson (1973)
7	Exchangeable Calcium and Magnesium	Neutral normal ammonium acetate extraction and estimation by versanate titration method	Hesse (1971)
8	Available sulphur	Calcium chloride extraction and estimation by turbidimetry	Chesnin and Yien (1950)
9	Iron, manganese, zinc and copper	0.5 N HCl extraction and estimation using atomic absorption spectrophotometer	O`Connor (1988)
10	Boron	Hot water extraction and estimation by Azomethine-H colorimetry using spectrophotometer	Gupta (1967)

3.7.2.2. Fruit analysis

Matured fruits were harvested, cleaned and dried at 70 ^{0}C. The dried samples were powdered and analysis was done for N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, and B. The procedures for fruit analysis were same as that of shoot analysis. The quality parameter of the fruits like capsaicin content was also determined.

3.8. Biometric observations

3.8.1. Plant height

Height of the plant was measured from ground level to the top most leaf bud at three growth stages viz. 30, 60 and 90 days after transplanting and expressed in centimeters.

3.8.2. Primary branches per plant

Number of primary branches in each plant was recorded.

3.8.3. Shoot weight

The plants after final harvest were uprooted, shoot and root portions were separated, fresh weight of shoot was recorded and expressed in g plant^{-1}.Then the shoot portions were chopped, dried under shade and finally oven dried at 70^{0}C till two consecutive weights coincided. Thus the dry weight was also recorded and expressed in g plant^{-1}.

3.8.4. Root weight

The plants after final harvest were uprooted, shoot and root portions were separated and fresh weight of root was recorded and expressed in g plant^{-1}. Then they were dried under shade and oven dried at 70 ^{0}C till two consecutive weights were obtained. The dry weight were recorded and expressed in g plant^{-1}.

3.8.5. Root volume

Water displacement method was used to find out the root volume. The roots were washed in water to clear the adhered soil particles, immersed in 1000 ml measuring cylinder containing water and the level of water raised was recorded. The volume of water displaced was equal to the volume of root and expressed in cm^{-3}.

3.9. Yield characteristics

3.9.1 Fruit yield

Fruits were harvested from each plant at 10 days intervals from first harvest onwards. Summation of weight of all fruits collected from individual plants gave respective fruit yield from each plant and expressed in g $plant^{-1}$.

3.9.2. Fruit length and girth

The length of ten fruits collected randomly from individual plants was recorded and their average was worked out. Length is measured from the point of pedicel to fruit apex and the girth was measured at the broadest part of fruit. The fruits used for measuring length were used for recording girth also. Both were expressed in cm.

3.9.3. No. of fruits per plant

Number of fruits from each harvest per plant was recorded and the sum was found out.

3.9.4. Total dry matter production

Plants were uprooted carefully. The root, shoot and fruits from each plant were separated and oven dried at 70 ^{0}C to get a constant weight. The sum of oven dried weight of root, shoot and fruits from each plant was worked out and expressed as g plant^{-1}.

3.10. Scoring for pest and diseases

Mite infestation was noticed in plants. But no incidence of disease was noticed in plants. The scoring for pest was done for each plant (Varghese, 2005). The details regarding scoring of mite was given in the Table 7. As a control the new generation pesticide Oberon 0.08 per cent was sprayed at weekly intervals.

3.11. B : C ratio

Benefit– Cost ratio was computed using the formula.

$$B : C \text{ ratio} = \frac{\text{Gross income}}{\text{Total expenditure}}$$

3.12. Statistical Analysis

The data generated from the experiment was subjected to statistical analysis (Cochran and Cox, 1965). ANOVA was done in simple CRD with 11 treatments and 3 replications.

Table 3. Standard analytical methods followed in plant analysis

Sl.No	Properties	Method	Reference
1	Nitrogen	Micro Kjeldahl method	Jackson (1973)
2	Phosphorous	Nitric- perchloric acid (9:4) digestion and spectrophotometry using vanadomolybdophosphoric yellow colour	Jackson (1973)
3	Potassium	Nitric- perchloric acid (9:4) digestion and flame photometry	Jackson (1973)
4	Calcium and magnesium	Nitric- perchloric acid (9:4) digestion and versanate titration	Piper (1966)
5	Sulphur	Nitric- perchloric acid (9:4) digestion and turbidimetry	Chesnin and Yien (1950)
6	Iron, manganese, zinc and	Nitric- perchloric acid (9:4) digestion and atomic absorption spectrophotometer	Jackson (1973)
7	Boron	Nitric- perchloric acid (9:4) digestion and Azomethine-H colorimetry	Gupta (1967)
8	Capsaicin	Folin-Dennis reagent colorimetry	Mathew *et al.* (1971)

Table 4. Pest score for assessing the damage caused by chilli mites

Score	Symptoms
0	No symptom
1	1-25 % of leaves or plant show curling
2	26-50 % of leaves or plant show curling
3	51-75 % of leaves or plant show curling
4	>75 % of leaves or plant show curling severe and complete destruction of growing points

3.13. PART II - STANDARDISATION AND CUSTOM BLENDING OF TD WITH FERTILIZERS FOR YIELD MAXIMIZATION IN CHILLIES

For standardisation and custom blending of TD with fertilizers for yield maximization in chillies, another pot culture experiment was conducted at the Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vellayani. All the intercultural operations, observations recorded, chemical analyses done were same as that of first experiment except in the case of rate and levels of application of fertilizers.

3.13.1. Growth medium

The best growth medium identified from the first part of the experiment was used in this part. The medium consisted of thermochemical digest of degradable waste, coirpith compost and soil in 1:2:1ratio.

3.13.2. Season

The crop was grown from January to April 2016. The weather parameters such as maximum and minimum temperature, relative humidity and average rainfall at weekly intervals were collected from the Metereological Observatory of College of Agriculture, Vellayani and are presented in Table 8.

3.13.3. Design and layout of experiment

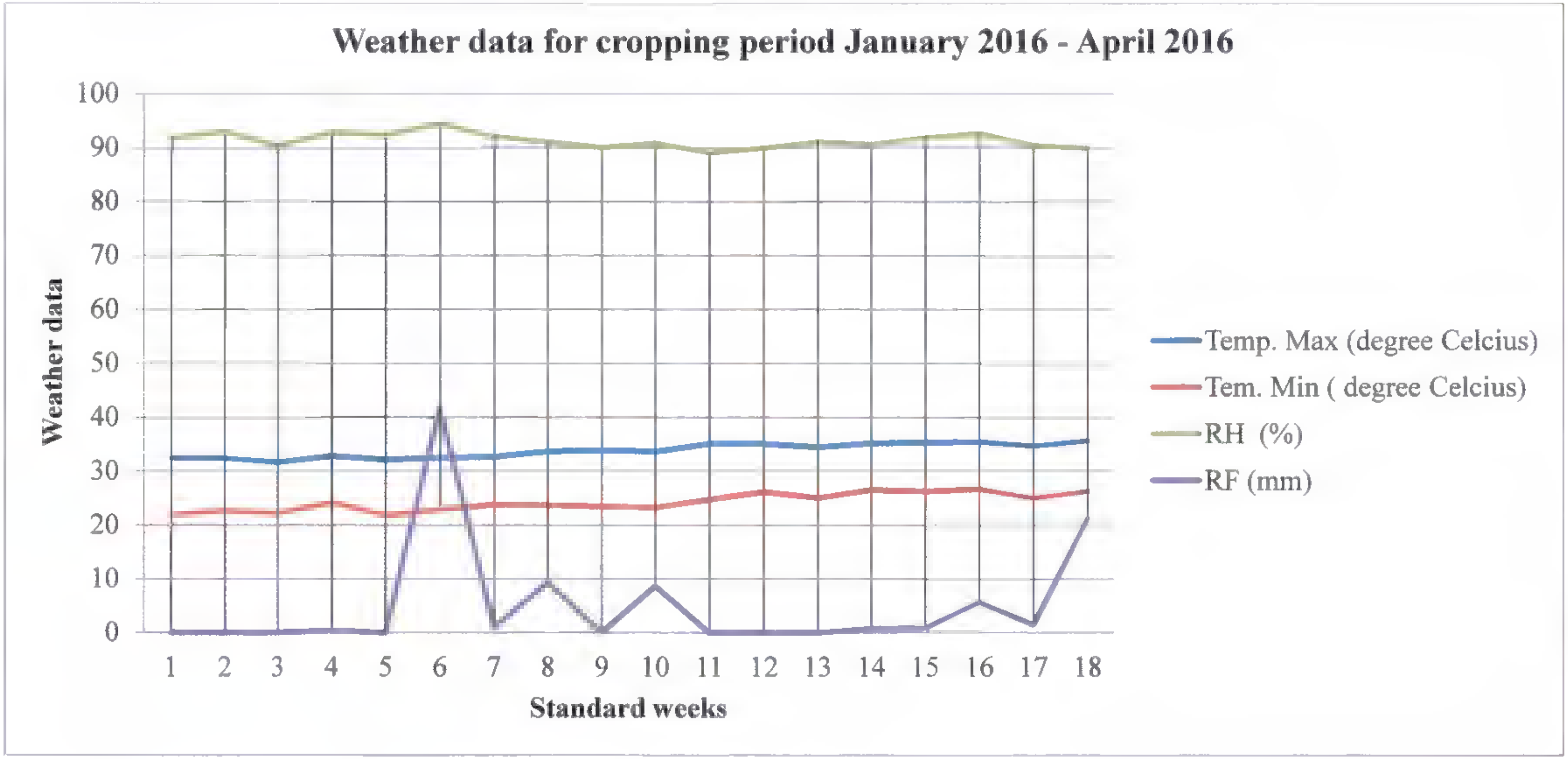
Design : Factorial CRD

Replication : 4

Crop : Chilli

Variety : Vellayani Athulya

Fig. 2 Weather data for cropping period of second pot culture experiment



Treatments :

Levels of NPK

F1 - 75% (1.13: 0.60: 0.38 N, P_2O_5, K_2O g plant $^{-1}$ respectively) as per POP

F2 - 100% (1.50: 0.80: 0.50 N, P_2O_5, K_2O g plant $^{-1}$ respectively) as per POP

F3 - 125% (1.88: 1.00: 0.63 N, P_2O_5, K_2O g plant $^{-1}$ respectively) as per POP

Levels of application – except phosphorous

P1 -Weekly interval

P2 - Biweekly interval

3.13.4. Application of fertilizers

The nutrients were applied through fortified thermochemical digest (TD) to the crop. The application was started from fifth day after transplanting onwards. For biweekly application, 50 g custom blended thermochemical digest and for weekly application, 25 g of the same was used. Entire P was given as basal. Secondary and micronutrients as per adhoc POP recommendation were used for fortifying the thermochemical digest. TD was fortified with N, P, K, Ca, Mg and B only because, the growth medium already contained sufficient quantity of S, Fe, Mn, Zn and Cu. For weekly application, 25g of fortified TD were given 10 times to the respective plants within the growth period and for biweekly application 50 g of fortified TD were given 5 times to the respective plants.

3.13.5. Statistical Analysis

The data generated from the experiment was subjected to statistical analysis (Cochran and Cox, 1965). ANOVA was done in factorial CRD with 2 factors one at 3 levels and other at 2 levels.

Results

4. RESULTS

An investigation entitled "Evaluation of thermochemical digest of degradable waste for container cultivation of chilli" was carried out at the Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vellayani during 2014-2016. Two pot culture experiments were conducted to develop and standardize plant growth medium based on custom blended thermochemical digest of degradable waste for container cultivation of chillli. The investigation comprised of two experiments. First experiment was for standardisation of growth medium based on thermochemical digest of degradable waste and the second one was for standardization of the application rate and frequency of custom blended thermochemical digest fortified with fertilizers for yield maximization in chilli. The observations and data collected were statistically analysed and results of both experiments are presented in this section.

4.1 PART 1. STANDARDISATION OF GROWTH MEDIUM BASED ON THERMOCHEMICAL DIGEST OF DEGRADABLE WASTE (TD)

4.1. Analysis of growth medium components

The components of growth medium includes soil, thermochemical digest of degradable waste, coirpith compost and cocopeat. The characters of the components are presented in Table 5 and 6.

The soil was moderately acidic with very low EC and organic carbon. It has been rated as low in N, K, Ca and Mg and high in P. Micronutrients and S were above sufficiency (Table 5). The thermochemical digest showed slightly alkaline pH, moderate EC and high organic carbon content. It has been fortified with the N, P, K and other essential nutrients to meet the crop requirement. The coirpith compost

Table 5. pH, EC and available nutrient contents of soil

Parameter	Content	Parameters (mg kg^{-1})	Content
pH	5.27	Available Mg	100
EC (dS m^{-1})	0.087	Available S	5
Organic Carbon (%)	0.41	Available Fe	18.02
Available N (mg kg^{-1})	80	Available Mn	5.16
Available P (mg kg^{-1})	16	Available Zn	1.4
Available K (mg kg^{-1})	79	Available Cu	0.91
Available Ca (mg kg^{-1})	218	Available B	0.90

Table 6. Chemical characteristics of the components of growth medium

Parameters	Thermochemical digest	Coirpith compost	Cocopeat	Farmyard Manure
pH	7.49	6.2	5.88	5.8
EC (dS m^{-1})	2.14	5.65	7.45	4.83
Organic Carbon %	21.9	12.7	14.4	40.1
Total N %	3.64	1.01	0.76	1.34
Total P %	0.4	0.07	0.03	0.3
Total K %	1.5	1.25	0.25	0.97
Total Ca %	0.27	0.8	0.68	0.08
Total Mg %	0.12	0.7	0.67	0.05
Total S %	0.065	0.07	0.03	0.02
Total Fe mg kg^{-1}	3518	4585	4440	5300
Total Mn mg kg^{-1}	172	61.7	44.2	140
Total Zn mg kg^{-1}	197	56	29.6	200
Total Cu mg kg^{-1}	52	40.6	34.6	28
Total B mg kg^{-1}	1.2	1.7	1	0.1

showed nearly neutral pH, moderate EC and high organic carbon content. The cocopeat and farmyard manure showed a slightly acidic pH with high EC. The farmyard manure showed higher organic carbon content than other growth medium components (Table 6).

4.2.1 Effect of treatments on shoot biometric characteristics

The data on shoot biometric characteristics of chilli are presented in Table 7.

4.2.1.1 Plant height

The plant height of chilli at 30, 60 and 90 days was significantly influenced by the treatments. At all the three stages of observations, highest values were observed for the treatment receiving thermochemcial digest, coirpith compost and soil in 1:2:1 ratio (T3 - TD1:CC2:S1) which was significantly superior to all other treatments. This was followed by the treatment T7 (TD1:CP2:S1) and T9 (TD1:S1). The lowest value was recorded by the treatment T10 (TD2:S1).

4.2.1.2 Number of primary branches per plant

The number of primary branches per plant was significantly influenced by the treatments (Table 7). The treatments T3 (TD1:CC2:S1) and T7 (TD1:CP2:S1) recorded the highest value of 7.67 followed by the treatment T9 (TD1:S1) which recorded a value of 7.33. The lowest value was noticed for the treatment T10 (TD2:S1) which was on par with treatment T11 (S2:SS1:F1).

4.2.2 Effect of treatments on shoot weight and dry matter production

The shoot weight of chilli was significantly influenced by the treatments (Table 8). For shoot weight, the treatment T7 (TD1:CP2:S1) showed the highest value of 309.57 g plant^{-1} for fresh weight and 77.39 g plant^{-1} on dry weight basis, which was followed by the treatments T3 (TD1:CC2:S1) and T9 (TD1:S1). Treatment T10 (TD2:S1) recorded the lowest values.

Total dry matter production (Table 8) was significantly influenced by the treatments. The highest value for total dry matter production was registered by the treatment T7 (TD1:CP2:S1) with a mean value of 145.91 g plant^{-1} which was significantly superior to all other treatments. This was followed by the treatments T3 (TD1:CC2:S1) and T9 (TD1:S1). The lowest value was registered by treatment T10 (TD2:S1) with mean value of 45.79 g plant^{-1}.

4.2.3 Effect of treatments on root characteristics

The data on root weight and root volume are given in Table 8 and the root characters were significantly influenced by the treatments. For root weight, the treatment T7 (TD1:CP2:S1) recorded the highest value of 81.19 g plant^{-1} on fresh weight basis and 11.61 g plant^{-1} on dry weight basis, and were significantly superior to all other treatments. Each treatment was significantly different from other. The treatment T10 (TD2:S1) showed the lowest values.

For root volume also, the highest value was noticed for the treatment T7 (TD1:CP2:S1) which was significantly superior to all other treatments, followed by the treatments T3 (TD1:CC2:S1) and T9 (TD1:S1). The treatment T10 (TD2:S1) recorded the lowest value of 6.47 cm^3 plant^{-1}.

4.2.4 Effect of treatments on fruit yield and yield characteristics

The data on fruit yield, fruit length, fruit girth and number of fruits per plant are presented in Table 9.

Plate 3. Overview of the experiment for standardization of growth medium

Plate 4. Effect of growth medium on root growth

Table 7. Effect of treatments on shoot biometric characteristics of chilli

Treatments	Plant height (cm)			Number of Primary branches
	30 days	60 days	90 days	
T1-TD1:CC1:S1	16.97	31.30	39.43	4.33
T2-TD2:CC1:S1	20.07	40.40	50.42	6.00
T3-TD1:CC2:S1	28.26	53.60	65.81	7.67
T4-TD2:CC2:S1	19.48	36.30	45.43	5.66
T5-TD1:CP1:S1	17.46	33.80	41.93	5.00
T6-TD2:CP1:S1	19.77	38.80	49.82	6.32
T7-TD1:CP2:S1	25.38	50.50	62.14	7.67
T8-TD2:CP2:S1	18.06	34.30	42.43	5.31
T9-TD1:S1	25.19	48.30	60.72	7.33
T10-TD2:S1	15.47	21.80	29.94	3.34
T11-S2:SS1:F1	15.97	28.40	36.52	3.66
CD (0.05)	0.43	3.00	1.60	0.88

Table 8. Effect of treatments on shoot weight, dry matter production and root characteristics by chilli

Treatments	Shoot weight		Total dry matter production	Root weight		Root volume
	Fresh	Dry		Fresh	Dry	
	g plant^{-1}					cm^3
T1 - TD1:CC1:S1	95.41	23.85	56.89	19.86	2.68	11.40
T2 - TD2:CC1:S1	180.56	45.14	90.01	40.62	5.70	32.15
T3- TD1:CC2:S1	255.63	63.91	136.79	71.83	10.15	63.36
T4- TD2:CC2:S1	157.50	39.38	79.85	35.68	4.99	27.22
T5- TD1:CP1:S1	150.25	37.56	72.13	24.89	3.43	16.42
T6- TD2:CP1:S1	165.51	41.38	84.17	38.52	5.41	30.05
T7- TD1:CP2:S1	309.57	77.39	145.91	81.19	11.61	72.72
T8- TD2:CP2:S1	151.44	37.86	74.12	29.50	4.11	21.03
T9- TD1:S1	228.28	57.07	113.39	53.52	7.54	45.05
T10- TD2:S1	70.66	17.67	45.79	8.93	1.06	6.47
T11- S2:SS1:F1	84.71	21.18	51.47	14.77	1.93	9.99
CD (0.05)	2.03	1.67	1.81	1.63	1.59	1.60

4.2.4.1 Fruit yield

The fruit yield and yield characteristics such as fruit length, fruit girth and number of fruits per plant were significantly influenced by the treatments. The treatment T3 recorded the highest fruit yield of 690.08 g $plant^{-1}$ which was significantly superior to other treatments. This was followed by treatments T7 (TD1:CP2:S1) and T9 (TD1:S1). The lowest value was recorded by the treatment T10 (TD2:S1) having a fruit yield of 297.59 g $plant^{-1}$ and was on par with the treatment T11 (S2:SS1:F1).

4.2.4.2 Fruit length

The treatment effects were statistically significant for fruit length and the treatment T3 (TD1:CC2:S1) recorded highest value of 13.44 cm and was on par with the treatment T7 (TD1:CP2:S1). Treatment T10 (TD2:S1) recorded the lowest fruit length of 7.94 cm which was on par with the treatment T11 (S2:SS1:F1).

4.2.4.3 Fruit girth

The effect of treatments on fruit girth was also statistically significant. The highest fruit girth was noticed for the treatment T3 (TD1:CC2:S1) with mean value 6.99 cm which was significantly superior to all other treatments. Treatment T10 (TD2:S1) showed the lowest value of 5.08 cm which was statistically on par with the treatment T11 (S2:SS1:F1).

4.2.4.4 Number of fruits per plant

The number of fruits per plant was significantly influenced by the treatments. The highest number was recorded by the treatment T3 (TD1:CC2:S1) with a mean value of 58.7 per plant which was on par with the treatment T7 (TD1:CP2:S1). The

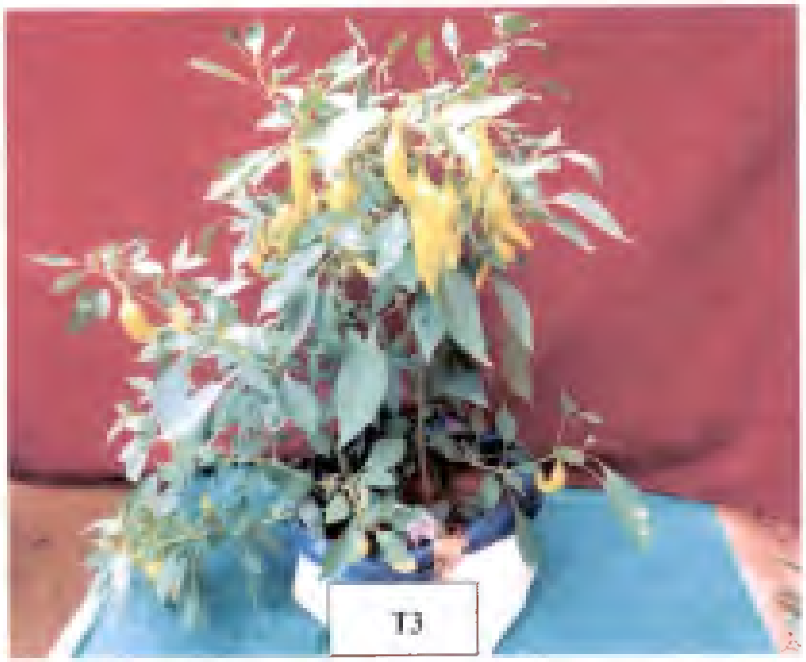


Plate 5. Treatments T3 and T7

Plate 6. Treatments T10 and T11

Table 9. Effect of treatments on fruit yield and yield characteristics of chilli

Treatments	Fruit yield (g plant^{-1})	Fruit length (cm)	Fruit girth (cm)	Number of fruits per plant
T1- TD1:CC1:S1	334.00	8.81	5.18	30.66
T2- TD2:CC1:S1	430.85	10.23	5.57	39.65
T3- TD1:CC2:S1	690.08	13.44	6.99	58.70
T4- TD2:CC2:S1	390.24	9.97	5.38	37.81
T5- TD1:CP1:S1	342.56	9.74	5.27	32.59
T6- TD2:CP1:S1	411.22	10.03	5.52	36.67
T7- TD1:CP2:S1	625.97	12.93	6.58	52.64
T8- TD2:CP2:S1	353.67	9.91	5.30	33.69
T9 -TD1:S1	536.63	11.42	7.29	50.60
T10 -TD2:S1	297.59	7.94	5.08	26.68
T11- S2:SS1:F1	311.99	8.42	5.17	28.70
CD (0.05)	17.01	0.76	0.12	2.59

Table 10. Effect of treatments on pH, EC and organic carbon content of the growth medium

Treatments	pH		EC (dS m^{-1})		OC (%)	
	Initial*	Final*	Initial*	Final*	Initial*	Final*
T1- TD1:CC1:S1	6.66	6.16	2.74	0.125	1.68	1.61
T2- TD2:CC1:S1	6.89	6.2	3.51	0.115	2.74	2.02
T3- TD1:CC2:S1	6.79	6.42	2.92	0.123	2.09	1.25
T4- TD2:CC2:S1	6.95	6.28	5.43	0.108	3.18	2.06
T5- TD1:CP1:S1	6.53	6.29	2.93	0.114	1.7	1.62
T6- TD2:CP1:S1	6.81	6.25	4.51	0.108	2.8	1.72
T7- TD1:CP2:S1	6.45	6.25	3.07	0.106	2.21	1.33
T8- TD2:CP2:S1	6.59	6.32	4.99	0.182	3.3	2.47
T9- TD1:S1	6.71	6.26	2.82	0.125	1.79	1.10
T10- TD2:S1	7.29	6.24	5.85	0.185	3.43	3.23
T11- S2:SS1:F1	5.63	5.41	0.641	0.126	0.88	0.65
CD (0.05)	0.216	0.182	0.098	0.006	0.037	0.112

Initial* –at the time of planting; Final* – after harvest lowest number of fruits per plant was recorded by the treatment T10 (TD2:S1) which was on par with the treatment T11 (S2:SS1:F1).

