NUTRIENT SCHEDULING IN BUSH PEPPER (*Piper nigrum* L.)

by

FARHANA C.

(2016-12-016)

THESIS

Submitted in partial fulfilment of the

requirement for the degree of

MASTER OF SCIENCE IN HORTICULTURE

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF PLANTATION CROPS AND SPICES

COLLEGE OF AGRICULTURE

VELLAYANI, THIRUVANANTHAPURAM-695 522

KERALA, INDIA

2018

DECLARATION

I, hereby declare that this thesis, entitled **"NUTRIENT SCHEDULING IN BUSH PEPPER (*Piper nigrum* L.)"** 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 of any degree, diploma, associateship, fellowship or othersimilar title, of any other University or Society.

Vellayani

Date: 29/9/2018

FARHANA C.

(2016-12-016)

CERTIFICATE

Certified that this thesis, entitled **"NUTRIENT SCHEDULING IN BUSH PEPPER (*Piper nigrum* L.)"** is a record of bonafide research work done independently by **Ms. Farhana C. (2016-12-016)** 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.

Place: Vellayani

Date: 29/9/2018

Dr. G. S. Sreekala
(Major Advisor, Advisory Committee)
Assistant Professor
Department of Plantation Crops & Spices,
College of Agriculture, Vellayani.

CERTIFICATE

We, the under signed members of the advisory committee of Ms. Farhana C. a candidate for the degree of **Master of Science in Horticulture** with major in Plantation Crops and Spices agree that the thesis entitled **"NUTRIENT SCHEDULING IN BUSH PEPPER (*Piper nigrum* L.)"** may be submitted by Ms. Farhana C. in partial fulfilment of the requirement for the degree.

29/9/18

Dr. G. S. Sreekala
(Chairman, Advisory Committee)
Assistant Professor
Department of Plantation Crops and Spices
College of Agriculture, Vellayani
Thiruvananthapuram

29/9/18

Dr. Deepa S. Nair
(Member, Advisory Committee)
Assistant Professor and Head
Department of Plantation Crops and Spices
College of Agriculture, Vellayani
Thiruvananthapuram

29/09/18

Dr. Shalini Pillai, P.
(Member, Advisory Committee)
Professor
Department of Agronomy
College of Agriculture, Vellayani
Thiruvananthapuram

29/9/2018

Dr. Biju Joseph
(Member, Advisory Committee)