4.2.5 Effect of treatments on growth medium characteristics

The data on chemical characteristics of the growth medium at the time of planting and after final harvest are presented in Table 10 to 13.

4.2.5.1 Growth medium pH

The pH of medium at the time of planting (Table 10) was significantly influenced by the treatments. The treatment T10 (TD2:S1) which contains two parts of TD and one part soil recorded the highest pH of 7.29 and was significantly superior to all other treatments. The presence of two parts of TD which had a pH of 7.49 might have resulted the high pH for T10 (TD2:S1). The lowest value was noticed for the treatment T11 (S2:SS1:F1) with mean value of 5.63.

The growth medium pH after final harvest was also statistically significant. And it showed a slight decrease from towards final harvest. The highest value of 6.42 was recorded by the treatment T3 (TD1:CC2:S1) and was statistically on par with the T8 (TD2:CP2:S1). This was followed by the treatments T5 (TD1:CP1:S1) and T4 (TD2:CC2:S1). The treatment T11 (S2:SS1:F1) recorded the lowest value of 5.41.

4.2.5.2 Electrical conductivity

The effect of treatments on electrical conductivity of the medium at the time of planting was found to be statistically significant influenced (Table 10). It also followed the same trend as that of the pH of the medium. The treatment T10 (TD2:S1) recorded the highest value of 5.85 dS m^{-1} and was significantly superior to all other treatments followed by treatments T4 (TD2:CC2:S1) and T8 (TD2:CP2:S1). The treatment T11 (S2:SS1:F1) recorded the lowest mean value 0.641 dS m^{-1}.

The electrical conductivity of the growth medium after final harvest was also significantly influenced by the treatments and showed a drastic decrease towards the end of the crop. The highest value for electrical conductivity (0.185 dS m^{-1}) was recorded by the treatment T10 (TD2:S1) followed by the treatment T8 (TD2:CP2:S1). The treatment T7 (TD1:CP2:S1) with a mean value of 0.106 dS m^{-1} recorded the lowest value which was on par with treatments T4 (TD2:CC2:S1) and T6 (TD2:CP1:S1).

4.2.5.3 Organic carbon content

Organic carbon content of the growth medium at the time of planting (Table 10) was significantly influenced by various treatments. It also showed the same trend as that of pH and EC. Treatment T10 (TD2:S1) showed the highest value of 3.43 per cent which was significantly superior to all other treatments. Treatment T11 (S2:SS1:F1) recorded the lowest value of 0.88 per cent.

After final harvest also, the organic carbon content was significantly influenced by the treatments with treatment T10 (TD2:S1) recording the highest value of 3.23 per cent. The lowest value 0.65 per cent was recorded treatment T11 (S2:SS1:F1). Organic carbon content also showed a decreasing trend toward the end of the crop.

4.2.5.4 Available nitrogen, phosphorus and potassium

The data on available N, P and K contents of growth medium are given in the Table 11. The statistical analysis revealed that, available N, P and K contents of the growth medium, both at the time of planting and after final harvest were significantly influenced by the treatments.

With regard to the available N at the time of planting, treatment T10 (TD2:S1) recorded the highest value of 490.54 mg kg^{-1} followed by treatments T4 (TD2:CC2:S1) and T8 (TD2:CP2:S1). The treatment T11 (S2:SS1:F1) showed the lowest value. Available N content of the growth medium after final harvest showed a steep decrease from the initial value and was also significantly influenced by the treatments. The treatment T10 (TD2:S1) recorded the highest value of 130.8 mg kg-^{1}, followed by treatments T4 (TD2:CC2:S1) and T8 (TD2:CP2:S1). The lowest value was recorded by the treatment T9 (TD1:S1) with mean value of 120.23 mg kg^{-1} which was on par with T1 (TD1:CC1:S1).

The highest value for available P at the time of planting was recorded by the treatment T10 (TD2:S1) and the lowest by the treatment T11 (S2:SS1:F1) to which all other treatments were significantly superior. After final harvest also, though it was considerably reduced from initial value, the highest value was recorded by the treatment T10 (TD2:S1) which was significantly superior to all other treatments. The lowest value was observed for treatment T3 (TD1:CC2:S1).

On scrutinizing the data, it was found that the available K content at the time of planting for all the treatments except T11 showed very high values. The TD had a very high content of K and that is too in soluble form. Again the another component CC was also high in K. The presence of these two makes the total K content of the growth medium high. So as the content of TD increases, an increase in available K content was noted in the growth medium. Thus the treatment T10 (TD2:S1) having highest proportion of TD recorded the highest available K (2123.0 mg kg^{-1}) and lowest for T11 (S2:SS1:F1) where there is no TD (486.0 mg kg^{-1}). Available K content showed a remarkable decrease by the end of crop. After final harvest also, the treatment T10 (TD2:S1) recorded the highest value (325.50 mg kg^{-1}) which was significantly superior to all other treatments and was followed by treatment T4 (TD2:CC2:S1). The treatment T3 (TD1:CC2:S1) showed the lowest mean value 65.83 mg kg^{-1} which was on par with treatment T7 (TD1:CP2:S1).

4.2.5.5 Available calcium, magnesium and sulphur

The Table 12 depicted the data on available Ca, Mg and S contents of the growth medium at the time of planting and after final harvest of chilli. The analysed data revealed that available Ca, Mg and S contents of the growth medium at both stages of sampling were significantly influenced by the treatments, though the values showed considerable reduction towards the end of crop.

For the available Ca at the time of planting, the highest value of 2745 mg kg^{-1} was recorded by the treatment T10 (TD2:S1) which was statistically on par with treatments T4 (TD2:CC2:S1) and T8 (TD2:CP2:S1). The treatment T11 (S2:SS1:F1) recorded the lowest value of 1713 mg kg^{-1}. After final harvest also it was significantly influenced by the treatments and highest value of 1400 mg kg^{-1} was noted for the treatment T11 (S2:SS1:F1) which was on par with treatment T10 (TD2:S1. The lowest value was noted for treatment T3 (TD1:CC2:S1)

The available Mg content at the time of planting followed the same trend as that of available Ca with highest values for treatment T10 (TD2:S1) and lowest for treatment T11 (S2:SS1:F1). The available Mg content after final harvest followed the same trend as that of initial sampling.

The available S content of growth medium was significantly influenced by the treatments at both stages of sampling. The available S content of the growth medium for treatment T1 to T10 was very high. All the above treatments contain TD in varying proportions which had been fortified with essential elements where cationic elements are mainly in the sulphates form. The treatment T10 (TD2:S1) recorded the highest mean value and treatment T11 (S2:SS1:F1) the lowest values at both stages.

Table 11. Effect of treatments on available N, P and K contents of the growth medium, mg kg^{-1}

Treatments	N		P		K	
	Initial*	Final*	Initial*	Final*	Initial*	Final*
T1- TD1:CC1:S1	238.53	130.87	34.86	18.52	1061.8	192.83
T2- TD2:CC1:S1	367.27	237.86	36.37	15.10	1681.0	129.17
T3- TD1:CC2:S1	328.07	142.64	35.27	7.55	1321.8	65.83
T4- TD2:CC2:S1	428.90	305.05	37.57	16.84	1916.0	251.82
T5- TD1:CP1:S1	249.77	139.29	34.16	13.96	829.3	153.50
T6- TD2:CP1:S1	356.12	227.21	35.67	12.61	1492.0	187.83
T7- TD1:CP2:S1	311.40	142.66	34.46	9.89	867.2	73.81
T8- TD2:CP2:S1	389.75	271.45	35.86	13.39	1481.0	138.85
T9- TD1:S1	255.37	120.23	35.56	12.19	1098.0	84.83
T10- TD2:S1	490.54	383.44	39.85	23.17	2123.0	325.50
T11- S2:SS1:F1	148.94	137.04	28.20	14.06	486.0	183.17
CD (0.05)	20.57	22.07	2.59	1.32	102.82	12.64

Initial* –at the time of planting; Final* – after harvest

Table 12. Effect of treatments on available Ca, Mg and S contents of the growth medium, mg kg^{-1}

Treatments	Ca		Mg		S	
	Initial*	Final*	Initial*	Final*	Initial*	Final*
T1- TD1:CC1:S1	466.60	240	226	86	51.16	10.65
T2- TD2:CC1:S1	502.60	232	257	71	77.77	15.54
T3- TD1:CC2:S1	478.60	128	248	54	65.91	5.42
T4- TD2:CC2:S1	540.00	244	268	78	91.30	13.04
T5- TD1:CP1:S1	454.60	220	227	79	41.80	9.02
T6- TD2:CP1:S1	486.60	208	250	72	68.89	12.11
T7- TD1:CP2:S1	470.60	136	243	58	44.32	6.04
T8- TD2:CP2:S1	532.40	248	263	92	70.65	11.13
T9- TD1:S1	462.60	148	240	62	52.00	10.07
T10- TD2:S1	549.00	268	270	122	93.80	19.15
T11- S2:SS1:F1	342.60	280	133	60	17.55	4.49
CD (0.05)	35.49	17.92	7.30	3.50	5.14	1.82

Initial* –at the time of planting; Final* – after harvest

4.2.5.6 Available iron, manganese, zinc, copper and boron

The data on available Fe, Mn, Cu, Zn and B contents of the growth medium at the time of planting and after final harvest are presented in the Table 13. They were significantly influenced by the treatments at both stages of sampling. The micronutrient content also decreased considerably towards the end of the crop.

The treatment T4 (TD2:CC2:S1) recorded the highest value of 94.3 mg kg^{-1} for available Fe content in the medium at the time of planting and was significantly superior to all other treatments. This was closely followed by treatments T8 (TD2:CP2:S1) and T10 (TD2:S1). The lowest value was observed for the treatment T9 (TD1:S1). The treatment T10 recorded the highest value of 28.33 mg kg^{-1} after final harvest followed by treatments T4 (TD2:CC2:S1) and T8 (TD2:CP2:S1. The lowest value of 10.47 mg kg^{-1} was recorded for the treatment T5 (TD1:CP1:S1) which was on par with treatments T1 (TD1:CC1:S1) and T11 (S2:SS1:F1).

In the case of available Mn content, both at the time of planting and after final harvest, the highest values were registered by treatment T10 (TD2:S1) followed by treatment T4 (TD2:CC2:S1). At both stages of sampling the lowest value was recorded the by treatment T11 (S2:SS1:F1).

Available Zn content of the growth medium was high in general for all the treatments. All the growth medium components especially TD and FYM had found higher Zn content and this can be readily observed in the data on available Zn at the time of planting. Available Zn content at time of planting followed the same trend as that of Mn. The treatment T10 (TD2:S1) recorded the highest value of 15.29 mg kg^{-1} and was on par with treatment T8 (TD2:CP2:S1). The treatment T11 (S2:SS1:F1) recorded the lowest value of 13.20 mg Zn kg^{-1}. After final harvest also almost same trend was followed for available Zn with treatment T10 (TD2:S1) recording the highest value and the lowest by treatment T11 (S2:SS1:F1).

Available Cu content at the time of planting was also highest (1.94 mg kg^{-1}) for the treatment T10 (TD2:S1)) followed by treatments T4 (TD2:CC2:S1) and T8 (TD2:CP2:S1). The lowest value was noted for treatment T11 (S2:SS1:F1). After final harvest also the treatment T10 (TD2:S1) showed the highest content for available Cu followed by treatments T4 (TD2:CC2:S1) and T8 (TD2:CP2:S1). The lowest value of 0.32 mg kg^{-1} was recorded by the treatment T7 (TD1:CP2:S1) which was statistically on par with treatment T3 (TD1:CC2:S1).

Available B content of the growth medium for various treatments was also high. As in the case of Zn here also the B content of the growth medium components (TD, CC and CP) was generally high. For available B, the highest values of 2.8 mg kg^{-1} was noticed for treatment T4 (TD2:CC2:S1) and was statistically on par with the treatment T10 (TD2:S1). The lowest value of 1.2 mg kg^{-1} was recorded for treatment T11 (S2:SS1:F1). After final harvest also the highest value was noted for the treatment T10 (TD2:S1). This was followed by the treatments T4 (TD2:CC2:S1) and T8 (TD2:CP2:S1). The lowest value of 0.80 mg kg^{-1} was registered by the two treatments viz., T9 (TD1:S1) and T11 (S2:SS1:F1).

4.2.6 Effect of treatments on nutrient composition of chilli shoot

4.2.6.1 Nitrogen, phosphorous and potassium

N, P and K contents of chilli shoot were significantly influenced by the treatments and are presented in the Table 14.

The highest value for N content of shoot was recorded by the treatment T3 (TD1:CC2:S1) with a value of 4.26 per cent and was on par with the treatment T7 (TD1:CP2:S1) and followed by the treatment T9 (TD1:S1). The lowest value of 2.72 per cent was observed for treatment T11 (S2:SS1:F1).

With regard to shoot P content, the treatment T3 (TD1:CC2:S1) recorded the highest value and was significantly superior to all other treatments with a mean value 0.49 per cent, followed by treatments T7 (TD1:CP2:S1) and T9 (TD1:S1). The treatment T11 (S2:SS1:F1) recorded the lowest value and all other treatments were significantly superior to it.

The K content of shoot ranged from 7.82 to 3.20 per cent, where the treatment T3 (TD1:CC2:S1) recorded the highest value which was on par with treatment T7 (TD1:CP2:S1) and the lowest value was observed for the treatment T10 (TD2:S1).

4.2.6.2 Calcium, magnesium and sulphur

The data regarding Ca, Mg and S contents of chilli shoot are presented in the Table 14 and all the three nutrients were significantly influenced by the treatments.

The treatment T3 (TD1:CC2:S1) showed the highest value of 2.23 per cent for Ca and was on par with the treatment T7 (TD1:CP2:S1). The lowest value 0.38 per cent was obtained for treatment T11 (S2:SS1:F1).

The Mg content of shoot also followed the same trend as that of Ca and the treatment T3 (TD1:CC2:S1) recorded the highest value of 1.99 per cent which was on par with the treatment T7 (TD1:CP2:S1). The lowest value 1.02 per cent was noticed for the treatment T11 (S2:SS1:F1).

The S content of the shoot also followed the same trend as that of Ca and Mg. The highest value was obtained for the treatment T3 (TD1:CC2:S1) with mean value 0.212 per cent followed by treatment T7 (TD1:CP2:S1). The treatment T11 (S2:SS1:F1) registered the lowest value 0.026 per cent.

Table 13. Effect of treatments on available Fe, Mn, Zn, Cu and B contents of the growth medium, mg kg^{-1}

Treatments	Fe		Mn		Zn		Cu		B	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
T1- TD1:CC1:S1	53.60	11.50	32.46	26.10	13.53	11.18	1.10	0.82	1.90	1.31
T2- TD2:CC1:S1	82.60	25.40	48.03	36.00	14.47	10.59	1.40	0.64	2.40	1.35
T3- TD1:CC2:S1	72.40	22.70	42.38	28.30	13.94	10.00	1.30	0.33	2.40	1.09
T4- TD2:CC2:S1	94.30	24.50	56.61	44.30	14.76	11.18	1.90	0.98	2.80	1.81
T5- TD1:CP1:S1	48.80	10.50	33.29	26.60	11.29	9.41	1.10	0.79	1.80	1.19
T6- TD2:CP1:S1	76.00	23.50	47.57	36.30	14.29	11.19	1.40	0.71	2.00	1.28
T7- TD1:CP2:S1	69.60	21.60	34.33	23.70	13.94	10.01	1.20	0.32	2.00	1.01
T8- TD2:CP2:S1	91.70	23.10	52.56	41.60	14.88	11.17	1.50	0.81	2.60	1.58
T9- TD1:S1	46.40	14.70	45.72	32.10	14.24	10.59	1.30	0.35	1.80	0.80
T10- TD2:S1	81.00	28.30	58.73	49.30	15.29	12.35	1.90	1.12	2.60	2.10
T11- S2:SS1:F1	62.00	11.30	28.74	19.70	13.20	6.47	0.90	0.78	1.20	0.80
CD (0.05)	1.03	1.54	2.00	2.00	1.49	1.66	0.20	0.16	0.17	0.11

Initial –at the time of planting; Final – after harvest

Table 14. Effect of treatments on N, P, K, Ca, Mg and S contents of chilli shoot, %

Treatments	N	P	K	Ca	Mg	S
T1- TD1:CC1:S1	3.22	0.18	4.55	0.67	1.29	0.173
T2- TD2:CC1:S1	3.64	0.39	7.24	1.59	1.84	0.199
T3- TD1:CC2:S1	4.26	0.49	7.82	2.23	1.99	0.212
T4- TD2:CC2:S1	3.64	0.365	5.9	1.19	1.70	0.181
T5- TD1:CP1:S1	3.33	0.225	4.93	0.91	1.36	0.176
T6- TD2:CP1:S1	4.14	0.38	6.47	1.31	1.74	0.187
T7- TD1:CP2:S1	4.17	0.45	7.44	2.15	1.94	0.211
T8- TD2:CP2:S1	3.36	0.20	6.09	1.03	1.46	0.197
T9- TD1:S1	4.03	0.445	6.47	2.02	1.86	0.203
T10- TD2:S1	3.19	0.16	3.20	0.59	1.22	0.127
T11- S2:SS1:F1	2.72	0.12	3.97	0.39	1.02	0.026
CD (0.05)	0.136	0.008	0.497	0.10	0.062	0.008

4.2.6.3 Iron, manganese, zinc, copper and boron

The data on concentration of Fe, Mn, Zn, Cu and B contents of chilli shoot are presented in the Table 15. Treatment effects were statistically significant for all the above nutrients.

The treatment T11 (S2:SS1:F1) recorded the highest value of 883.96 mg kg^{-1} of Fe content in shoot which was on par with treatment T10 (TD2:S1). The lowest value of 309.63 mg kg^{-1} was observed for the treatment T11 (S2:SS1:F1) which was on par with the treatment T3 (TD1:CC2:S1).

For Mn content, the treatment T4 (TD2:CC2:S1) recorded the highest value and was significantly superior to all other treatments. The Mn content of shoot ranged from 57.73 to 194.91 mg kg^{-1}. The lowest value was recorded by the treatment T3 (TD1:CC2:S1).

For the Zn content of shoot, the highest value of 144.23 mg kg^{-1} was observed for the treatment T3 (TD1:CC2:S1). It was followed by the treatments T7 (TD1:CP2:S1) and T9 (TD1:S1). The lowest value was observed for treatment T11 (S2:SS1:F1).

The highest content for Cu was observed for the treatment T3 (TD1:CC2:S1) with value of 14.00 mg kg^{-1} and was significantly superior to all other treatments. The treatment T11 recorded the lowest value of 2.07 mg kg^{-1} and all other treatments were significantly superior to it.

The treatment T3 (TD1:CC2:S1) recorded the highest B content in shoot (30.40 mg kg^{-1}) which was on par with the treatment T7 (TD1:CP2:S1). The lowest value 25.79 mg kg^{-1} was noticed in treatment T11 (S2:SS1:F1) which was on par with treatment T10 (TD2:S1).

4.2.7 Effect of treatments on nutrient composition of chilli fruit

4.2.7.1 Nitrogen, phosphorous and potassium

The data on concentration of N, P and K of chilli fruit are presented in Table 16. The statistical analysis of the data revealed that N, P and K contents of chilli fruit were significantly influenced by the treatments.

With regard to N, the highest value of 3.33 per cent was recorded by the treatment T3 (TD1:CC2:S1) which was significantly superior to all other treatments. It was followed by the treatments T7 (TD1:CP2:S1) and T9 (TD1:S1). The lowest value of 1.62 per cent was recorded by the treatment T11 (S2:SS1:F1) which was on par with the treatment T10 (TD2:S1).

The P content of fruits followed the same trend as that of N content of fruit and it ranged from 0.120 to 0.505 per cent (Table 18). The treatment T3 (TD1:CC2:S1) recorded the highest value followed by the treatments T7 (TD1:CP2:S1) and T9 (TD1:S1). The lowest value was recorded by the treatment T11 (S2:SS1:F1)

In the case of K content of fruit, the treatment T3 (TD1:CC2:S1) registered the highest value (4.43 %) and was found to be statistically on par with the treatment T7 (TD1:CP2:S1). The lowest value (1.93 %) was registered by treatment T11 (S2:SS1:F1).

4.2.7.2 Calcium, magnesium and sulphur

The Ca, Mg and S contents of chilli fruit were significantly influenced by the treatments and are presented in Table 16.

The highest value for Ca content in fruit (0.408 %) was observed for the treatment T3 (TD1:CC2:S1 followed by treatments T7 (TD1:CP2:S1) and T9

Table 15. Effect of treatments on Fe, Mn, Zn, Cu and B contents of chilli shoot, mg kg^{-1}

Treatments	Fe	Mn	Zn	Cu	B
T1- TD1:CC1:S1	883.96	64.63	109.73	4.90	26.68
T2- TD2:CC1:S1	505.23	106.92	134.71	9.00	29.63
T3- TD1:CC2:S1	309.63	57.73	144.23	14.00	30.40
T4- TD2:CC2:S1	615.22	194.91	128.12	8.80	28.35
T5- TD1:CP1:S1	735.63	105.62	119.61	6.90	27.97
T6- TD2:CP1:S1	534.52	90.43	131.03	8.90	28.48
T7- TD1:CP2:S1	446.03	69.53	139.83	13.70	30.14
T8- TD2:CP2:S1	639.32	128.23	121.74	7.00	28.09
T9- TD1:S1	484.74	71.56	137.84	12.20	28.61
T10- TD2:S1	857.15	186.73	100.23	2.60	26.04
T11- S2:SS1:F1	301.11	91.84	55.71	2.07	25.79
CD (0.05)	55.50	1.39	2.63	0.155	4.26

Table 16. Effect of treatments on N, P, K, Ca, Mg and S contents of chilli fruit, %

Treatments	N	P	K	Ca	Mg	S
T1- TD1:CC1:S1	2.10	0.24	2.89	0.240	0.336	0.086
T2- TD2:CC1:S1	2.63	0.322	3.66	0.336	0.480	0.117
T3- TD1:CC2:S1	3.33	0.505	4.43	0.408	0.528	0.131
T4- TD2:CC2:S1	2.44	0.26	3.47	0.288	0.408	0.104
T5- TD1:CP1:S1	2.21	0.29	3.08	0.264	0.336	0.099
T6- TD2:CP1:S1	2.60	0.315	3.28	0.312	0.456	0.112
T7- TD1:CP2:S1	3.16	0.405	4.24	0.384	0.504	0.126
T8- TD2:CP2:S1	2.27	0.255	3.26	0.264	0.408	0.104
T9- TD1:S1	2.69	0.355	3.85	0.360	0.504	0.117
T10- TD2:S1	1.71	0.225	2.50	0.264	0.240	0.078
T11- S2:SS1:F1	1.62	0.12	1.93	0.216	0.192	0.074
CD (0.05)	0.142	0.008	0.342	0.041	0.041	0.008

(TD1:S1). The lowest value 0.216 per cent was recorded for the treatment T11 (S2:SS1:F1).

Mg content of the fruit followed the same trend as that of Ca, with treatment T3 (TD1:CC2:S1) recording the highest value of 0.528 per cent and was significantly superior to all other treatments. The treatments T7 (TD1:CP2:S1) and T9 (TD1:S1) followed it. The treatment T11 (S2:SS1:F1) recorded the lowest value of 0.192 per cent and all other treatments were significantly superior to it.

In the case of S also the same trend of Ca and Mg was followed, the highest value was registered by the treatment T3 (TD1:CC2:S1) which was on par with treatments T7 (TD1:CP2:S1) and T9 (TD1:S1). The lowest value 0.074 per cent was registered by the treatment T11 (S2:SS1:F1).

4.2.7.3 Iron, manganese, zinc, copper and boron

The statistically analyzed data regarding effects of treatments on micronutrient content of chilli fruit viz. Fe, Mn, Zn, Cu and B are depicted in the Table 17. Different treatments had significantly influenced their concentration in chilli fruit.

Treatment T11 (S2:SS1:F1) recorded the highest value for Fe content (627.64 mg kg^{-1}) followed by the treatment T10 (TD2:S1). The lowest value of 141.75 mg kg^{-1} was recorded by the treatment T9 (TD1:S1) which was found to be on par with treatment T3 (TD1:CC2:S1).

With regard to Mn content of fruit, treatment T3 (TD1:CC2:S1) recorded the highest value of 29.34 mg kg^{-1} and followed by treatments T7 (TD1:CP2:S1) and T9 (TD1:S1). The treatment T11 (S2:SS1:F1) showed the lowest value of 10.09 mg kg^{-1} and all other treatments were significantly superior to it.

Table 17. Effect of treatments on Fe, Mn, Zn, Cu and B contents of chilli fruit, mg kg^{-1}

Treatments	Fe	Mn	Zn	Cu	B
T1- TD1:CC1:S1	342.84	11.82	31.46	5.81	22.76
T2- TD2:CC1:S1	188.75	24.23	40.97	8.4	25.32
T3- TD1:CC2:S1	143.73	29.34	49.38	9.51	26.22
T4- TD2:CC2:S1	265.34	18.92	39.45	6.92	24.94
T5- TD1:CP1:S1	311.83	12.21	37.57	6.11	23.14
T6- TD2:CP1:S1	256.14	23.32	39.86	7.93	25.07
T7- TD1:CP2:S1	158.04	24.93	44.26	9.11	25.83
T8- TD2:CP2:S1	241.73	13.81	38.07	6.41	24.04
T9- TD1:S1	141.75	22.03	42.47	8.74	25.45
T10- TD2:S1	507.63	10.66	23.16	5.50	22.50
T11- S2:SS1:F1	627.64	10.09	16.48	4.62	21.86
CD (0.05)	3.68	0.391	1.98	1.62	4.14

Table 18. Effect of treatments on capsaicin content of chilli fruit, %

Treatments	Capsaicin
T1- TD1:CC1:S1	0.666
T2- TD2:CC1:S1	0.739
T3- TD1:CC2:S1	0.777
T4- TD2:CC2:S1	0.713
T5- TD1:CP1:S1	0.668
T6- TD2:CP1:S1	0.721
T7- TD1:CP2:S1	0.756
T8- TD2:CP2:S1	0.700
T9- TD1:S1	0.748
T10- TD2:S1	0.637
T11- S2:SS1:F1	0.653
CD (0.05)	0.007

In case of Zn, the values ranged from 10.09 to 49.38 mg kg^{-1}. It also followed the same trend as that of Mn content of fruit. The treatment T3 (TD1:CC2:S1) recorded the highest value followed by treatments T7 (TD1:CP2:S1) and T9 (TD1:S1). The lowest value was registered by treatment T11 (S2:SS1:F1) with normal potting media.

For Cu also the highest value of 9.51 mg kg^{-1} was registered by the treatment T3 (TD1:CC2:S1) which was found to be on par with the treatment T7 (TD1:CP2:S1). The lowest value was observed for treatment T11 (S2:SS1:F1) which was on par with treatment T10 (TD2:S1).

B also followed the same trend as that of Mn and Cu with treatment T3 (TD1:CC2:S1) recording the highest value. This was closely followed by the treatments T7 (TD1:CP2:S1) and T9 (TD1:S1). The lowest mean value of 21.86 mg kg^{-1} was recorded by T11 (S2:SS1:F1).

4.2.7.4 Effect of treatments on capsaicin content of chilli fruit

The data on capsaicin content of chilli fruit are depicted in Table 18. Capsaicin content was significantly influenced by the treatments. The highest value 0.777 per cent was recorded by the treatment T3 (TD1:CC2:S1) followed by the treatments T7 (TD1:CP2:S1) and T9. The treatment T3 (TD1:CC2:S1) significantly superior to all other treatments. The lowest value of 0.637 per cent was recorded by the treatment T11 (S2:SS1:F1).

4.2.8 Scoring of pest and diseases

Details regarding the scoring for pest and diseases are given in the Table 19. The experimental plants did not show any disease incidence. With regard to the pests, mite attack was noticed. The mite infestation was about 25 per cent. Effective control measures were taken to manage it. A new generation pesticide Oberon @ 0.8

ml L^{-1} at weekly intervals was sprayed. The pesticide application had ensured 100 per cent recovery of affected plants.

4.2.9 Economic analysis

The details regarding economic analysis are presented in Table 20. Statistical analysis revealed that the B:C ratio was significantly influenced by the treatments. The treatment T3 (TD1:CC2:S1) recorded the highest B:C ratio of 2.47 which was significantly superior to all others. This was followed by the treatments T9 (TD2:S1) and T7 (TD1:CP2:S1). The lowest value 0.614 was recorded by the treatment T10 which was on par with treatment T11 (S2:SS2:F1).

Table 19. Scoring for pest (chilli mite)

Treatments	Before application of pesticide	After application of pesticide
T1- TD1:CC1:S1	1	0
T2- TD2:CC1:S1	1	0
T3- TD1:CC2:S1	1	0
T4- TD2:CC2:S1	1	0
T5- TD1:CP1:S1	1	0
T6- TD2:CP1:S1	1	0
T7- TD1:CP2:S1	1	0
T8- TD2:CP2:S1	1	0
T9 -TD1:S1	1	0
T10 -TD2:S1	1	0
T11- S2:SS1:F1	1	0

*0 = No symptom

*1 = 1-25 % of leaves or plant show curling

Table 20. Effect of treatments on B:C ratio

Treatments	Benefit (Rs)	Cost (Rs)	B:C Ratio
T1- TD1:CC1:S1	751500	504000	1.49
T2- TD2:CC1:S1	969420	879000	1.10
T3- TD1:CC2:S1	1552680	629000	2.47
T4- TD2:CC2:S1	878040	1004000	0.875
T5- TD1:CP1:S1	770753	529000	1.46
T6- TD2:CP1:S1	925245	904000	1.02
T7- TD1:CP2:S1	1408440	679000	2.07
T8- TD2:CP2:S1	795765	1054000	0.755
T9- TD1:S1	1297418	566500	2.29
T10- TD2:S1	669578	1129000	0.614
T11- S2:SS1:F1	701993	1102000	0.615
CD (0.05)			0.050

4.2 PART 11. STANDARDISATION AND CUSTOM BLENDING OF TD WITH FERTILIZERS FOR YIELD MAXIMIZATION IN CHILLIES

4.2.1 Effect of treatments on shoot biometric characteristics

The data on shoot biometric characteristics of chilli viz., plant height and number of primary branches are presented in Table 21.

4.2.1.1 Plant height

Regarding the plant height, the individual effect of levels of NPK for custom blending of thermochemical digest had significant influence at 30, 60 and 90 days after planting while the same for frequency of application was significant only at 60 and 90 days after planting. The interaction effect was significant only for 90 days after planting. Among the individual effects, plant height was highest for weekly application (P1) and NPK @100 % POP (F2). The treatment combination P1F2 (weekly application of NPK @100 % POP) showed the highest value and P2F3 (biweekly application of NPK @125 % POP) the lowest value for plant height.

Number of primary branches

Scrutinizing data, it was observed that the treatment effects, either the individual or interaction of levels of NPK for custom blending of thermochemical digest and frequency of application, did not significantly influence the number of primary branches per plant.

Shoot weight and dry matter production

Shoot weight (Table 22) was significantly influenced by the individual effects of levels of NPK and frequency of application while their interaction effect was not significant. The highest values for shoot weight were recorded by P1 (weekly

Table 21. Effect of treatments on shoot biometric characteristics of chilli

Treatments	Plant height (cm)			Primary branches per plant
Frequency	30 DAP*	60 DAP*	90 DAP*	
P1	30.66	58.29	74.18	7.75
P2	28.65	54.33	70.33	7.00
SE	0.493	0.304	0.222	0.220
CD (0.05)	NS	0.639	0.466	NS
Levels of NPK				
F1	28.83	55.58	71.35	7.13
F2	32.16	60.18	76.11	8.00
F3	27.98	53.17	69.31	7.00
SE	0.604	0.373	0.271	0.27
CD (0.05)	1.27	0.783	0.57	NS
Interaction				
P1F1	29.93	57.93	73.40	7.50
P1F2	33.23	61.03	77.05	8.25
P1F3	28.83	55.92	72.10	7.50
P2F1	27.73	53.22	69.30	6.75
P2F2	31.10	59.33	75.18	7.75
P2F3	27.13	50.43	66.53	6.50
SE	0.854	0.527	0.384	0.382
CD (0.05)	NS	NS	0.807	NS

DAP* – Days after planting

application) and F2 (NPK @100 % POP). The lowest values were recorded by P2 (biweekly application) and F3 (NPK @125 % POP).

The statistical analysis of total dry matter production (Table 22) revealed that individual effects of levels of NPK and frequency of application, and their interaction were statistically significant. For individual effects, the highest values were noticed for P1 (weekly application) and F2 (NPK @100 % POP). The lowest values were observed for P2 (biweekly application) and F3 (NPK @125 % POP). For interaction effects the highest value was recorded by P1F2 (weekly application of NPK @100 % POP) and lowest by P2F3 (biweekly application @125 % POP).

4.1.3 Effect of treatments on root characteristics

Root weight (Table 22) was significantly influenced by both the individual effects of levels of NPK for custom blending of thermochemical digest and frequency of application and their interaction effects. For individual effects, highest values were observed for P1 (weekly application) and F2 (NPK @100 % POP) and for interaction effect the combination P1F2 (weekly application of NPK @100 % POP) recorded the highest value. The lowest values were noticed for P2 (biweekly application), F3 (NPK 125 % POP) and P2F3 (biweekly application of NPK @125 % POP) respectively.

For root volume, only the individual effects were statistically significant. The highest values were noticed for P1 (weekly application) and F2 (NPK @ 100 % POP) and lowest by P2 (biweekly application) and F3 (NPK @125 % POP) respectively.

4.1.4 Effect of treatments on fruit yield and yield characteristics

The data on fruit yield and yield attributes are depicted in the Table 23.

Plate7. Overview of experiment for standardization and custom blending of TD for yield maximization

Plate 8. Treatment combination showing best performance (P1F2)

Table 22. Effect of treatments on shoot weight, dry matter production and root characteristics of chilli

Treatments	Shoot weight		Total	Root weight		Root volume
	Fresh	Dry	dry matter	Fresh	Dry	cm^3
	g $plant^{-1}$					
Frequency						
P1	293.43	62.99	76.74	7.67	60.55	140.96
P2	259.63	55.07	68.21	6.82	55.65	128.93
SE	2.00	0.500	0.344	0.034	0.381	0.598
CD (0.05)	4.21	1.05	0.723	0.710	0.800	1.26
Levels of NPK						
F1	267.55	56.44	68.85	6.88	55.55	130.48
F2	304.53	65.78	85.21	8.52	65.00	146.73
F3	257.51	54.88	63.36	6.34	53.75	127.63
SE	2.45	0.613	0.421	0.42	0.467	0.732
CD (0.05)	5.15	1.29	0.885	0.890	0.980	1.54
Interaction						
P1F1	282.06	58.28	74.75	7.50	57.35	133.60
P1F2	322.70	72.54	90.07	9.10	68.45	157.54
P1F3	275.55	58.19	65.39	6.60	55.85	131.73
P2F1	253.04	54.59	62.95	6.30	53.75	127.36
P2F2	286.38	59.02	80.34	8.03	61.55	135.92
P2F3	239.47	51.57	61.32	6.13	51.65	123.53
SE	3.47	0.867	0.596	0.600	0.660	1.04
CD (0.05)	NS	1.822	1.25	1.23	NS	2.18

4.1.4.1 Fruit yield

Perusal of the data on fruit yield revealed that it was significantly influenced by both the individual and interaction effects of the levels of NPK for custom blending of thermochemical digest and frequency of application. With regard to the individual effects, the highest values were recorded by P1 (weekly application) and F2 (NPK @100 % POP) and for interaction the same was noted for P1F2 (weekly application of NPK @100 % POP) and were significantly superior to all other treatments. Among the levels of fertilizers, F3 (NPK @125 % POP) and for frequency of application, P2 (biweekly application) their interaction (P2F3) recorded the lowest values for fruit yield.

4.1.4.2 Fruit length

For fruit length, the individual effects of levels of NPK and frequency of application alone were found to be significantly influenced. Among the levels of fertilizers, F2 (NPK @100 % POP) and for frequency of application P1 (weekly application) recorded the highest values and were significantly superior to others. The lowest values were recorded by F3 (NPK @125 % POP) and P2 (biweekly application).

4.1.4.3 Number of fruits per plant

For number of fruits per plant also, only the individual effects of levels of NPK and frequency of application were found to be significantly affected. It also followed the same trend as that of fruit length. The highest values were noticed for P1 (weekly application) and F2 (NPK @100 % POP) and were significantly superior to others. The lowest values were registered by P2 (biweekly application) and F3 (NPK @125 % POP) respectively.

Plate 9. Treatment combination showing lowest performance (P2F2)

Plate 10. Fruits from best performed treatment (P1F2)

4.1.4.4 Fruit girth

Statistical analysis revealed that only the individual effects of levels of NPK for custom blending of thermochemical digest and frequency of application had significantly influenced the fruit girth. It followed the same trend as that of fruit length, showing highest values for P1 (weekly application) and F2 (NPK @100 % POP) and were significantly superior to others. The lowest values were registered by P2 (biweekly application) and F3 (NPK @125 % POP) respectively.

4.1.5 Effect of treatments on chemical characteristics of growth medium

The growth medium that consists of thermochemical digest, coirpith compost and soil in 1:2:1 ratio which had shown best performance in the first part of the investigation was used for second part of the investigation. So the initial characteristics of the growth medium were same as that of the first part of investigation and presented in Table 24. The data on chemical characteristics of the growth medium such as pH, EC and organic carbon content after final harvest are given in the Table 25.

4.1.5.1 Growth medium pH

Soil pH had showed a drop in pH after final harvest from that at the time of planting (Table 25). Statistical analysis revealed that the individual effect of levels of NPK for custom blending of thermochemical digest had significantly influenced the pH of the growth medium. Among the levels of fertilizers, the highest value was noticed by F3 (NPK @125 % POP) and lowest was by F1 (NPK @75 % POP). Each level was significantly different from other. The individual effect of frequency of application and its interaction levels of NPK were not statistically significant.

Table 23. Effect of treatments on fruit yield and yield characteristics of chilli

Treatments / Frequency	Fruit yield (g/plant)	Fruit length (cm)	Fruit girth (cm)	Number of fruits per plant
P1	738.31	13.47	6.07	55.17
P2	707.08	12.31	5.82	51.58
SE	0.888	0.081	0.056	0.507
CD (0.05)	1.87	0.169	0.118	1.06
Levels of NPK				
F1	707.96	12.56	5.85	52.13
F2	757.41	13.96	6.23	58.00
F3	702.72	12.14	5.75	50.00
SE	1.09	0.099	0.069	0.621
CD (0.05)	2.29	0.208	0.144	1.30
Interaction				
P1F1	712.40	13.05	5.98	54.50
P1F2	794.34	14.78	6.35	59.50
P1F3	708.20	12.58	5.88	51.50
P2F1	703.53	12.07	5.73	49.75
P2F2	720.48	13.15	6.10	56.50
P2F3	697.25	11.70	5.63	48.50
SE	1.54	0.140	0.097	0.878
CD (0.05)	3.23	NS	NS	NS

Table 24. Initial chemical characteristics of the growth medium for chilli

Parameters	Quantity	Parameters	Quantity ($mg\ kg^{-1}$)
pH	6.79	Exchangeable Mg	745.00
EC (dS/m)	2.92	S	65.91
OC (%)	2.09	Fe	72.36
Available N ($mg\ kg^{-1}$)	328.07	Mn	42.38
Available P ($mg\ kg^{-1}$)	35.27	Zn	13.94
Available K($mg\ kg^{-1}$)	1321.80	Cu	1.29
Exchangeable Ca ($mg\ kg^{-1}$)	2393.00	B	2.40

4.1.5.2 Electrical conductivity

At the time of planting, the growth medium recorded an electrical conductivity of 2.92 dS m^{-1} (Table 24) which had declined considerably by the end of final harvest of chillies. The individual effects of levels of NPK for custom blending of thermochemical digest and frequency of application were found to influence the electrical conductivity of the medium significantly while interaction effects were not significant (Table 25). For the individual effects of levels of NPK, F3 (NPK @ 125 % POP) had shown the highest value and was significantly superior to others. For the individual effect of frequency of application, P2 (biweekly application) recorded the highest value which was significantly superior to P1 (weekly application).

4.1.5.3 Organic Carbon

At the time of planting the growth medium recorded an organic carbon content of 2.09 per cent (Table 24) which had shown a steep decline towards the end of the crop. The individual as well as the interaction effect of levels of NPK and frequency of application were found to influence significantly the organic carbon content of medium after final harvest. While considering the individual effects, F3 (NPK @125% POP) and P2 (biweekly application) recorded the highest values and were significantly superior to all other treatments. Their treatment combination P2F3 (biweekly application of NPK @125 % POP) recorded the highest value which was significantly superior to all other combinations.

4.1.5.4 Available nitrogen, phosphorus and potassium

The data on available N, P and K contents of growth medium after final harvest are depicted in Table 26.

Scrutinizing the data on available N, it was observed that available N content of the medium after final harvest was almost half of that at the time of planting (Table

Table 25. Effect of treatments on pH, EC and organic carbon content of growth medium after final harvest of chilli

Treatments	pH	EC (dS m^{-1})	OC (%)
Frequency			
P1	6.640	0.290	1.290
P2	6.720	0.308	1.310
SE	0.035	0.004	0.004
CD (0.05)	NS	0.008	0.008
Levels of NPK			
F1	6.460	0.256	1.180
F2	6.660	0.306	1.250
F3	6.930	0.335	1.150
SE	0.043	0.005	0.004
CD (0.05)	0.090	0.010	0.009
Interaction			
P1F1	6.410	0.240	1.150
P1F2	6.620	0.300	1.300
P1F3	6.900	0.330	1.420
P2F1	6.500	0.271	1.200
P2F2	6.700	0.314	1.200
P2F3	6.950	0.339	1.520
SE	0.061	0.007	0.006
CD (0.05)	NS	NS	0.013

26). But neither the individual or interaction effects of levels of NPK nor that of frequency of application was significant on available N content after final harvest.

In the case of available P content of the medium also a drastic decrease was noted by the end of the crop from that at the time of planting (Table 26). The available P content after final harvest was significantly influenced only by the individual effects of levels of NPK for custom blending of thermochemical digest and frequency of application. The interaction effects were not significant. With regard to the individual effect of levels of NPK the treatment F3 (NPK @125 % POP) recorded the highest value and was significantly superior to all other treatments. For period of application, P2 (biweekly application) recorded the highest value. The lowest values were observed for F1 (NPK @75 % POP) and P1 (weekly application) respectively.

With regard to the available K content of the medium after final harvest, the decrease observed from that at the time of planting (Table 24) was very high. Only the individual effects of levels of NPK and frequency of application were found to influence significantly the available K content of the medium after final harvest (Table 26). It followed the same trend as that of available P content of the growth medium. Among the levels of NPK, third level F3 (NPK @125 % POP) and among frequency of application P2 (biweekly application), recorded the highest values which were significantly superior to others. The lowest values were observed for P1 (weekly application) and F1 (NPK @75 % POP) respectively.

4.1.5.5 Available calcium, magnesium and sulphur

The data regarding the concentration of available Ca, Mg and S contents of the growth medium are presented in Table 26.

Available Ca content of the medium also showed a drastic decrease towards the end of the crop from that at the time of planting (Table 26). But the different

Table 26. Effect of treatments on available N, P, K, Ca, Mg and S contents of the growth medium after final harvest of chilli, mg kg^{-1}

Treatments	N	P	K	Ca	Mg	S
Frequency	mg kg^{-1}					
P1	167.53	11.02	158.51	310	103	10.59
P2	162.37	11.64	164.24	186	112	11.89
SE	15.47	0.122	0.211	133	1.66	0.604
CD (0.05)	NS	0.256	0.442	NS	3.48	1.27
Levels of NPK						
F1	156.10	10.72	134.37	172	100	10.01
F2	170.80	11.35	162.59	382	106	11.12
F3	167.96	11.93	187.16	190	116	12.59
SE	18.95	0.149	0.258	163	2.027	0.74
CD (0.05)	NS	0.314	0.542	NS	4.26	1.55
Interaction						
P1F1	141.40	10.07	130.69	168	98	9.22
P1F2	163.80	11.157	160.13	576	102	10.49
P1F3	197.40	11.84	184.70	186	111	12.07
P2F1	170.80	11.36	138.05	176	103	10.80
P2F2	177.80	11.55	165.06	187	111	11.75
P2F3	138.52	12.02	189.62	195	121	13.21
SE	26.80	0.211	0.365	231	2.87	1.05
CD (0.05)	NS	NS	NS	NS	NS	NS

levels of NPK and frequency of application, and their interaction effects were not statistically significant in this case.

Available Mg content of the medium also showed a drastic decrease towards the end of the crop from that at the time of planting (Table 26). It was significantly influenced only by the individual effects of different levels of NPK and frequency of application. Their interaction effect was not significant. It also followed the same trend as that of P and K showing highest values for F3 (NPK @125%) and P2 (biweekly application). The lowest values were noticed for F1 (NPK @75% POP and P1 (weekly application).

Available S content of the medium showed a very steep decrease towards the end of the crop from that at the time of planting (Table 26). It was significantly influenced only by the individual effects of different levels of NPK and frequency of application. Their interaction effect was not significant. Here also, the highest values were recorded by F3 (NPK @125%) and P2 (biweekly application) as in the case of available Mg and were significantly superior to others. The lowest values were noticed for F1 (NPK @75% POP and P1 (weekly application).

4.1.5.4 Available iron, manganese, zinc, copper and boron

The available Fe, Mn, Zn, Cu and B contents of the growth medium after final harvest are presented in Table 27. It was observed that all the above nutrients showed a decrease in their contents of the growth medium toward the end of the crop from that at the time of planting (Table 24). The decrease was much higher for Fe and least for B.

The Fe content of the growth medium also followed the same trend as that of available P and K, where only the individual effects of different levels of NPK and frequency of application were significant and not their interaction effect. Among the individual effects of levels of NPK and frequency of application, the highest values

Table 27. Effect of treatments on available Fe, Mn, Zn, Cu and B contents of the growth medium after final harvest of chilli (mg kg^{-1})

Treatments	Fe	Mn	Zn	Cu	B
Frequency	mg kg^{-1}				
P1	29.89	27.52	8.96	0.358	1.34
P2	34.36	29.53	9.48	0.396	1.42
SE	0.657	0.129	0.15	0.004	0.034
CD (0.05)	1.38	0.271	0.31	0.009	NS
Levels of NPK					
F1	28.83	27.19	8.77	0.342	1.33
F2	29.35	28.81	9.06	0.373	1.35
F3	38.20	29.58	9.82	0.418	1.47
SE	0.804	0.158	0.181	0.005	0.041
CD (0.05)	1.69	0.332	0.380	0.011	NS
Interaction					
P1F1	25.99	26.12	8.54	0.322	1.25
P1F2	26.28	27.91	8.65	0.342	1.26
P1F3	37.4	28.53	9.70	0.411	1.51
P2F1	31.67	28.26	9.00	0.361	1.40
P2F2	32.42	29.71	9.48	0.403	1.44
P2F3	39.00	30.62	9.95	0.424	1.43
SE	1.14	0.224	0.256	0.007	0.058
CD (0.05)	NS	NS	NS	NS	NS

were recorded by F3 (NPK @125 % POP) and P2 (biweekly application) respectively. The lowest values were recorded by F1 (NPK @75 % POP) and P1 (weekly application).

The concentration of available Mn, Zn and Cu of the growth medium after final harvest followed the same trend as that of available Fe where only the individual effects of different levels of NPK and frequency of application were significant and not their interaction effects. Among the individual effects of levels of NPK and frequency of application, the highest values were recorded by F3 (NPK @125 % POP) and P2 (biweekly application) respectively for available Mn, Zn and Cu. The lowest values were recorded by F1 (NPK @75 % POP) and P1 (weekly application) respectively. With regard to available B, both the levels of NPK and frequency of application, and their interaction were not significant.

4.1.6 Effect of treatments on nutrient composition of chilli shoot

4.1.6.1 Nitrogen, phosphorous, and potassium

The data on N, P and K contents of chilli shoot are presented in the Table 28.

The statistical analysis revealed that the individual effects as well as interaction effects of levels of NPK and frequency of application had significantly influenced the N content of shoot. Among the individual effects, F2 (NPK @100% POP) and P1 (weekly application), and their interaction P1F2 (weekly application of NPK @100% POP) showed the highest values which were significantly superior to all others. The lowest values were recorded by F3 (NPK @125% POP) and P2 (biweekly application), and P2F3 (biweekly application of NPK @125% POP) respectively.

In the case of P, only the individual effects of levels of NPK and frequency of application showed significant influence and the interaction effect was not significant. The highest values were recorded by F2 (NPK @100 % POP) and P1 (weekly application). The lowest values were recorded by F3 (NPK @125 % POP) and P2 (biweekly application).

The K content of shoot followed the same trend as that of N with treatments F2 (NPK @100% POP) and P1 (weekly application), and their interaction P1F2 (weekly application of NPK @100% POP) showing the highest values and the lowest by F3 (NPK @125% POP) and P2 (biweekly application), and P2F3 (biweekly application of NPK @125% POP) respectively.

4.1.6.2 Calcium, magnesium and sulphur contents of chilli shoot

The data regarding Ca, Mg and S contents of chilli shoot are presented in the Table 28.

The Ca content of shoot followed the same trend as that of P showing significant effect only for the individual effects of levels of NPK and frequency of application. The highest values were recorded by F2 (NPK @100 % POP) and P1 (weekly application). The lowest values were recorded by F3 (NPK @125 % POP) and P2 (biweekly application).

The Mg and S contents of shoot followed the same trend as that of N and K with treatments F2 (NPK @100% POP) and P1 (weekly application), and their interaction P1F2 (weekly application of NPK @100% POP) showing the highest values and were significantly superior to others. The lowest values were recorded by F3 (NPK @125% POP) and P2 (biweekly application), and P2F3 (biweekly application of NPK @125% POP) respectively.

Table 28. Effect of treatments on N, P, K, Ca, Mg and S contents of chilli shoot, %

Treatments	N	P	K	Ca	Mg	S
Frequency			%			
P1	4.30	0.356	7.92	1.06	0.834	1.01
P2	3.98	0.311	6.70	0.931	0.778	0.723
SE	0.019	0.002	0.046	0.003	0.002	0.004
CD (0.05)	0.041	0.004	0.097	0.007	0.004	0.009
Levels of NPK						
F1	4.08	0.322	7.15	0.951	0.779	0.799
F2	4.56	0.382	8.81	1.16	0.888	1.21
F3	3.79	0.297	5.98	0.871	0.749	0.595
SE	0.024	0.002	0.056	0.004	0.003	0.005
CD (0.05)	0.05	0.005	0.118	0.009	0.005	0.011
Interaction						
P1F1	4.24	0.339	8.15	1.01	0.798	0.864
P1F2	4.63	0.409	9.15	1.23	0.918	1.43
P1F3	4.04	0.319	6.48	0.93	0.786	0.738
P2F1	3.93	0.305	6.15	0.89	0.762	0.736
P2F2	4.49	0.354	8.48	1.09	0.858	0.983
P2F3	3.54	0.275	5.48	0.811	0.714	0.451
SE	0.034	0.003	0.078	0.006	0.004	0.007
CD (0.05)	0.071	NS	0.167	NS	0.007	0.016

4.1.6.3 Iron, manganese, zinc, copper and boron

The data on concentration of Fe, Mn, Zn, Cu and B contents of chilli shoot are presented in the Table 29. Treatment effects were significantly influenced for all the above nutrients.

With regard to the Fe and Mn contents of shoot, they were significantly influenced by individual as well as interaction effects of the levels of NPK and frequency of application. Among the individual effects, F2 (NPK @100% POP) and P1 (weekly application), and their interaction P1F2 (weekly application of NPK @100% POP) showed the highest values which were significantly superior to all others. The lowest values were recorded by F3 (NPK @125% POP) and P2 (biweekly application), and P2F3 (biweekly application of NPK @125% POP) respectively. In the case of Mn content of shoot the treatment combination P2F1 (biweekly application of NPK @75 % POP) which was found to be on par with P2F3 (biweekly application of NPK @125 % POP).

Zn content was significantly influenced by the individual effect of levels of NPK only. The individual effect of frequency of application and interaction effect were not significant. The highest value was noticed for F2 (NPK @ 100 % POP) and the lowest for F3 (NPK @125 % POP).

Statistical analysis of data revealed that the Cu content was not significantly influenced by neither the individual nor the interaction effects of levels of NPK nor frequency of application and their interaction effect.

B content of shoot followed the same trend as that of P and Ca showing significant effect only for the individual effects of levels of NPK and frequency of application. The highest values were recorded by F2 (NPK @100 % POP) and P1 (weekly application). The lowest values were recorded by F3 (NPK @125 % POP) and P2 (biweekly application).

Table 29. Effect of treatments on Fe, Mn, Zn, Cu and B contents of chilli shoot, mg kg^{-1}

Treatments	Fe	Mn	Zn	Cu	B
Periods	mg kg^{-1}				
P1	463.83	56.14	147.22	11.02	31.99
P2	434.82	52.41	141.88	10.35	29.73
SE	1.63	0.270	1.54	0.278	0.14
CD(0.05)	3.42	0.566	NS	NS	0.294
NPK levels					
F1	446.70	52.48	144.55	10.45	30.44
F2	484.60	58.77	150.15	11.55	33.32
F3	416.70	51.57	138.95	10.05	28.83
SE	1.99	0.330	1.88	0.34	0.171
CD(0.05)	4.19	0.694	3.96	NS	0.36
Interaction					
P1F1	472.30	55.27	145.55	10.75	31.91
P1F2	493.70	59.28	152.15	11.95	34.09
P1F3	425.50	53.87	143.95	10.35	29.99
P2F1	421.10	49.68	143.55	10.15	28.96
P2F2	475.50	58.26	148.15	11.15	32.55
P2F3	407.90	49.27	133.95	9.75	27.68
SE	2.82	0.467	2.66	0.481	0.242
CD(0.05)	5.93	0.981	NS	NS	NS

4.1.7 Effect of treatments on nutrient composition of chilli fruit

4.1.7.1 Nitrogen, phosphorous and potassium

The data on concentration of N, P and K contents of chilli fruit are presented in Table 30.

The statistical analysis of data revealed that contents of N, P and K of fruit were significantly influenced by the individual as well as interaction effects of levels of NPK and frequency of application. For all the three nutrients, among the individual effects, F2 (NPK @100% POP) and P1 (weekly application), and their interaction P1F2 (weekly application of NPK @100% POP) recorded the highest values which were significantly superior to all others. The lowest values were recorded by F3 (NPK @125% POP) and P2 (biweekly application), and P2F3 (biweekly application of NPK @125% POP) respectively.

4.1.7.2 Effect of treatments on calcium, magnesium and sulphur contents of chilli fruit

The data on Ca, Mg and S contents of chilli fruit are presented in Table 30. The statistical analysis of data revealed that contents of Ca, Mg and S of fruit were significantly influenced only by the individual effects of levels of NPK and frequency of application and their interaction effects were not significant. The highest values were recorded by the levels, F2 (NPK @100 % POP) and P1 (weekly application) and the lowest values were recorded by the levels, F3 (NPK @125% POP) and P2 (biweekly application) for Ca, Mg and S contents of fruit.

Table 30. Effect of treatments on N, P, K, Ca, Mg and S contents of chilli fruit, %

Treatments	N	P	K	Ca	Mg	S
Frequency			%			
P1	3.41	0.509	6.066	0.538	0.372	0.14
P2	3.20	0.458	5.30	0.457	0.358	0.129
SE	0.016	0.005	0.017	0.007	0.002	0.001
CD (0.05)	0.034	0.01	0.035	0.015	0.004	0.0014
Levels of NPK						
F1	3.28	0.475	5.52	0.478	0.369	0.134
F2	3.48	0.532	6.48	0.598	0.384	0.141
F3	3.16	0.443	5.04	0.418	0.342	0.127
SE	0.019	0.006	0.021	0.008	0.002	0.0008
CD (0.05)	0.041	0.012	0.043	0.018	0.005	0.002
Interaction						
P1F1	3.38	0.508	6.20	0.538	0.372	0.139
P1F2	3.52	0.539	6.58	0.618	0.39	0.146
P1F3	3.32	0.485	5.43	0.457	0.354	0.134
P2F1	3.18	0.447	4.85	0.418	0.366	0.129
P2F2	3.44	0.524	6.39	0.577	0.378	0.136
P2F3	2.99	0.402	4.66	0.378	0.330	0.121
SE	0.028	0.008	0.029	0.012	0.003	0.001
CD (0.05)	0.058	0.017	0.061	NS	NS	NS

4.1.7.3 Effect of treatments on iron, manganese, zinc, copper and boron contents of chilli fruit

The statistically analyzed data regarding effects of treatments on micronutrients viz. Fe, Mn, Zn, Cu and B are depicted in the Table 31.

With regard to the Fe, Mn, Cu and B contents of fruit, they were significantly influenced only by the individual effects of the levels of NPK and frequency of application. Among the individual effects, F2 (NPK @100% POP) and P1 (weekly application) showed the highest values which were significantly superior to all others. The lowest values were recorded by F3 (NPK @125% POP) and P2 (biweekly application).

With regard to the Zn content of fruit, it was significantly influenced by the individual as well as interaction effects of the levels of NPK and frequency of application. Among the individual effects, F2 (NPK @100% POP) and P1 (weekly application), and their interaction P1F2 (weekly application of NPK @100% POP) showed the highest values which were significantly superior to all others. The lowest values were recorded by F3 (NPK @125% POP) and P2 (biweekly application), and P2F3 (biweekly application of NPK @125% POP) respectively.

4.1.7.4 Effect of treatments on capsaicin content of chilli fruit

Details regarding the capsaicin content of fruits were given in the Table 32.

Perusal of the data revealed that the individual effect of levels of N, P, K alone showed significant influence on capsaicin content of chilli. The period of application and interaction effects were not significantly influenced. With respect to the levels of NPK, the highest value was recorded by F2 (NPK @100 % POP) and lowest was recorded by F3 (NPK @125 % POP) which was on par with F1 (NPK @75 % POP).

Table 31. Effect of treatments on Fe, Mn, Zn, Cu and B contents of chilli fruit, mg kg^{-1}

Treatments	Fe	Mn	Zn	Cu	B
Periods	mg kg^{-1}				
P1	163.75	27.99	41.18	9.78	28.81
P2	155.58	26.03	36.71	8.93	27.79
SE	0.907	0.108	0.361	0.149	0.106
CD (0.05)	1.91	0.227	0.759	0.313	0.222
NPK levels					
F1	155.30	26.07	37.43	8.90	27.66
F2	171.50	30.72	44.58	10.75	29.9
F3	152.20	24.27	34.83	8.43	27.34
SE	1.11	0.132	0.442	0.182	0.129
CD (0.05)	2.33	0.278	0.929	0.383	0.272
Interaction					
P1F1	157.65	27.07	40.08	9.35	28.044
P1F2	175.35	31.37	47.98	11.15	30.74
P1F3	158.25	25.56	35.47	8.85	27.66
P2F1	152.95	25.06	34.77	8.45	27.28
P2F2	167.65	30.07	41.17	10.35	29.07
P2F3	146.15	22.96	34.18	8.00	27.02
SE	1.57	0.187	0.626	0.258	0.183
CD (0.05)	NS	NS	1.31	NS	NS

4.1.8 Scoring of pest and diseases

Table 33. depicted the details regarding the scoring for pest and diseases. No incidence of disease was recorded. With regard to the pests, mite attack was noticed. 25 per cent of the plants were infested by mites. Effective control measures were taken to manage it. Spraying of new generation pesticide Oberon @ 0.8ml L^{-1} at weekly intervals was done. After pesticide application recovery of plants were recorded and it was of about 100 per cent.

4.1.9 Economic analysis

Details regarding the economic analysis are presented in the Table 34. It was revealed that the individual as well as their interaction effects of levels of NPK and frequency of application had significantly influenced the B:C ratio. Among the individual effect of levels of NPK, the highest value was recorded by the F2 (NPK @100% POP) and for frequency of application and their interaction effect P1F2 (weekly application of NPK @100 % POP). P2 (biweekly application), F3 (125 %) and their interaction P2F3 (biweekly application 125 % POP) recorded the lowest values respectively.

Table 32. Effect of treatments on capsaicin content of chilli fruit, %

Treatments	Capsaicin (%)
Frequency	
P1	0.778
P2	0.773
SE	0.002
CD (0.05)	NS
Levels of NPK	
F1	0.774
F2	0.782
F3	0.770
SE	0.002
CD (0.05)	0.004
Interaction	
P1F1	0.778
P1F2	0.783
P1F3	0.772
P2F1	0.770
P2F2	0.780
P2F3	0.768
SE	0.0027
CD (0.05)	NS

Table 33. Scoring for pest (chilli mites) in chilli

Treatments	Before application of pesticide	After application of pesticide
P1F1	1	0
P1F2	1	0
P1F3	1	0
P2F1	1	0
P2F2	1	0
P2F3	1	0

0 = No symptom **1** = 1-25 % of leaves or plant show curling

Table 34. Effect of treatments on B:C ratio

Treatments	B:C Ratio
Frequency	
P1	2.10
P2	2.01
SE	0.003
CD (0.05)	0.005
Levels of NPK	
F1	2.09
F2	2.16
F3	1.93
SE	0.003
CD (0.05)	0.007
Interaction	
P1F1	2.10
P1F2	2.26
P1F3	1.95
P2F1	2.08
P2F2	2.05
P2F3	1.91
SE	0.004
CD (0.05)	0.009

Discussion

5. DISCUSSION

An investigation entitled "Evaluation of thermochemical digest of degradable waste for container cultivation of chilli" was carried out at the Department of Soil Science and Agricultural Chemistry, College of Agriculture Vellayani, during 2014-2016. Two pot culture experiments were conducted to develop and standardize the plant growth medium based on thermochemical digest of degradable waste for container cultivation of chilli. It also aimed at standardization of the levels of N, P and K fertilizers for custom blending of thermochemical digest and frequency of application for yield maximization in chilli. The results of both experiments are discussed in this section.

EFFECT OF GROWTH MEDIUM COMPOSITION ON GROWTH CHARACTERISTICS AND FRUIT YIELD OF CHILLI

The growth characteristics viz., plant height at 30, 60 and 90 days after planting (DAP) and number of primary branches per plant were significantly influenced by the treatments (Table 7). For plant height, highest value was recorded by the treatment T3 receiving thermochemical digest, coir pith compost and soil in 1:2:1 ratio followed by the treatment T7 receiving thermochemical digest, cocopeat and soil in the same ratio. The number of primary branches was same for both the treatments. This had indicated that the crop prefers a ratio of 1:2:1 of the above components and among them coir pith was found to be significantly superior to cocopeat. The C:N ratio of coirpith compost was 12.5 and for cocopeat it was 18.9. Hence a C:N ratio near to that of ideal C:N ratio of soil might have promoted better growth rate for treatments receiving coirpith compost instead of cocopeat. This was true with all the treatments receiving coirpith compost instead of cocopeat (Table 7). The compost having a lower C:N ratio added to the potting media in appropriate quantities had significant positive effects on growth and flowering of marigold seedlings including plant biomass, plant height, number of buds and flowers (Gupta *et al.*, 2014).

In general the mineral nutrient contents and pH were higher for coirpith compost (Table 2) compared to cocopeat. At the same time the electrical conductivity was much lesser for it. This might have also facilitated a better growth rate for treatments receiving coirpith compost instead of cocopeat. The initial electrical conductivity of the growth medium was lesser for treatment T3 (2.92 dS m^{-1}) compared to treatment T7 (3.07 dS m^{-1}).

On comparing the different ratios for mixing thermochemical digest of degradable waste (TD) with other components of growth medium, it was observed that as the proportion of TD increases to two parts irrespective of total volume, a decrease in growth characters were noted. Those treatments have registered an electrical conductivity > 4 dS m^{-1} which is the critical limit for the effect of salinity on crop growth. Eynard *et al.* (2005) reported that when the electrical conductivity of the soil exceeds the critical threshold limit of 4 dS m^{-1}, the plant growth was very much retarded. Thus the treatments receiving TD and soil alone in 2:1 ratio which recorded highest electrical conductivity showed the poorest performance with regard to plant growth. Chauhan and Kumar (2014) reported that as the electrical conductivity of the medium increases, the growth and yield characters of the plant *Citronella java* were correspondingly decreased.

When it comes to shoot weight, root weight and total dry matter production, all were highest for the treatment T7 (TD1:CP2:S1) followed by the treatment T3 (TD1:CC2:S1) though the plant height was higher for treatment T3. The higher shoot weight for treatment T7 was due to the higher number of secondary branches/ more vegetative growth for it compared to T3 as evident from Plate. 5 However the ratio of 1:2:1 was found to be the best ratio with regard to plant growth and the ratio of 2:1

comprising only TD and soil was the worst. Treatment T10 (TD2:S1) showed the lowest value of 70.66 g plant^{-1}. Leno *et al.* (2016) reported that the plants which received the fortified manure produced from degradable waste by rapid conversion technology (FMRCT) exhibited significant difference in crop biometric characters and vine length of melon over the poultry manure and FYM applied plants.

On comparing the performance of different treatments, the fruit yield was highest for treatment T3 (690.08 g plant^{-1}) (Fig:1) receiving thermochemical digest, coir pith compost and soil in 1:2:1 ratio followed by the treatment T7 receiving thermochemical digest, cocopeat and soil in the same ratio while the dry matter production showed a reverse trend. The increase in fruit yield for treatment T3 could not overcome the increase in shoot weight and root weight attained by treatment T7. The data on availability of major nutrients in the growth medium (Table 11 and Figs. 4 to 9) and their concentration in shoot and fruit supports the above result. The impact of a comparatively lower C:N ratio of coirpith compost (12.5) compared to cocopeat (18.95) also might have favorably influenced the partitioning of vegetative biomass to reproductive biomass and had resulted a comparatively higher fruit yield for treatment T3. The application of fortified manure based on thermochemical digest of waste to the crop showed a significant increase in fruit yield of chilli, tomato and brinjal (Sudharmaidevi *et al,* 2015). Leno *et al.* (2016) also reported that fortified manure produced from degradable waste by rapid conversion technology (FMRCT) applied to melon recorded an yield increase of 63 and 125 per cent over poultry manure and FYM respectively and this has been attributed to the supply of almost all essential major, secondary and micronutrient by the fortified organic manure.

The lowest fruit yield was registered by the treatment T10 (TD2:S1) showing a fruit yield of 297.59 g plant^{-1} clearly indicating that the higher quantities of TD ie., more than 50 percent of the medium is not good for crop production since the treatment T9 receiving TD and soil in 1:1 proportion had showed third highest fruit yield. However, treatment T10 was statistically on par with the treatment T11 (Soil : Sand: FYM in 2:1:1) the normal practice followed by farmers. Thus the use of TD is much better to normal practice of farmers (T11) when it is incorporated in the growth medium at a rate less than 50 per cent.

The yield characteristics such as fruit length, fruit girth and number of fruits per plant also followed the same trend as that of fruit yield which is actually a reflection of all those yield attributing characters. Thus the ratio of 1:2:1 was found to be the best ratio with regard to fruit yield either 2 parts of coirpith compost or cocopeat was used in the medium. However the coipith compost showed the best performance followed by cocopeat with growth medium components viz., thermochemical digest, coirpith compost/cocopeat and soil in 1:2:1 ratio. The growth as well as fruit yield was lowest for the ratio of 2:1 of thermochemcial digest and soil resulting the poorest performance.

EFFECT OF THE COMPOSITION OF GROWTH MEDIUM ON pH AND NUTRIENT AVAILABILITY TO CHILLI

The pH, electrical conductivity and organic carbon content of medium at the time of planting was significantly influenced by the composition of the growth medium and highest values for all the above parameters were recorded by the treatment T10 (TD2:S1) which was significantly superior to all other treatments. The hike in pH, electrical conductivity and organic carbon content was mainly due to the high proportion of TD (66.6 %) in the growth medium, whose pH, electrical conductivity and organic carbon content were very high compared to other components (Table 10). The lowest value was noticed for the treatment T11 (S2:SS1:F1) the normal practice followed by farmers, where the components are having lowest pH and highest C:N ratio (C:N ratio of FYM -29.9). But after final harvest, all the treatments except T11 were statistically on par and treatment T11 (S2:SS1:F1) recorded the lowest pH since all of its growth medium components are having an acidic pH. The organic carbon content by the end of the crop was also lowest for the treatment T11 (S2:SS1:F1). The FYM which had the widest C:N ratio among the growth medium components, might have decomposed almost completely resulting a low organic carbon content.

The availability of major nutrients were significantly influenced by the growth media composition and highest values for available N, P, K, Ca, Mg and S were recorded by the treatment T10 (TD2:S1). The high proportion of TD which had been fortified with major nutrients and that too in soluble form resulted in higher availability of those nutrients. With the increase in the amount of TD in the growth medium, the available nutrient contents also increased. This was very evident in the case of available K, since the entire K present in the TD was in soluble form, naturally it had resulted very high values for available K in the medium. The same is in the case with S, Zn and B. Though the nutrient concentrations in the media at the time of planting were high, the plants did not show any toxicity symptoms. But the end of the crop, the values of available nutrients had come down. This might be due to the crop uptake or adsorption of nutrients on the charcoal added to the TD (30 g kg^{-1}) and due to the loss through the drained out water after irrigation. Lehmann *et al.* (2003) reported that the addition of charcoal to the growth medium has a good ability to adsorb nutrients. Johnes and Schwab (1993) reported that most of the nutrients accumulated in the root zone leached through the drained water after irrigation and therefore not drawn to the soil particles. Similarly the treatment T11 which was not fortified with any nutrients showed the lowest values for the above nutrients. On analyzing the availability of major nutrients after final harvest, it was observed that the treatment T10 maintained highest content of all the major nutrients. Two reasons can be attributed to this. One is the higher nutrient content in TD which contribute 66.6 per cent of growth medium of treatment T10 (Table 12) as well as the lesser removal of nutrients by the crop due to low nutrient content within plant parts and dry matter production. Leno *et al.* (2016) reported that the fortified organic manure produced by rapid conversion technology contains almost all plant essential macro and micro nutrients.

For all the micronutrients except Fe and B, the availability at the time of planting was highest for treatment T10. The highest Mn, Cu, Zn and B content for treatment T10 is definitely due to higher content of TD which is having higher content of above nutrients in the medium. Treatment T4 which received thermochemical digest, coirpith compost and soil in 2:2:1 ratio recorded the highest values for Fe and B. Higher proportion of coirpith compost having higher contents of Fe and B compared to TD and cocopeat might have enhanced their concentration. The lowest values for all except Fe were recorded by the treatment T11, the treatment consist of components with low nutrient value. After final harvest, the micronutrients also followed the same trend as that of macronutrients showing highest content for treatment T10, definitely due to lower nutrient removal by crop (Figs. 4 to 14).

EFFECT OF GROWTH MEDIUM COMPOSITION ON NUTRIENT CONCENTRATION OF CHILLI SHOOT

The growth medium composition had significantly influenced the N, P, K, Ca, Mg and S concentration of chilli shoot. The highest values were recorded by the treatment T3 receiving thermochemical digest, coirpith compost and soil in 1:2:1 ratio followed by the treatment T7 receiving the same in same ratio with cocopeat instead of coirpith compost. The nutrient concentration was more for treatment T3 compared to treatment T7 which recorded highest shoot weight, root weight and total dry matter production. The higher biomass of T7 might have resulted a lower content of nutrient in plant parts due to the dilution effect.

The treatment T11 receiving soil, sand and FYM in ratio 2:1:1 recorded the lowest values for major nutrients since the amount of available nutrients present in that treatment was comparatively low compared to other treatments (Figs. 4 to 9).

Though the available nutrient contents were highest for treatment T10, the high value of electrical conductivity (5.85 dS m^{-1}) might have adversely affected the nutrient absorption by plant roots in initial stages of plant growth. More over the growth was also very poor for treatment T10 recording the lowest values for shoot weight, root weight and root volume.

With regard to the micronutrients, only Zn and B followed the same trend as that of macronutrients. The attributed reason is that the thermochemical digest (TD) was fortified with Zn and B and because of that the similar behavior was noticed. In the case of other micronutrients (Fe, Mn and Cu) a definite trend was not observed.

EFFECT OF GROWTH MEDIUM COMPOSITION ON NUTRIENT CONCENTRATION OF CHILLI FRUIT

The growth medium composition had significantly influenced the N, P, K, Ca, Mg and S concentration of chilli fruit. As in the case of chilli shoot, the highest values were recorded by the treatment T3 receiving thermochemical digest, coirpith compost and soil in 1:2:1 ratio followed by the treatment T7 with same growth media components except coirpith compost but with cocopeat, in the same ratio. The nutrient removal/uptake was also highest for treatment T3. The growth medium conditions persisted in treatment T3 (Table 11 to 14) might have facilitated better nutrient absorption and better translocation of photosynthates and nutrients to fruits. The treatment T7 had 19.2 per cent higher biomass (shoot + root) over the treatment T3 and much of the nutrients taken by it might have been utilized for production of vegetative biomass. Here also the treatment T11 receiving soil, sand and FYM in ratio 2:1:1 recorded the lowest values. This was definitely due to low nutrient status of the growing medium which had resulted lower nutrient removal by plant roots and consequent growth. Though the available nutrient contents were highest for treatment T10, the high value of electrical conductivity during initial stages of crop

Fig. 3 Effect of treatments on fruit yield of chilli (g $plant^{-1}$)

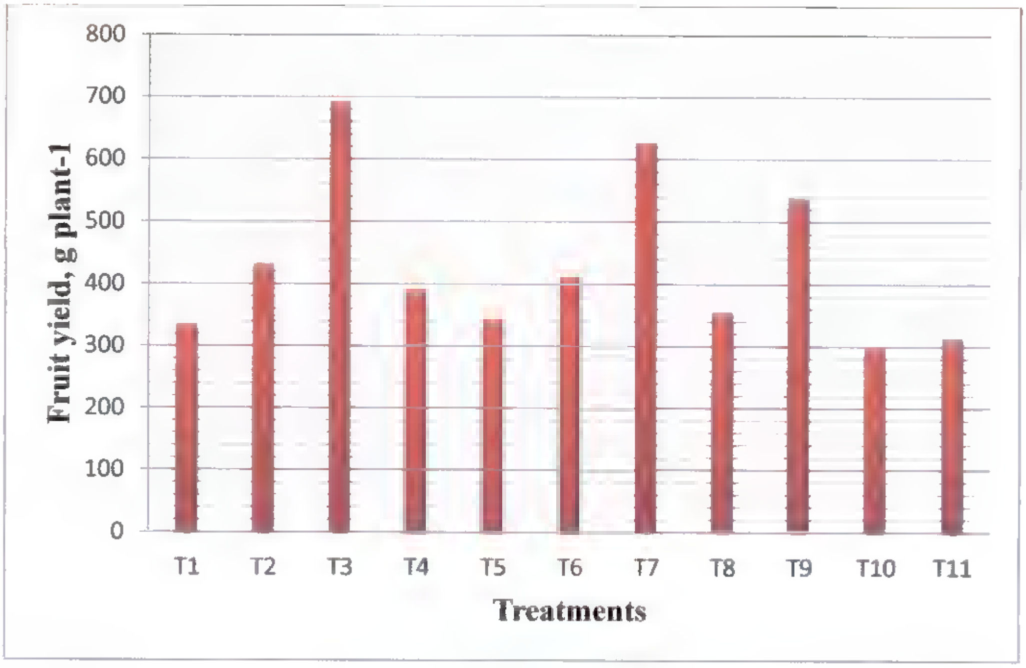


Fig. 4 Effect of treatments on N uptake by chilli (g $plant^{-1}$)

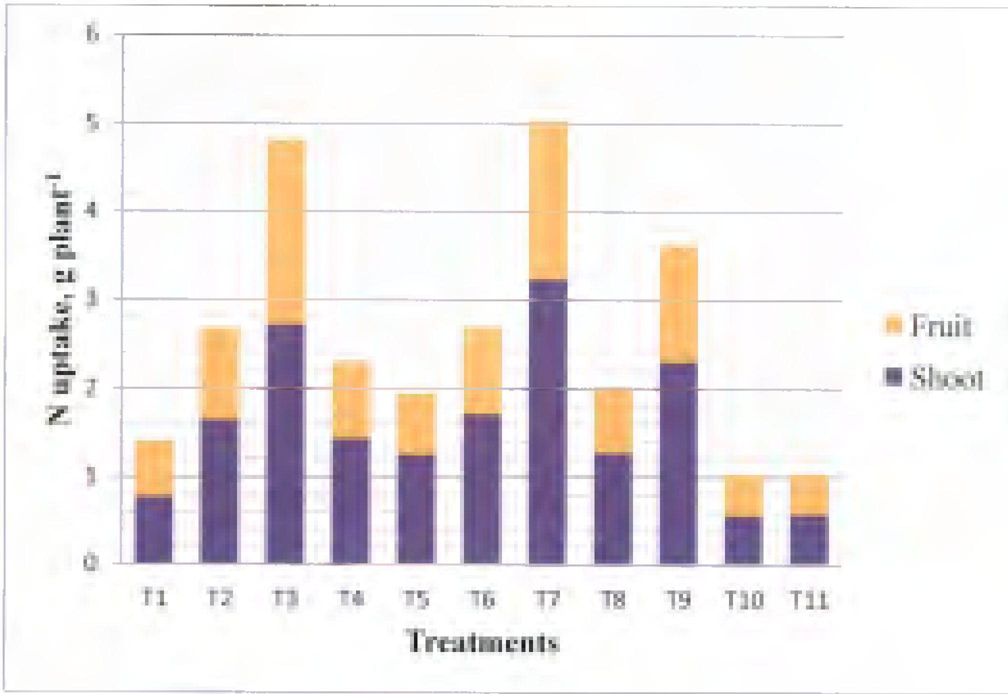


Fig. 5 Effect of treatments on P uptake by chilli (g plant^{-1})

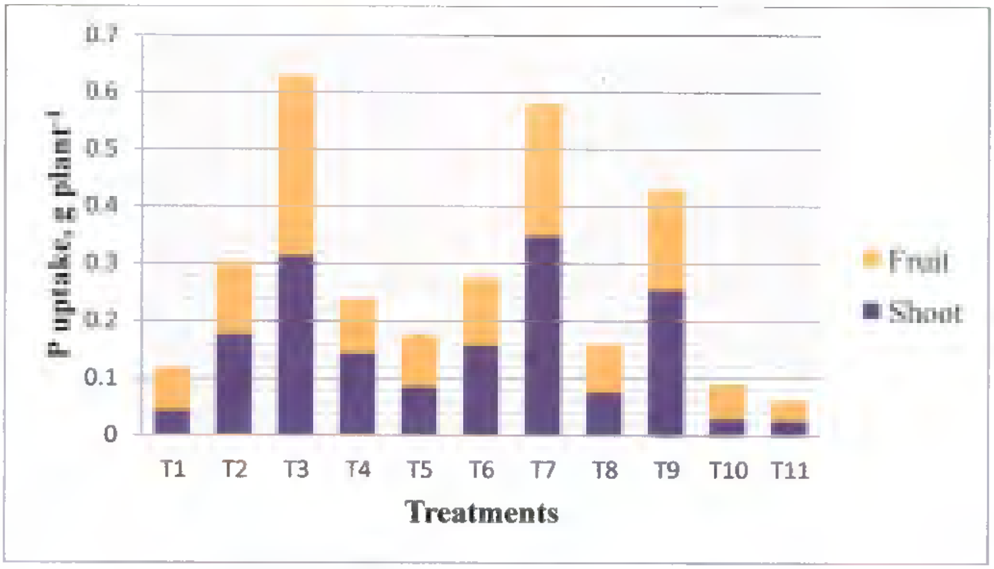


Fig. 6 Effect of treatments on K uptake by chilli (g plant^{-1})

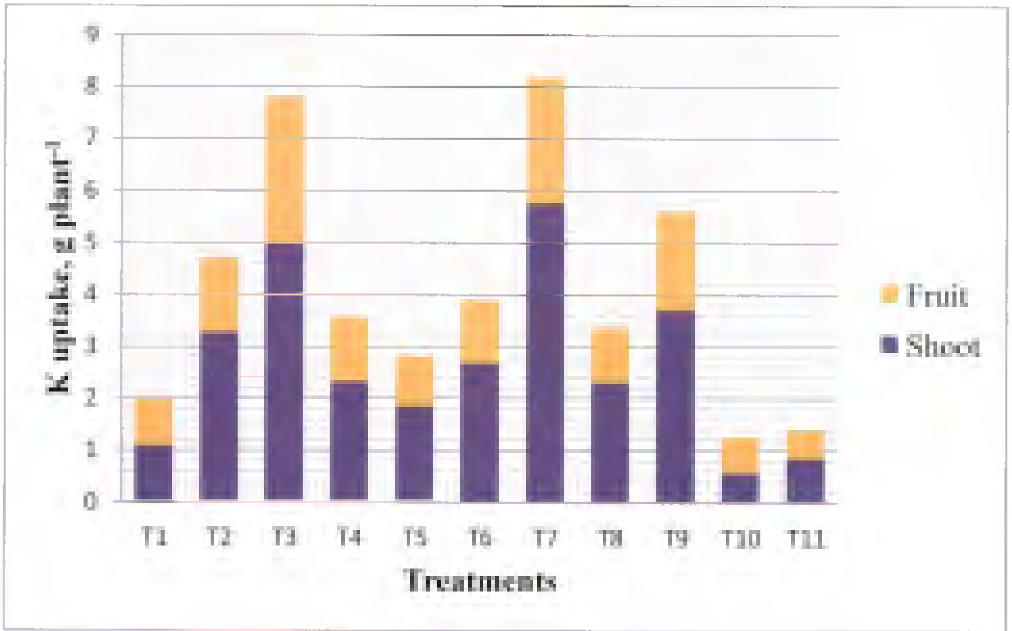


Fig. 7 Effect of treatments on Ca uptake by chilli (g $plant^{-1}$)

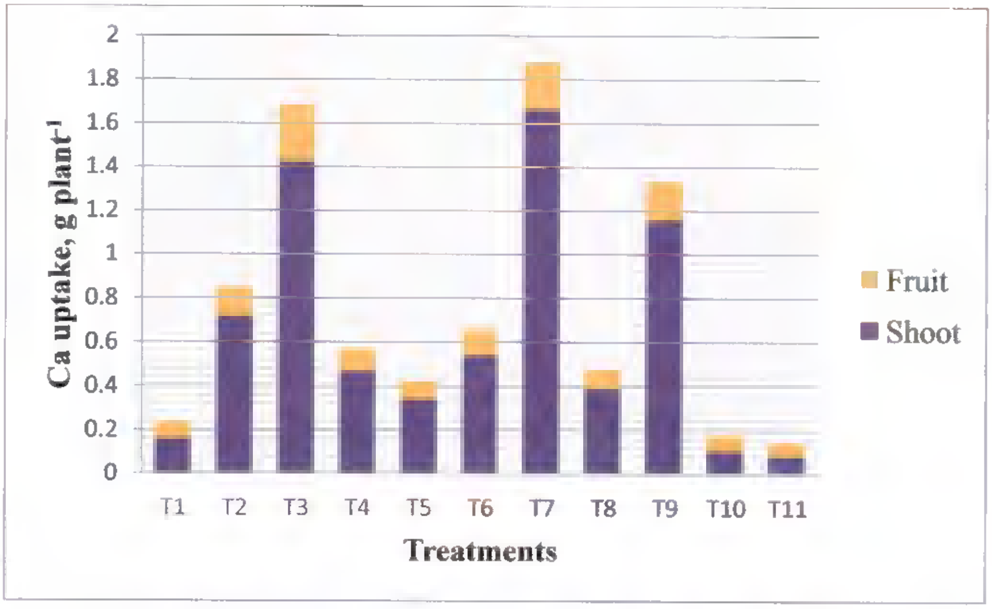


Fig. 8 Effect of treatments on Mg uptake by chilli (g $plant^{-1}$)

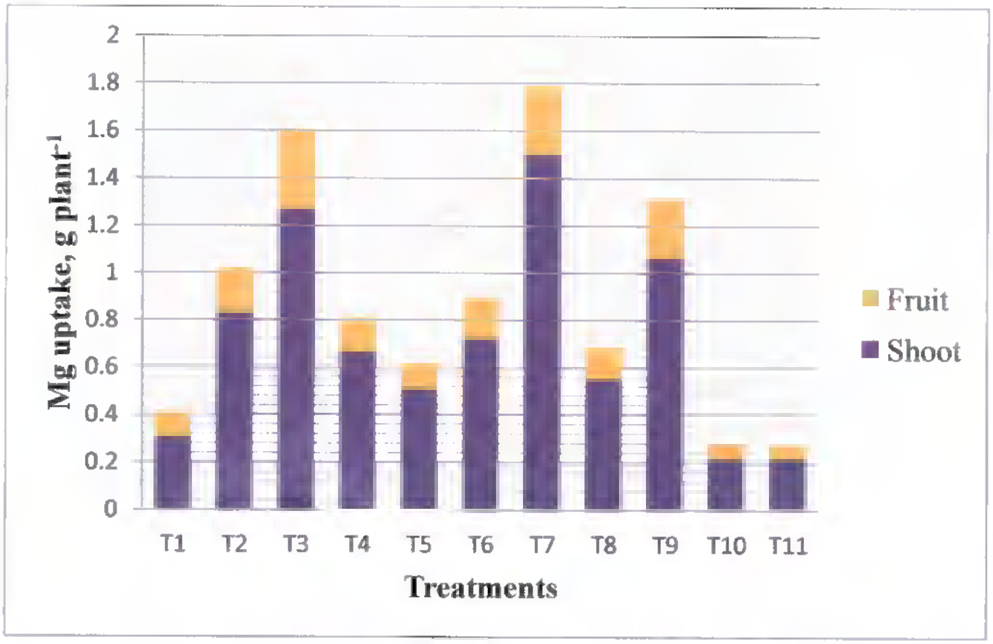


Fig.9 Effect of treatments on S uptake by chilli (g plant^{-1})

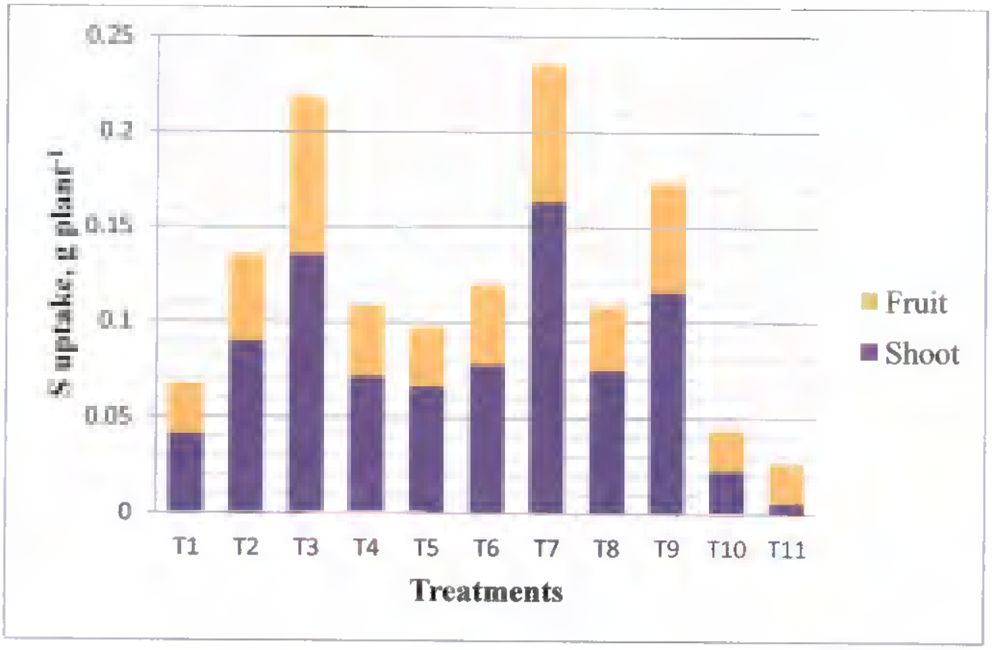


Fig.10 Effect of treatments on Fe uptake by chilli (mg plant^{-1})

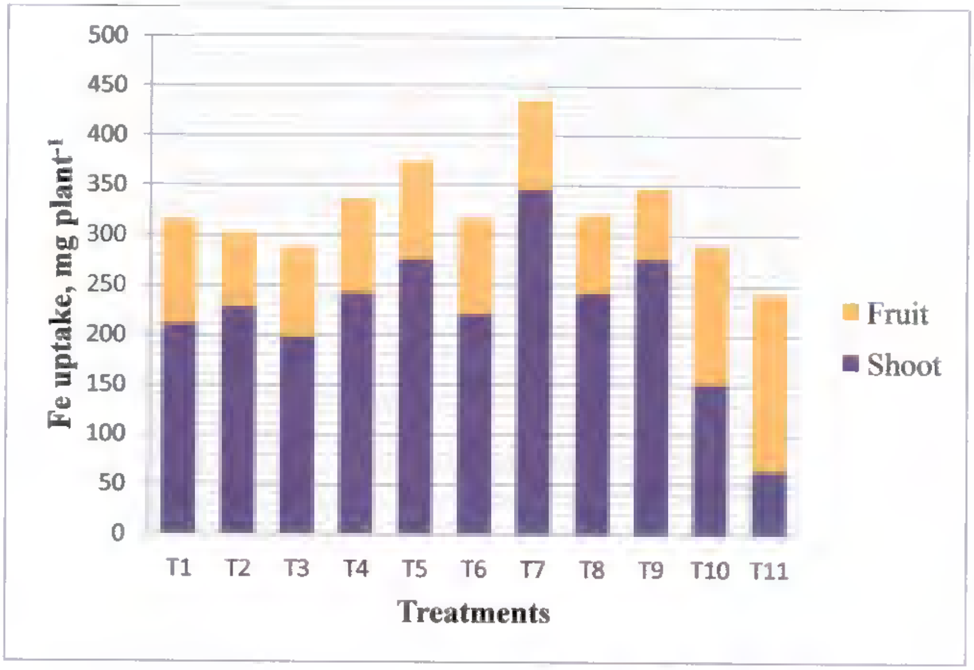


Fig. 11 Effect of treatments on Mn uptake by chilli (mg plant^{-1})

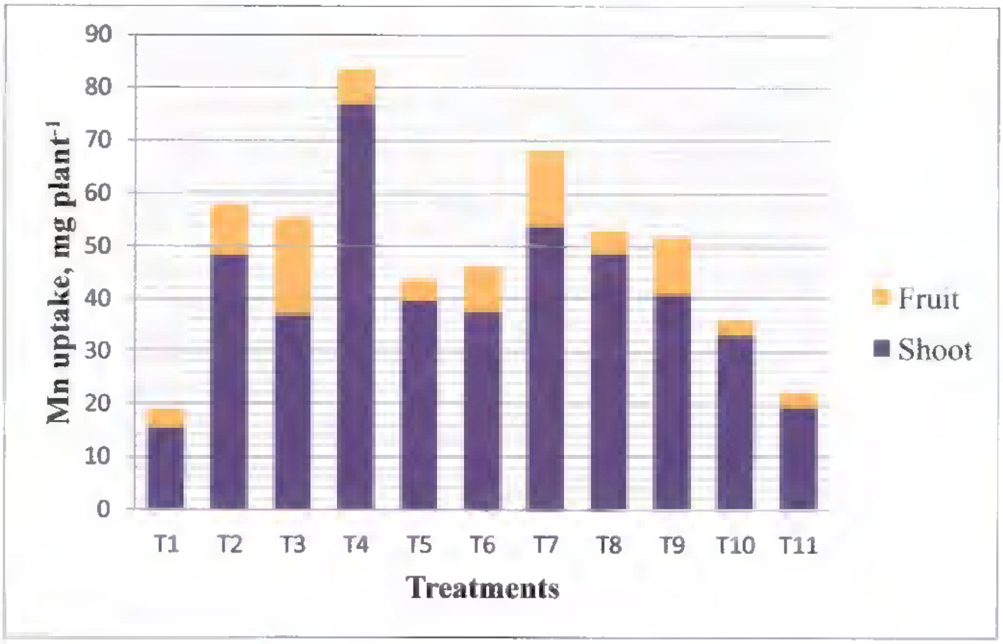


Fig.12 Effect of treatments on Zn uptake by chilli (mg plant^{-1})

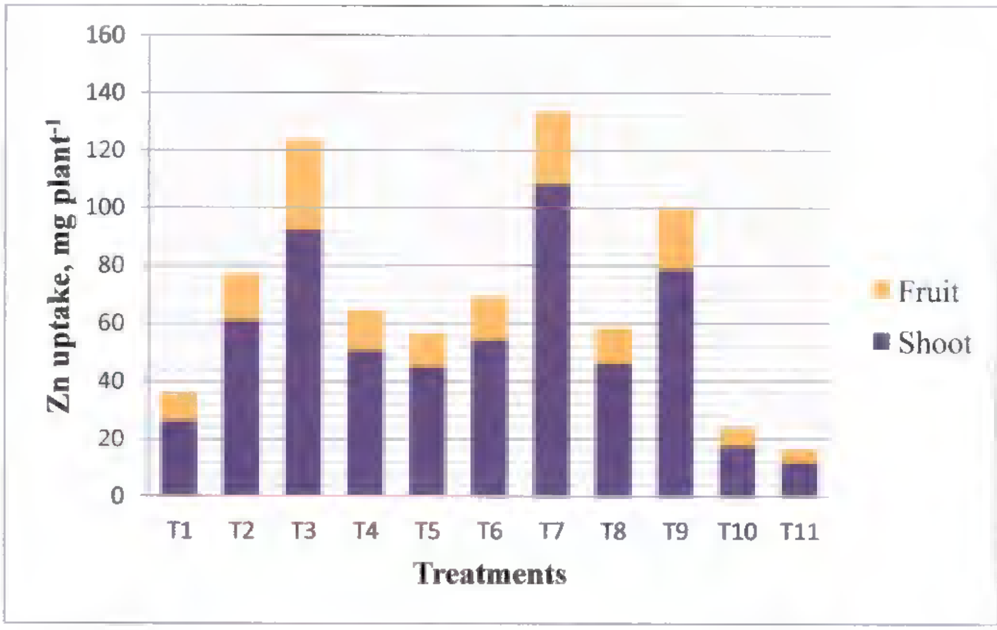


Fig. 13 Effect of treatments on Cu uptake by chilli (mg plant^{-1})

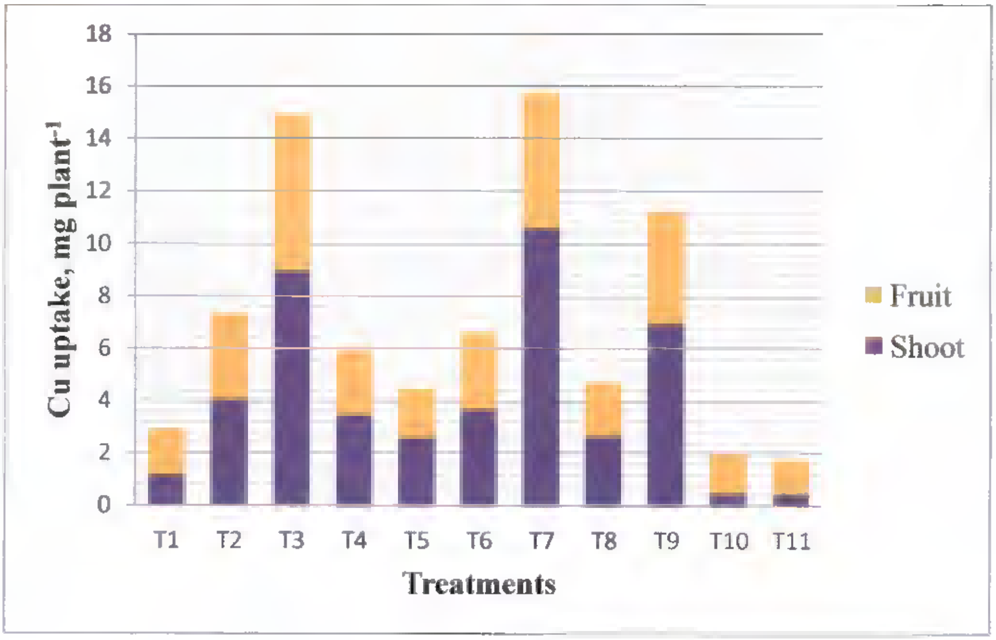
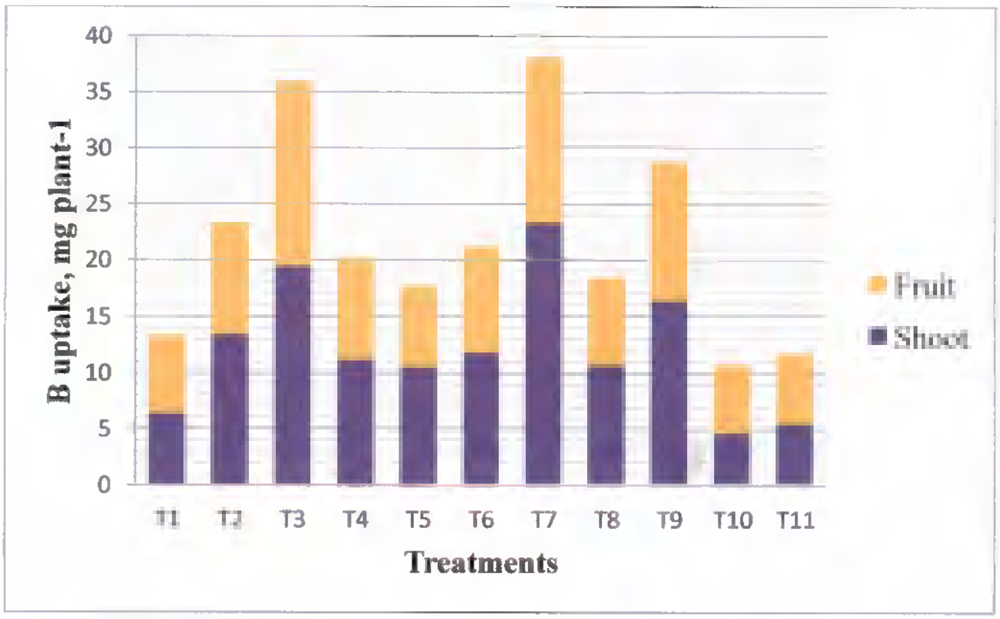


Fig.14 Effect of treatments on B uptake by chilli (mg plant^{-1})



growth (Table 10) might have adversely affected the nutrient absorption by plant roots. More over the growth was also very poor for treatment T10.

With regard to the micronutrients, Mn, Zn, Cu and B followed the same trend as that of macronutrients. The attributed reasons for their higher contents are the higher nutrient availability under treatment T3 compared to treatment T7 and the higher contents of Mn, Zn, Cu and B for coirpith compost compared to cocopeat. But the behavior of Fe was quite different where the highest Fe content in fruit was showed by treatment T11 which was on par with treatment T10. The lowest value for Fe was noted for the treatment T9 which was again on par with treatment T3. When it comes to Fe, the data on initial and final status in the growth medium revealed that FYM is having the highest Fe content and the acidic pH of the medium might have facilitated a higher availability and plant absorption.

EFFECT OF GROWTH MEDIUM COMPOSITION ON CAPSAICIN CONTENT AND GENERAL PERFORMANCE OF CHILLI

The capsaicin content of chilli also followed the same trend as that of major nutrients. The better nutrient absorption might have improved the quality parameters like capsaicin content resulting the treatment T3 showing the highest value followed by treatments T7 and T9. The B:C ratio also followed the same trend.

Thus with regards to the composition of growth medium, the ratio of one part thermochemical digest, 2 parts coirpith compost and one part soil was found to be the best with regard to fruit yield of chilli and B:C ratio. Hence it was selected as the growth medium for the second part of the study.

EFFECT OF LEVELS OF FERTILISERS FOR CUSTOM BLENDING OF THERMOCHEMICAL DIGEST AND FREQUENCY OF APPLICATION ON GROWTH AND YIELD CHARACTERISTICS OF CHILLI

On perusal of the data on plant height at 30, 60 and 90 days after planting and number of primary branches, it was observed that the levels of NPK fertilizers for custom blending of thermochemical digest (TD) had significantly influenced plant height at all the three stages of growth while the same for frequency of application was significant only at 60 and 90 days after planting.

Among the levels of fertilisers for custom blending, the plant height was highest for NPK @100 % POP (F2) and for frequency of application, weekly application (P1) showed the highest value. The treatment combination P1F2 (weekly application of NPK @100% POP) showed the highest value and P2F3 (biweekly application of NPK @125 % POP) the lowest value for plant height. Thus the best level for custom blending of thermochemical digest from degradable waste with N, P and K fertilizers can be taken as @100 per cent of POP and frequency of application should be at weekly intervals with regard to plant height. Similar study Leno *et al.* (2015) reported that application of fortified manure produced by rapid conversion technology @ 3.3 t ha^{-1} recorded better crop biometric characters than poultry manure and FYM. Since the thermochemical digest has been fortified with nutrients to ensure minimum availability of all the essential nutrients in a balanced way, further addition of N, P and K fertilizers are required only @100 per cent of POP. Both the fortification with a lower quantity (75 % POP) and a higher quantity (125% POP) could not achieve the growth characters as that of 100 per cent POP. The general nutrient availability showed an increase with levels of rate of custom blending since the treatments are getting proportionate increase in nutrients. But the nutrient uptake was not increased with higher levels of N P K. The fruit yield also followed the same trend. The higher rate may not be needed by the plant under this situation or some of the factors are not fully utilized and it seems that a lower rate could not satisfy the crop needs. The data on uptake of major and minor nutrients also revealed that the highest quantity of nutrients had been removed by the above treatments (Figs. 16 to 26).

The total dry matter production (shoot weight, fruit weight and root weight) was significantly influenced by both, the frequency of application and levels of fertilizers for custom blending and their interaction effects. Here also the same treatment ie., weekly application of custom blended thermochemical digest with N, P and K fertilizers @100 per cent POP (P1F2) showed highest value, clearly indicating the better growth rate for the above treatment combination compared to others. Better nutrient uptake by the treatment (Figs. 16 to 26) and its translocation to plant parts might have resulted better dry matter production. The lowest value was recorded by the combination P2F3 (biweekly application of NPK @125 % POP). Tars and Evrensel (2013) reported that in oats (*Avena sativa*) the dry matter production increased with the amount of nitrogen fertilizer given only up to certain limit but the excess application leads to the decrease in dry matter production.

Perusal of the data on fruit yield revealed that it was significantly influenced by both the individual as well as interaction effects of levels of NPK for custom blending of thermochemical digest and frequency of fertilizer application. The same treatment combination ie., weekly application of custom blended thermochemical digest with N, P and K fertilizers @100 per cent POP (P1F2) showed the highest fruit yield and was significantly superior to all other treatments. The highest fruit yield is surely a reflection of the nutrients absorbed by the plants from the growth medium as evidenced by the highest uptake of all the essential nutrients (Fig: 16 to 26). Thus the rate of N, P and K fertilizers to be applied through fortified thermochemical digest for chilli under container cultivation (growth medium - thermochemical digest, coirpith compost and soil in 1:2:1 ratio) is as per POP recommendation itself but should be applied at weekly interval with 25 g per plant from 5 days after transplanting.

The yield attributing characteristics like fruit length, fruit girth and number of fruits per plant were also highest for the treatment combination of weekly application of NPK @100 % POP (P1F2). Since all the yield attributing characters were highest for treatment combination P1F2, naturally the fruit yield was also highest for the same treatment. Better root growth and shoot growth might have facilitated better growing conditions for plant resulting highest fruit yield.

EFFECT OF LEVELS OF FERTILISERS FOR CUSTOM BLENDING OF THERMOCHEMICAL COMPOST AND FREQUENCY OF APPLICATION ON NUTRIENT COMPOSITION OF CHILLI SHOOT

The statistical analysis revealed that among the major nutrients, only N, K, Mg and S contents of shoot were significantly influenced by both the individual effects of the levels of fertilizers for custom blending of thermochemical digest and frequency of application, and their interaction effects. But for P and Ca, only the individual effects were statistically significant. The immobile nature of P and its fixation might have differently affected the nutrient absorption from the growth medium. For Ca also the retention power on soil exchange sites was comparatively higher when it is compared with retention power of K and Mg. This might have resulted a different response in the case of P and Ca. The shoot concentration of all the major nutrients was highest for the treatment combination that receives weekly application of custom blended thermochemical digest with N, P and K fertilizers @100 per cent POP. The regular nutrient availability and better root growth might have facilitated higher nutrient removal from the growing medium. Thus the rate of N, P and K fertilizers to be applied for chilli grown in thermochemical digest of degradable waste under container cultivation is as per POP recommendation itself and the frequency of application to be followed is @ weekly interval with 25 g per plant from 5 days after transplanting onwards.

The nutrient concentration was lowest for the treatment combination that receives biweekly application @ 125% POP (P2F3) which had recorded the lowest fruit yield also. The root growth was (Table 22 and Figs. 16 to 26) lowest for the above treatment compared to others and this might be the main reason for the lower nutrient concentration in shoot. The available N content was also lowest for the same treatment. Though the other nutrients except available Ca, were highest for this treatment that was not reflected on nutrient concentration of shoot. Some unfavorable nutrient interactions might have prevented better nutrient absorption and translocation to shoot.

Perusal of the data on micronutrient content of shoot revealed that among the micronutrients, only Fe, Mn and B contents were significantly influenced by both the individual effects of levels of custom blending and frequency of application, and their interaction effects. For Zn, only the individual effect of levels of custom blending alone was significant and for Cu, none of the effects were statistically significant. For all the micronutrients, the highest contents were recorded by the treatment combination receiving weekly application of custom blended thermochemical digest with N, P and K fertilizers @100 per cent POP (P1F2). The nutrient concentration was lowest for the treatment combination that receives biweekly application of fortified thermochemical digest with N, P and K fertilizers @125% POP (P2F3). The root growth and available N content were lower for P2F3 compared to P1F2 and this might have reflected on vegetative growth and absorption of other nutrients.

EFFECT OF LEVELS OF FERTILISERS FOR CUSTOM BLENDING OF THERMOCHEMICAL COMPOST AND FREQUENCY OF APPLICATION ON NUTRIENT COMPOSITION OF CHILLI FRUIT

The statistical analysis revealed that among the major nutrients, only N, P, K, and Mg contents of fruit were significantly influenced by both the individual effects of levels of custom blending and frequency of application and their interaction effects. The fruit concentration of N, P, K and Mg were highest for the treatment combination that receives weekly application of custom blended thermochemical digest with N, P and K fertilizers @100 per cent POP (P1F2). Among the individual effects also the same ie., weekly application (P1) and NPK fertilizers @100 per cent POP (F2) recorded the highest values, might be due to better root and shoot growth and balanced availability of nutrients throughout the crop period. From the data it was observed that the P content of fruit, the element which had direct influence on fruit nutrient concentration was much higher for treatment combination P1F2 compared to P2F3 and this might have influenced the nutrient concentration of fruit.

But for the Ca and S contents of fruit, only individual effects of levels of NPK and frequency of application were statistically significant. Here also, the results were same as that of N, P and K where the levels weekly application (P1) and NPK fertilizers @100 per cent POP (F2) recorded the highest values and biweekly application (P2) and NPK fertilizers @125 per cent POP (F3) recording the lowest values. In the case of Ca both shoot and root behaved similarly while for S a differential response was noticed. The available Ca content for treatment combination P2F3 was lowest and the difference with P1F2 was very high. The higher retention of Ca in the growth medium itself might have resulted such a trend. Thus the rate of N, P and K fertilizers to be applied for chilli grown in thermochemical digest of degradable wastes under container cultivation is as per POP recommendation itself and the frequency of application to be followed is @ weekly interval with 25 g per plant from 5 days after transplanting onwards.

The nutrient concentration was lowest for the treatment combination that receives fortified thermochemical digest at biweekly application @ 125% POP (F3P2 which had recorded the lowest fruit yield also. This might be definitely due to lower shoot and root growth for that treatment which had resulted lower nutrient extraction from the growing medium.

The statistically analyzed data regarding the effects of treatments on micronutrient concentration revealed that only the individual effects of levels of custom blending and frequency of application had significant influence on concentration of Fe, Mn, Cu and B in the fruits. The highest values were recorded by the individual effects P1 (weekly application) and F2 (NPK @100 % POP). The individual effects P2 (biweekly application) and F3 (NPK @125% POP) were found to be significantly inferior to all other treatments. In the case of Zn, both individual as well as interaction effects were significant and highest content was registered by the treatment combination that receives weekly application of custom blended thermochemical digest with N, P and K fertilizers @100 per cent POP. The same treatment combination had shown better shoot and root growth and that might have favored more nutrient uptake from the medium and its translocation to above ground plant parts. From the experiment, it is clear that the best treatment combination is that one receives weekly application of custom blended thermochemical digest with N, P and K fertilizers @100 per cent POP.

For capsaicin content, only the individual effect of rate of custom blending was statistically significant. The highest value was recorded by F2 (100 % POP) and lowest was recorded by F3 (125 % POP) which was on par with F1 (75 % POP). The NPK level that favored highest nutrient extraction might have influenced the quality aspects also in similar way. Lara *et al.* (2008) reported that the nitrogen fertilization had increased the capsaicin content of chilli plant.

EFFECT OF LEVELS OF FERTILISERS FOR CUSTOM BLENDING OF THERMOCHEMICAL DIGEST AND FREQUENCY OF APPLICATION ON NUTRIENT AVAILABILITY AND UPTAKE BY CHILLI

The data on availability of major nutrients revealed that among the applied nutrients, only P and K availability was significantly influenced by the levels of fertilisers for custom blending and their application frequency and that too only the individual effects. Among the levels of NPK fertilizers, 125 % POP (F3) and for frequency of application biweekly application (P2) recorded the highest values. Naturally the higher rate of application had released more nutrients to the growth medium and the nutrient removal by chilli for this treatment combination was also found to be the lowest (Figs. 16 to 26). This might have retained more nutrients in the growing medium. The behavior of Ca, Mg, S, Fe, Mn, Zn and Cu was similar to that of P and K. However the effect on N was not significant. The high N requirement for crops might have resulted more N removal from the medium. The effect on B was also not significant. The very low available B content in the soil might have resulted such an effect.

The lowest values were recorded for the treatment combination of weekly application @ 75 % POP (P1F1). This is quite natural since it has received lowest quantity of N, P and K fertilizers.

With regard to the nutrient uptake, (Figs. 16 to 26)) only the frequency of application had significant influence while the levels of NPK and the interaction effects were not significant. Among the frequency of application, the weekly application (P1) recorded the highest value and was significantly superior to biweekly

Fig.15 Effect of treatments on fruit yield of chilli (g $plant^{-1}$)

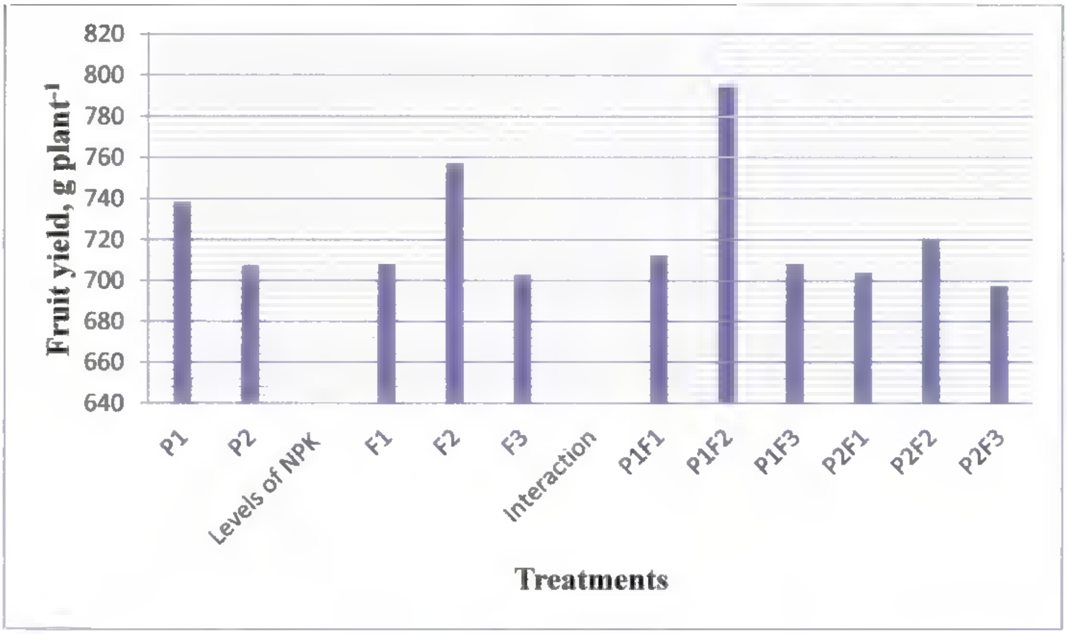


Fig. 16 Effect of treatments on N uptake by chilli (g $plant^{-1}$)

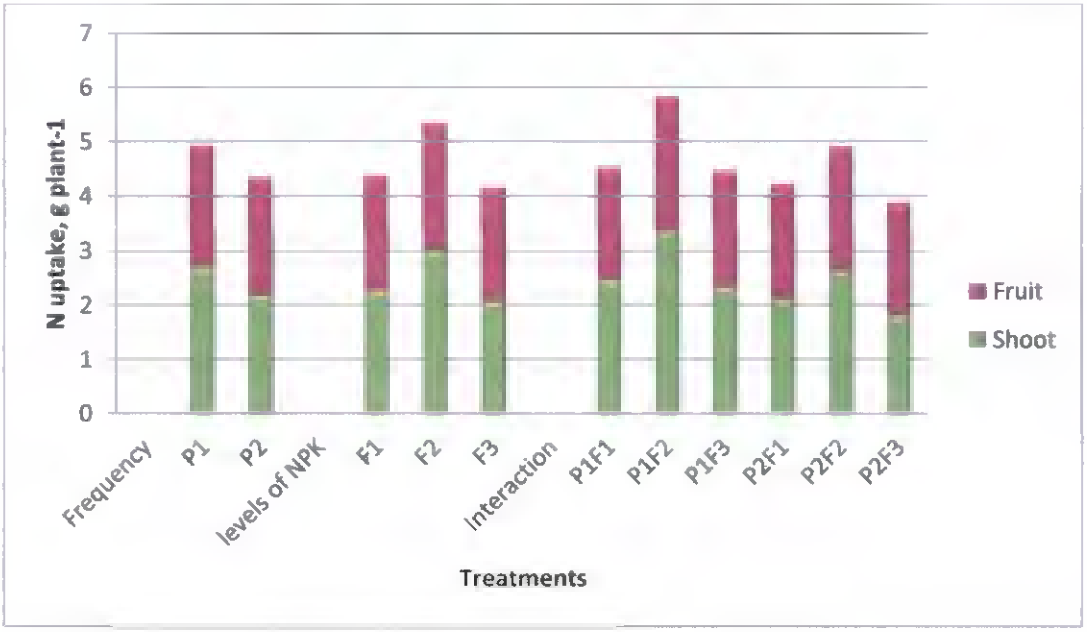


Fig. 17 Effect of treatments on P uptake by chilli (g plant^{-1})

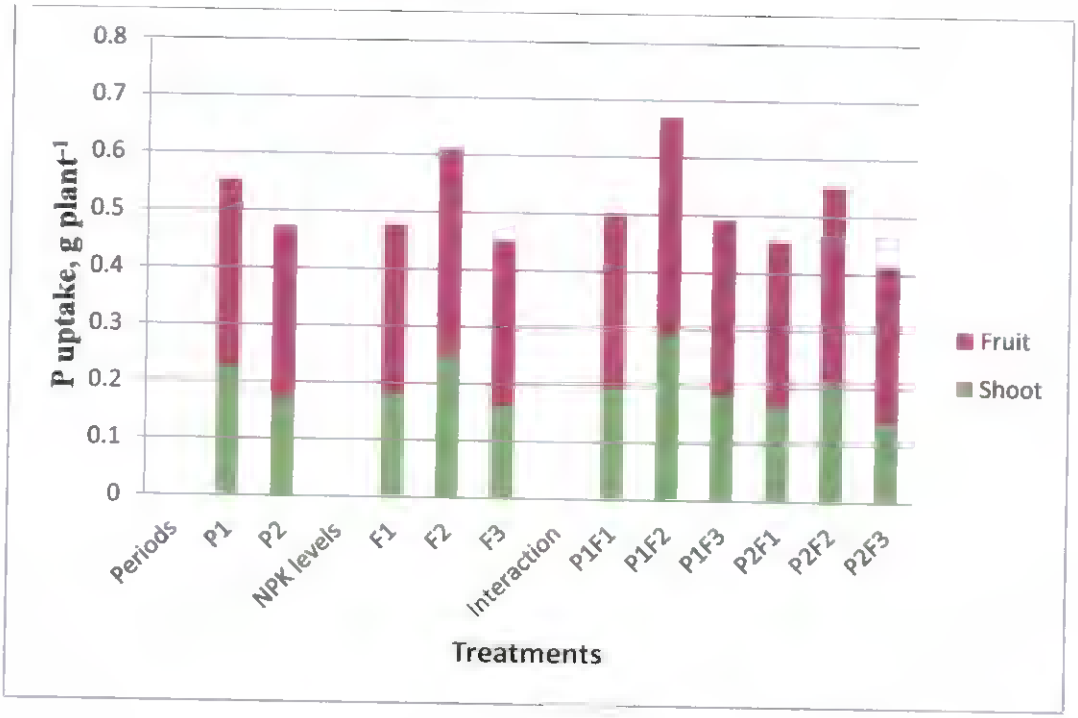


Fig. 18 Effect of treatments on K uptake by chilli (g plant^{-1})

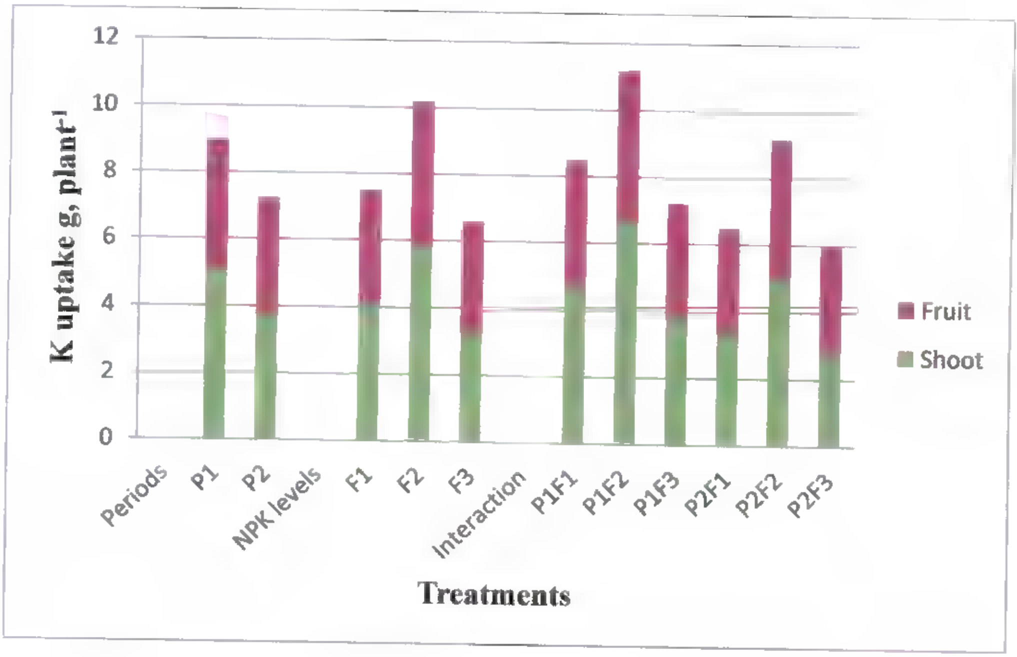


Fig. 19 Effect of treatments on Ca uptake by chilli (g plant^{-1})

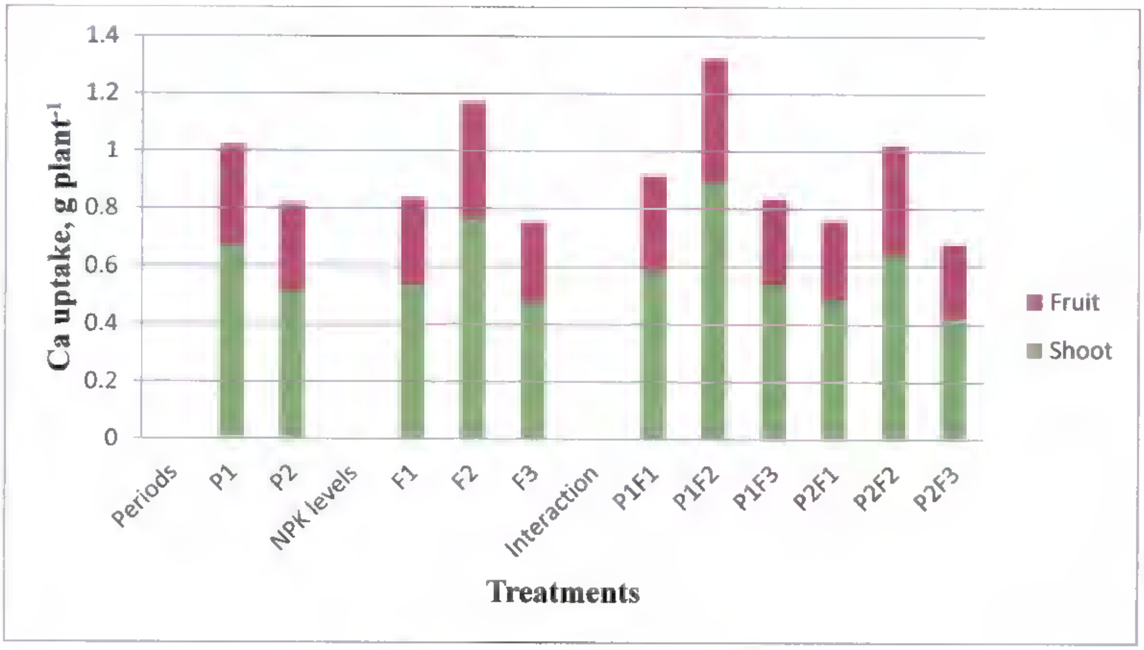


Fig. 20 Effect of treatments on Mg uptake by chilli (g plant^{-1})

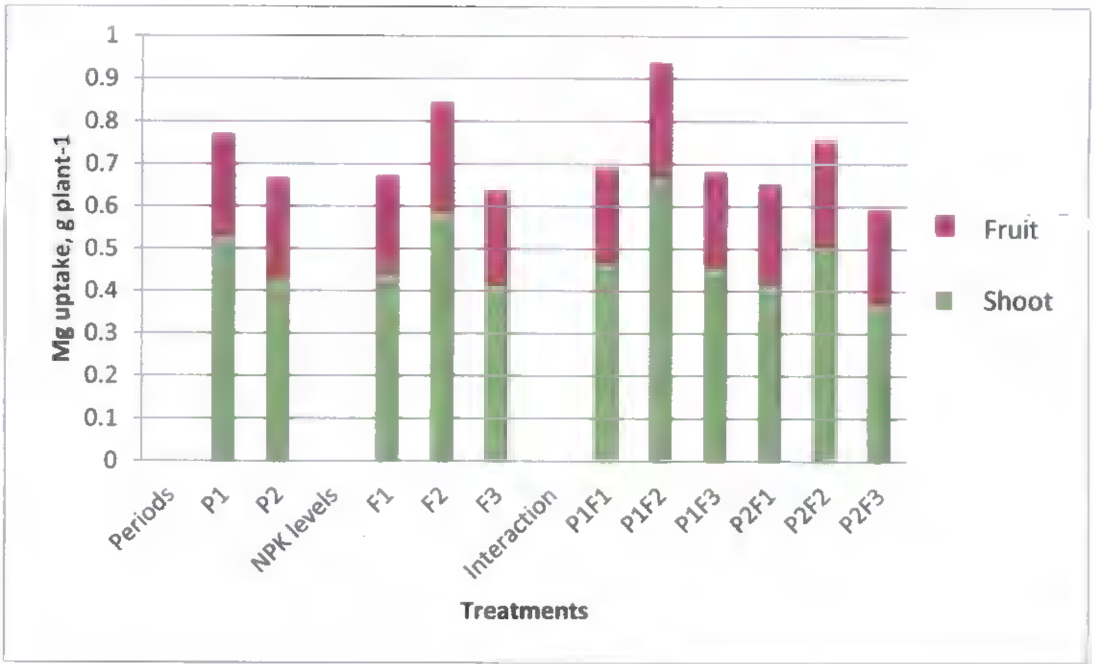


Fig.21 Effect of treatments on S uptake by chilli (g plant^{-1})

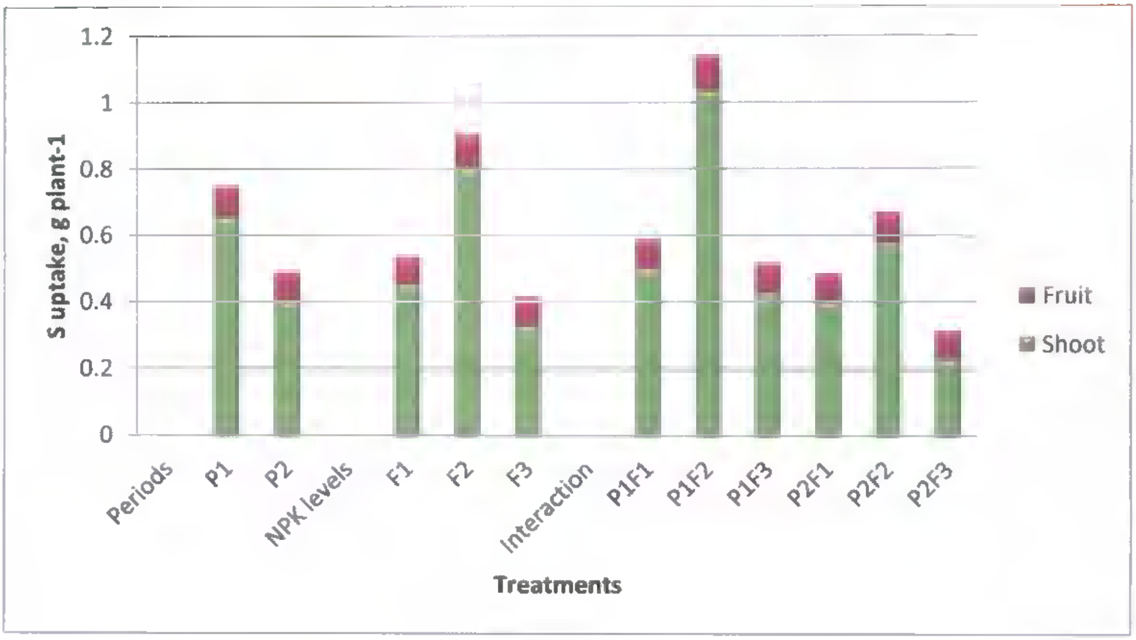


Fig.22 Effect of treatments on Fe uptake by chilli (mg plant^{-1})

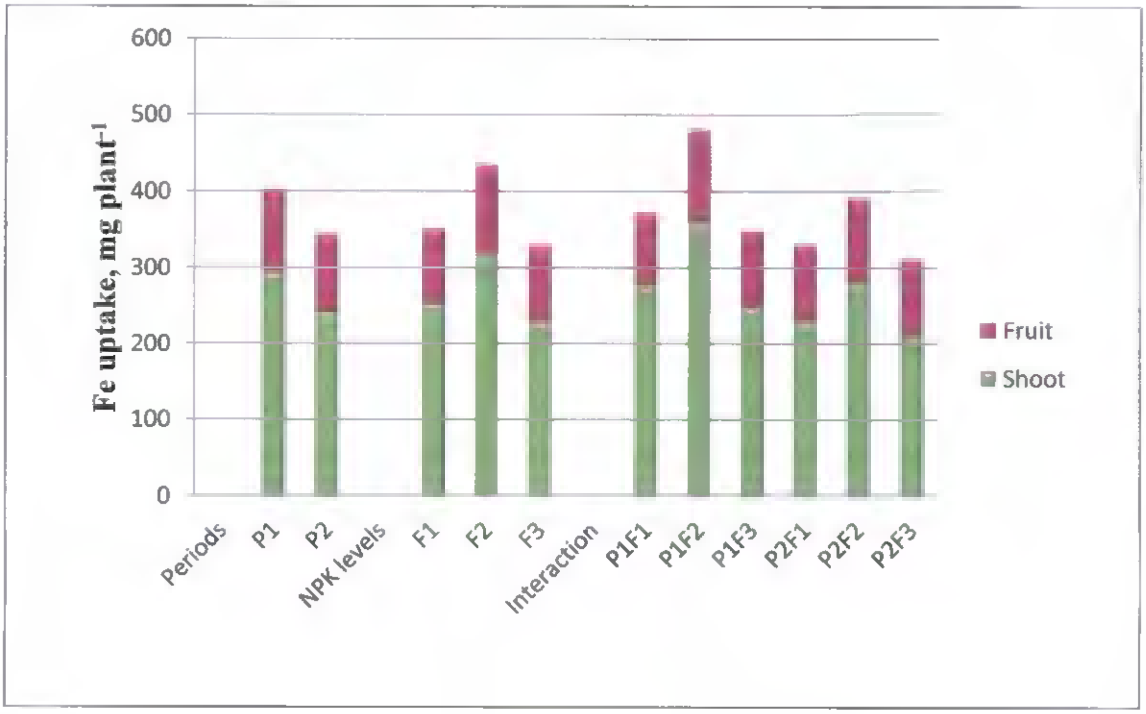


Fig. 23 Effect of treatments on Mn uptake by chilli (mg plant^{-1})

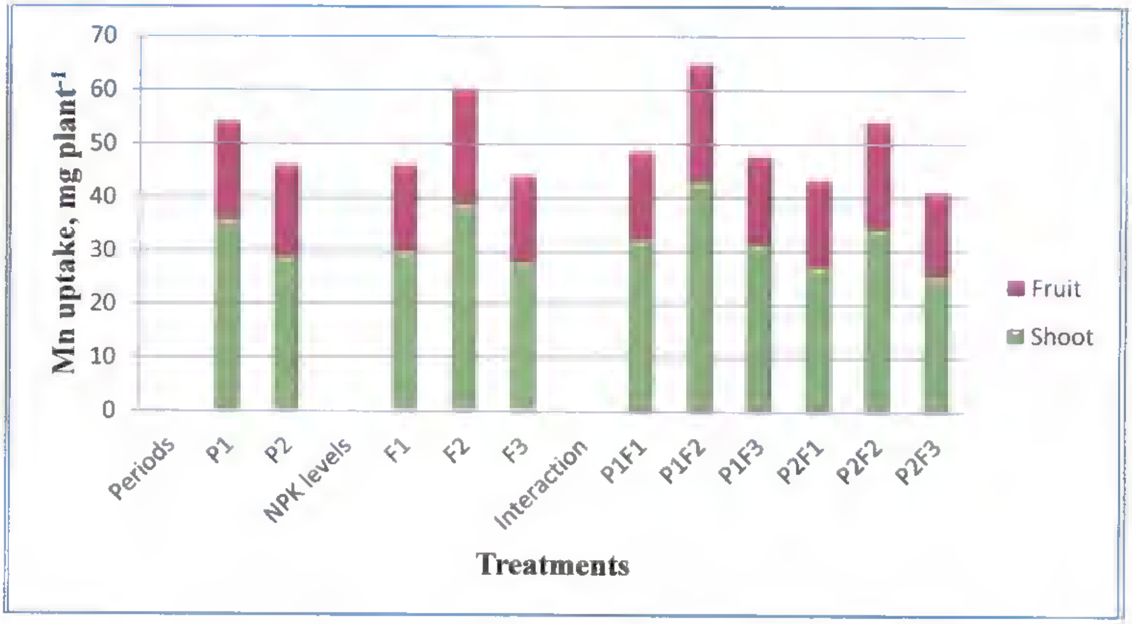


Fig.24 Effect of treatments on Zn uptake by chilli (mg plant^{-1})

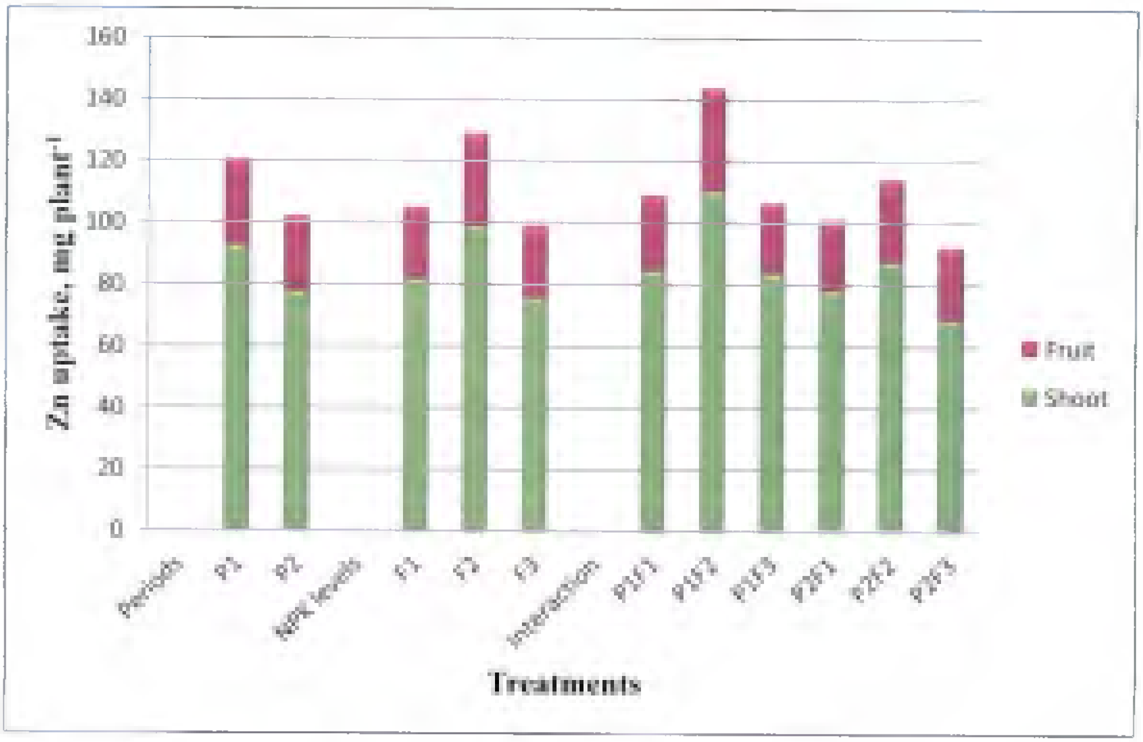


Fig. 25 Effect of treatments on Cu uptake by chilli (mg plant^{-1})

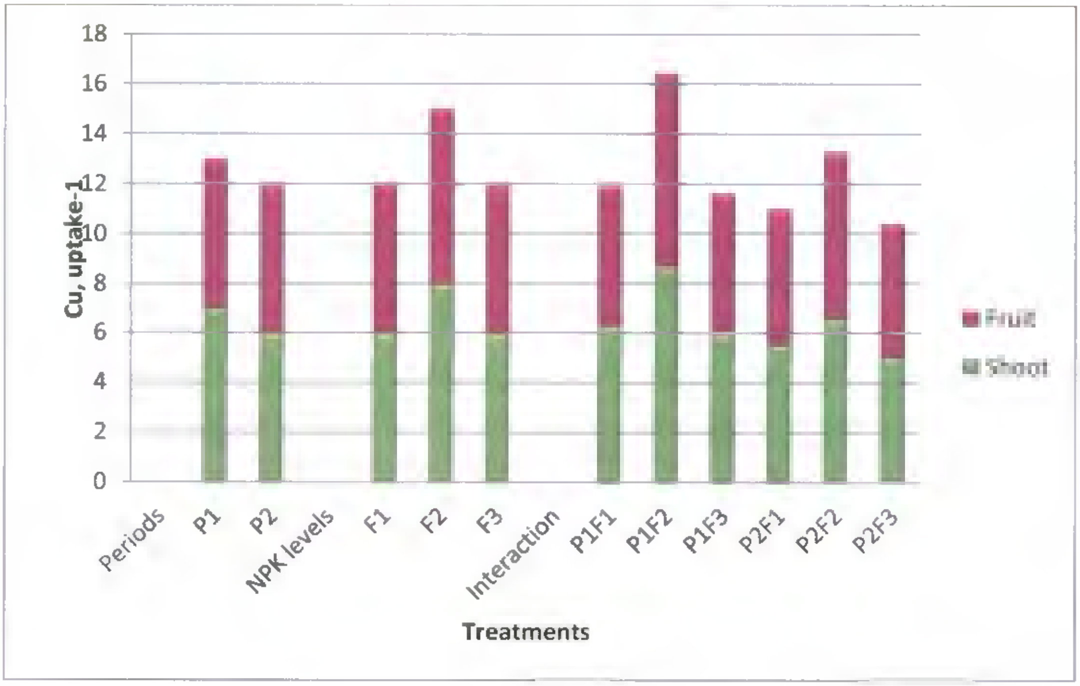
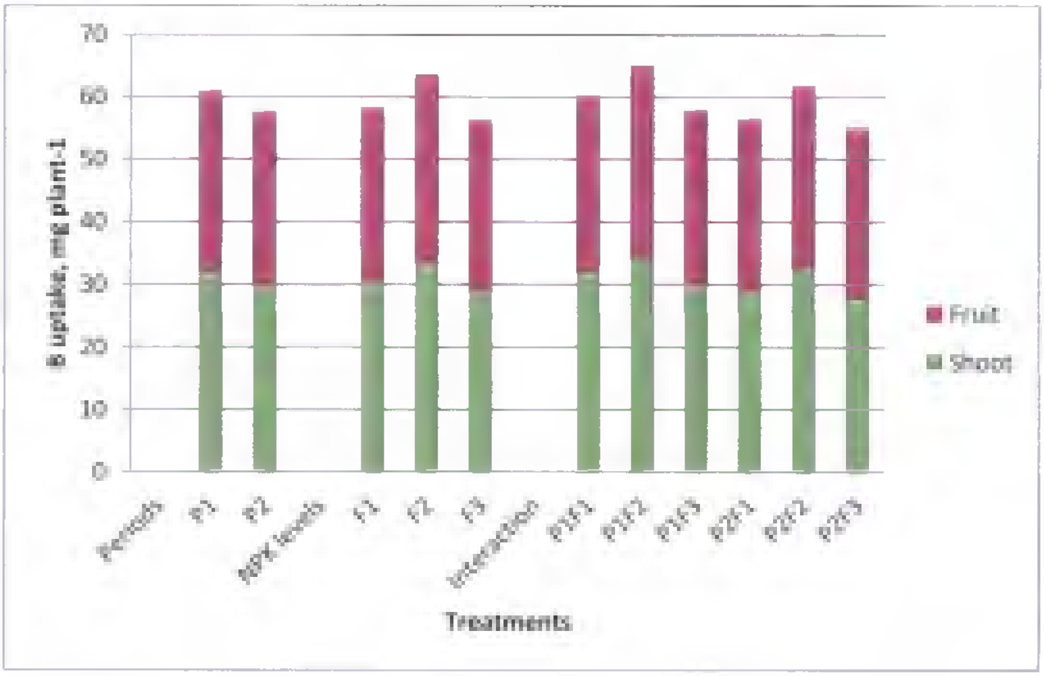


Fig.26 Effect of treatments on B uptake by chilli (mg plant^{-1})



application (P2). The weekly application might have maintained a regular supply of nutrients to the crop and had resulted better uptake.

B : C ratio

Both the individual as well as the interaction effects of levels of NPK and frequency of application had significantly influenced the B:C ratio. The highest values of 2.26 was recorded by the treatment combination that receives NPK fertilizers @100% POP at weekly intervals (P1F2) and the lowest for biweekly application of NPK @125% POP (P2F3). Since the economic yield was highest for the treatment combination P1F2, naturally the income from that will be the highest. More over the cost of f fertilizers was highest for P2F3 since 25 per cent more NPK has to be applied for this treatment. These two made the B:C ratio highest for treatment combination P1F2 and lowest for P2F3.

Thus the treatment combination that receives weekly application NPK fertilizers @100 per cent fortified through thermochemical digest of organic waste as the standard rate for chilli grown in containers with soil, thermochemcial digest and soil in 1:2:1 proportion.

Summary

SUMMARY

An investigation entitled "Evaluation of thermochemical digest of degradable waste for container cultivation of chilli" was carried out at the Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vellayani, during 2014-2016. The investigation comprised of two pot culture experiments. The first experiment was for standardization of growth medium based on thermochemical digest of degradable waste (TD) and the second for standardization of the rate and frequency of application of custom blended thremochemical digest fortified with N, P and K fertilizers for yield maximization in chillies. The chilli variety 'Vellayani Athulya' was used for the study.

In the first part, 11 treatments comprising growth medium components viz. thermochemical digest of degradable waste (TD), coirpith compost (CC) / cocopeat (CP) and soil in different ratios (1:1:1; 2:1:1; 1:2:1; 2:2:1, 1:0:1 and 2:0:1) were evaluated along with the normal potting medium (Soil: Sand: FYM -2:1:1). The best growth medium from the above experiment was selected for second experiment. In the second experiment, three levels of NPK viz. 75%, 100% and 125% of POP at two levels of application frequency (weekly and biweekly intervals except for P which was given as basal) were evaluated. The nutrients were applied through fortified thremochemical digest as per the treatments. The salient results emerged from the study are summarized below.

PART I.

- On evaluating shoot biometric characteristics of chilli, it was observed that plant height at 30, 60 and 90 days after planting was significantly influenced by the treatments and highest values were observed for the treatment receiving thermochemcial digest, coirpith compost and soil in 1:2:1 ratio (T3) which was significantly superior to all other treatments. The lowest value was

recorded by the treatment T10 (TD2:S1). With regard to the number of primary branches per plant, treatments T3 (TD1:CC2:S1) and T7 (TD1:CP2:S1) recorded the highest value of 7.67 and the lowest value by the treatment T10 (TD2:S1) which was on par with treatment T11 (S2:SS1:F1).

- The shoot weight of chilli was significantly influenced by the treatments and the treatment T7 (TD1:CP2:S1) showed the highest value which was significantly superior to all others and Treatment T10 (TD2:S1) recorded the lowest value. Total dry matter production, root weight and root volume followed the same trend as that of shoot weight.
- The fruit yield, fruit length, fruit girth and number of fruits per plant were significantly influenced by the treatments. The treatment T3 (TD1:CC2:S1) recorded the highest fruit yield of 690.08 g plant^{-1} (34.07 t ha^{-1}) which was significantly superior to other treatments. This was followed by treatments T7 (TD1:CP2:S1) and T9 (TD1:S1). The lowest value was recorded by the treatment T10 (TD2:S1) having a fruit yield of 297.59 g plant^{-1} (14.69 t ha^{-1}) and was on par with the treatment T11 (S2:SS1:F1). The yield attributing characters also behaved similarly.
- With regard to the chemical properties of the medium pH, electrical conductivity and available nutrients were significantly influenced by the treatments both at the time planting and after final harvest. A drastic reduction in all the above properties were observed by the time of final harvest compared to that at the time of planting, definitely due to the crop removal or adsorption of charcoal present in TD and loss through drained out water after irrigation.
- Both pH and electrical conductivity behaved in a similar manner by showing highest values for the treatment T10 (TD2:S1) where TD is the major component (66.6) whose pH and electrical conductivity were very high compared to other components. Treatment T10 was significantly superior to

all other treatments and the lowest value was noticed for the treatment T11 (S2:SS1:F1). After final harvest also, the trend was same.

- Organic carbon content of the growth medium also showed a decrease towards the end of the crop and the highest values were recorded by the treatment T10 (TD2:S1) and lowest by treatment T11 (S2:SS1:F1) both at the time of planting and after final harvest. The highest organic carbon content of T10 (TD2:S1) was mainly due to the high proportion of TD (66.6 %) in the growth medium, whose C:N ratio was narrowest compared to other components.
- The availability of major nutrients were significantly influenced by the growth media composition and highest values for available N, P, K, Ca, Mg and S were recorded by the treatment T10 (TD2:S1). The high proportion of TD which had been fortified with major nutrients resulted in higher availability of those nutrients. Similarly the treatment T11 which was not fortified with any nutrients showed the lowest values for the above nutrients.
- On analyzing the availability of major nutrients after final harvest, though the values were reduced considerably due to crop uptake and other losses, the treatment T10 (TD2:S1) maintained highest content for all the major nutrients. This might be due to higher nutrient content of TD which is the major component of that treatment and its lower nutrient removal.
- Available micronutrient contents (Fe, Mn, Zn and Cu) were significantly influenced by the treatments both at the time of planting and after final harvest. For all the micronutrients except Fe and B, the availability at the time of planting was highest for the treatment T10 (TD2:S1) mainly due to the higher proportion of TD which is having higher contents of the above nutrients. Treatment T4 (TD2:CC2:S1) showed the highest values for Fe and B definitely due to the high content of Fe and B in CC. The lowest values for all except Fe were recorded by the treatment T11, the treatment consist of

components with low nutrient value. For Fe, the lowest values were observed for the treatment T9 (TD1:S1) at the time of planting and treatment T5 (TD1:CP1:S1) after final harvest.

- At the time of planting, available B content was highest (3.8 mg kg^{-1}) for the treatment T4 (TD2:CC2:S1) and was statistically on par with the treatment T10 (TD2:S1). The lowest value of 2.2 mg kg^{-1} was recorded for treatment T11 (S2:SS1:F1). After final harvest, the highest value was noted for the treatment T10 (TD2:S1) and the lowest value of 1.80 mg kg^{-1} by the two treatments viz., T9 (TD1:S1) and T11 (S2:SS1:F1).
- The growth medium composition had significantly influenced the N, P, K, Ca, Mg and S concentration of chilli shoot. The highest values were recorded by the treatment T3 receiving thermochemical digest, coirpith compost and soil in 1:2:1 ratio followed by the treatment T7 receiving the same in same ratio with cocopeat instead of coirpith compost. The better root growth of plants under treatment T7 might have facilitated better nutrient absorption and translocation to plant parts.
- The treatment T11 receiving soil, sand and FYM in ratio 2:1:1 recorded the lowest values for all major nutrients since the amount of available nutrients present in that treatment was comparatively low compared to other treatments
- Fe, Mn, Zn, Cu and B contents of chilli shoot were significantly influenced by the treatments. Treatment T3 (TD1:CC2:S1) recorded the highest contents for Zn, Cu and B in shoot and treatment T11 (S2:SS1:F1) the lowest values. But at the same it recorded the highest content for Fe.
- The growth medium composition had significantly influenced the N, P, K, Ca, Mg and S concentration of chilli fruit. As in the case of chilli shoot, the highest values were recorded by the treatment T3 (TD1:CC2:S1) followed by the treatment T7 (TD1:CP2:S1). The nutrient uptake by plants was also highest for treatment T3. Here also the treatment T11 receiving soil, sand and

FYM in ratio 2:1:1 recorded the lowest values. This was definitely due to low nutrient status of the growing medium which had resulted lower nutrient removal by plant roots and consequent growth.

- The micronutrient contents of chilli fruit viz. Fe, Mn, Zn, Cu and B were significantly influenced by the treatments. Treatment T11 (S2:SS1:F1) recorded the highest value for Fe content in fruit and the lowest by the treatment T9 (TD1:S1). On scrutinizing the data on available Fe content of growth medium, it was revealed that FYM is having the highest Fe content and the acidic pH of the medium might have facilitated a higher availability and plant absorption resulting higher Fe content for treatment T11.
- With regard to Mn, Zn, Cu and B contents of fruit, they followed the same trend as that of macronutrients. The attributed reasons for their higher contents are the higher nutrient availability under treatment T3 compared to treatment T7 and the higher contents of Mn, Zn, Cu and B in coirpith compost compared to cocopeat.
- Capsaicin content of chilli fruit was significantly influenced by the treatments. The highest value 0.777 per cent was recorded by the treatment T3 (TD1:CC2:S1) which was significantly superior to all other treatments. The lowest value of 0.637 per cent was recorded by the treatment T11 (S2:SS1:F1).
- The treatment T3 (TD1:CC2:S1) recorded the highest B:C ratio of 2.47 which was significantly superior to all others. This was followed by the treatments T9 (TD2:S1) and T7 (TD1:CP2:S1). The lowest value 0.614 was recorded by the treatment T10 which was on par with treatment T11 (S2:SS2:F1).

PART II

- The individual effect of levels of NPK for custom blending of thermochemical digest had significant influence on plant height at 30, 60 and

90 days after planting while frequency of application was significant only at 60 and 90 days after planting. The interaction effect was significant only for 90 days after planting. Among the individual effects, plant height was highest for weekly application (P1) and NPK @ 100 % POP (F2). The treatment combination P1F2 (weekly application of NPK @ 100 % POP) showed the highest value and P2F3 (biweekly application of NPK @ 125 % POP) the lowest value for plant height. Since the thermochemical digest has been fortified with nutrients to ensure minimum availability of all the essential nutrients in a balanced way, further addition of N, P and K fertilizers are required only @ 100 per cent of POP.

- The total dry matter production was significantly influenced by both, the frequency of application and levels of fertilizers for custom blending and their interaction effects. The treatment that received weekly application of custom blended thermochemical digest with N, P and K fertilizers @ 100 per cent POP (P1F2) showed highest value. Higher nutrient uptake by the treatment and its translocation to plant parts might have resulted better dry matter production. The lowest value was recorded by the combination P2F3 (biweekly application of NPK @ 125 % POP).
- Fruit yield of chilli was significantly influenced by both the individual as well as interaction effects of levels of NPK and frequency of fertilizer application. The treatment that received weekly application of custom blended thermochemical digest with N, P and K fertilizers @ 100 per cent POP (P1F2) showed the highest fruit yield and was significantly superior to all other treatments might be due to higher uptake of all the essential nutrients. The yield attributing characteristics like fruit length, fruit girth and number of fruits per plant were also highest for the same treatment combination.
- Among the major nutrients, only N, K, Mg and S contents of shoot were significantly influenced by both the individual effects of the levels of

fertilizers and frequency of application, and their interaction effects. The individual effects alone were statistically significant for P and Ca. The shoot concentration of all the major nutrients was highest for the treatment combination that receives weekly application of custom blended thermochemical digest with N, P and K fertilizers @ 100 per cent POP (P1F2). The regular nutrient availability and better root growth might have facilitated higher nutrient removal from the growing medium. The nutrient concentration was lowest for the treatment combination that receives biweekly application @ 125% POP (P2F3) might be due the poor root growth.

- Among the micronutrients, only Fe, Mn and B contents of shoot were significantly influenced by both the individual effects of levels of custom blending and frequency of application, and their interaction effects. For Zn, only the individual effect of levels of custom blending alone was significant and for Cu none of the effects were statistically significant. For all the micronutrients, the highest contents were recorded by the treatment combination receiving weekly application of custom blended thermochemical digest with N, P and K fertilizers @ 100 per cent POP (P1F2), might be due to better root growth and consequent nutrient absorption. The nutrient concentration was lowest for the treatment combination that receives biweekly application of fortified thermochemical digest with N, P and K fertilizers @ 125% POP (P2F3).
- With regard to the concentration of major nutrients in fruit, only N, P, K, and Mg were significantly influenced by both the individual effects of levels of custom blending and frequency of application and their interaction while individual effects alone were significant for Ca and S. However, the concentration of all the major nutrients was highest for the treatment combination that receives weekly application of custom blended thermochemical digest with N, P and K fertilizers @ 100 per cent POP

(P1F2). This might be due to better root and shoot growth and balanced availability of nutrients throughout the crop period.

- With regard to the micronutrient concentration of fruits, only the individual effects of levels of custom blending and frequency of application were significant for Fe, Mn, Cu and B, while Zn was influenced by both. The highest values were recorded by the individual effects P1 (weekly application) and F2 (NPK @ 100 % POP). The individual effects P2 (biweekly application) and F3 (NPK @ 125% POP) were found to be significantly inferior to all other treatments.
- For capsaicin content, only the individual effect of rate of N, P and K fertilizers for custom blending was statistically significant. The highest value was recorded by F2 (NPK @ 100 % POP) and lowest was recorded by F3 (NPK @ 125 % POP) which was on par with F1 (NPK @75 % POP).
- Among the applied nutrients, the treatment effect was not significant for N. But the individual effects were significant for P and K availability and not the interaction effects. Among the levels of NPK fertilizers, 125 % POP (F3) and for frequency of application biweekly application (P2) recorded the highest values. Naturally the higher rate of application had released more nutrients to the growth medium and the nutrient removal by chilli for this treatment combination was also found to be the lowest. This might have retained more nutrients in the growing medium. The behavior of Ca, Mg, S, Fe, Mn, Zn and Cu was similar to that of P and K. The lowest values were recorded for the treatment combination of weekly application @ 75 % POP (P1F1). This is quite natural since it has received lowest quantity of N, P and K fertilizers.
- With regard to the nutrient uptake, only the frequency of application had significant influence while the levels of NPK and the interaction effects were not significant. Among the frequency of application, the weekly application (P1) recorded the highest value and was significantly superior to biweekly

application (P2). The weekly application might have maintained a regular supply of nutrients to the crop and had resulted better uptake.

- Both the individual as well as the interaction effects of levels of NPK and frequency of application had significantly influenced the B:C ratio. The highest values of 2.26 was recorded by the treatment combination that receives NPK fertilizers @ 100% POP at weekly intervals (P1F2) and the lowest for biweekly application of NPK @ 125% POP (P2F3).

CONCLUSION

The investigation revealed that the ideal composition for growth medium (using thermochemical digest of degradable waste) for container cultivation of chillies is thermochemical digest, coirpith compost and soil in 1:2:1 proportion.

For yield maximization in chilli, the thermochemical digest of degradable waste has to be fortified with N P K fertilizers @ 100% of POP and to be applied at weekly intervals @ 25 g per plant.

FUTURE LINE OF WORK

Suitablity of thermochemical digest (TD) for other crops have to be tested and the rate is to be standardized.

The loss of nutrients under container cultivation using thermochemical digest (TD) as growth medium has to be estimated.

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EVALUATION OF THERMOCHEMICAL DIGEST OF DEGRADABLE WASTE FOR CONTAINER CULTIVATION OF CHILLI

by

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ABSTRACT

An investigation entitled "Evaluation of thermochemical digest of degradable waste for container cultivation of chilli" was conducted at the Department of Soil Science and Agrl.Chemistry, College of Agriculture, Vellayani during 2014-16. The objective was to develop and standardize a plant growth medium based on custom blended thermochemical digest of degradable waste for container cultivation of chilli. The investigation comprised of two parts, one experiment for the standardization of growth medium based on thermochemical digest of degradable waste (TD) and the second for standardization of the rate and frequency of application of custom blended TD fortified with fertilizers for yield maximization in chillies. This was accomplished through two pot culture experiments with chilli variety Vellayani Athulya.

In the first part, 11 treatments comprising growth medium components viz. thermochemical digest of degradable waste (TD), coirpith compost (CC) / cocopeat (CP) and soil in different ratios (1:1:1; 2:1:1; 1:2:1; 2:2:1,1:0:1 and 2:0:1) were evaluated along with the normal potting medium (Soil: Sand: FYM -2:1:1). The best growth medium from the above experiment was selected for second experiment. In the second experiment, three levels of NPK viz. 75%, 100% and 125% of POP at two levels of application frequency (weekly and biweekly intervals except for P) were evaluated. The nutrients were applied through fortified TD as per the treatments.

The results of the first experiment revealed that treatment effects were significant. The treatment T3 (1:2:1) showed highest values for plant height, no. of primary branches per plant, no. of fruits per plant, length of fruit and weight of fruit. Highest shoot weight, dry matter, root weight and root volume were observed for treatment T7 (1:2:1). The treatment T10 (2:0:1) showed lowest values for the same. While evaluating the soil nutrient status, it was observed that the available nutrient status increased with levels of TD. The treatment T3 (1:2:1) maintained lowest values

of available P, K, Ca and Mg at final harvest. The treatment T3 (1:2:1) recorded highest nutrient content in fruit and shoot compared to other treatments except Fe. Treatment T10 (2:0:1) recorded the lowest values for all nutrients except Fe. Mite attack was noticed and measures were taken to control it. Economic analysis revealed that treatment T3 (1:2:1) is having the highest B:C ratio. Hence treatment T3 having TD, coirpith compost and soil in the ratio 1:2:1 was rated as the best treatment with regard to yield and economics and hence selected for second part.

In the second part, the individual effects of rate and frequency of fertilizer application were significant for most of the biometric, root and yield characteristics of chilli while only a few of their interaction effects were significant. Among the frequency of application, the weekly application (P1) and among the rate, 100% POP (F2) were found to be significantly superior to others with regard to growth, yield and nutrient content. The treatment combination, weekly application @ 100% POP (P1F2) recorded the highest values and (biweekly application @ 125% POP (P2F3) showed the lowest values for N, P, K, Ca, Mg, S, Fe, Mn, Cu, Zn and B. The interaction effects were not significant for most of the soil parameters and fruit and shoot nutrient concentration. In economic analysis the individual as well as interaction effects were highly significant and followed the same trend.

The investigation revealed that the ideal composition for growth medium (using thermochemical digest of degradable waste) for container cultivation of chillies is thermochemical digest, coirpith compost and soil in 1:2:1 proportion.

For yield maximization in chilli, the thermochemical digest of degradable waste has to be fortified with N P K fertilizers @ 100% of POP and to be applied at weekly intervals @ 25 g per plant.

സംഗ്രഹം

കേരള കാർഷിക സർവകലാശാലയിലെ ബിരുദാനന്തരബിരുദ പഠന പദ്ധതിയുടെ ഭാഗമായി വെള്ളായണി കാർഷിക കോളേജ് സോയിൽ സയൻസ് വിഭാഗത്തിൽ അതിവേഗ ഖരമാലിന്യ സംസ്കരണത്തിലൂടെ ഉത്പാദിപ്പിക്കുന്ന സമ്പുഷ്ട ജൈവവളം എങ്ങനെ മുളകിനുപറ്റിയ നടീൽ മിശ്രിതമാക്കാം എന്ന ഗവേഷണ പദ്ധതി 2014-2016 വർഷങ്ങളിൽ നടക്കുകയുണ്ടായി. ജൈവമാലിന്യത്തെ താപാരാസപ്രക്രിയയിലൂടെ വിഘടിപ്പിച്ചു ആവശ്യമായാ മൂലകങ്ങൾച്ചേർത്തു ഒറ്റദിവസംകൊണ്ടു സമ്പുഷ്ട ജൈവവളമാക്കിമാറ്റുവാനുള്ള സാങ്കേതികവിദ്യ ഈ വിഭാഗത്തിൽ വികസിപ്പിച്ചെടുത്തിട്ടുണ്ട്. ഈ ജൈവ വളത്തിനെ നടീൽമിശ്രിതമായി ഗ്രോബാഗിൽ ഉപയോഗപ്പെടുത്തുന്നതിനുള്ള സാധ്യതപരിശോധിക്കുകയും, അത് ഏതളവിൽ എപ്രകാരം നനൽകണമെന്നു നിർണയിക്കുകയായിരുന്നു ഈപഠനത്തിന്റെ ഉദ്ദേശ്യം. ഈ പഠനം രണ്ടുഘട്ടങ്ങളായാണ് ചെയ്തത്. ഒന്നാമത്തേതിൽ ഈ ജൈവവളം മറ്റുസസ്യ വളർച്ചാ മാധ്യമങ്ങളായ മണ്ണ്, ചകിരിച്ചോറ് / ചകിരിച്ചോറ് കംപോസ്റ്റ് എന്നിവയുമായി ഏതാനുപാതത്തിൽ ചേർക്കണമെന്നും, രണ്ടാമതായി ഇതിൽനിന്നുംകിട്ടുന്ന ഏറ്റവും നല്ല വളർച്ചാമാധ്യമത്തിൽ എത്രത്തോളം രാസവളം, ഏത് ആവൃത്തിയിൽ നൽകണമെന്നും കണ്ടുപിടിച്ചു . വെള്ളായണി അതുല്യ എന്ന മുളകിലാണ് പരീക്ഷണം നടത്തിയത്

ഏറ്റവും നല്ല നടീൽമിശ്രിതം ഒരു ഭാഗം തപാരാസപ്രക്രിയയിലൂടെ സംസ്ക്കരിച്ചെടുത്ത ജൈവവളം : രണ്ടു ഭാഗം ചകിരിച്ചോറ് കമ്പോസ്റ്റ് :ഒരു ഭാഗം മണ്ണ് എന്നതാണെന്ന് ഒന്നാമത്തെ പരീക്ഷണത്തിൽ തെളിയിച്ചു .രണ്ടാംഘട്ട പരീക്ഷണത്തിൽ കാർഷിക സർവകലാശാലാ ശുപാർശ പ്രകാരമുള്ള രാസവളത്തിന്റെ 75%, 100%, 125% എന്നിവ ഈ ജൈവവളവുമായി ചേർത്ത് ആഴ്ചയിലൊരിക്കൽ / രണ്ടാഴ്ച യിലൊരിക്കൽ എന്ന തോതിൽ നല്കി. ഇതിൽനിന്നും കാർഷിക സർവകലാശാലാ ശുപാർശ പ്രകാരമുള്ള രാസവാളത്തിന്റെ 100% ജൈവവളവുമായിചേർത്തു ആഴ്ച യിലൊരിക്കൽ 25 ഗ്രാം ജൈവവളമായി നൽകുന്നതാണ് ഏറ്റവും മികച്ചതെന്നു കണ്ടെത്തി .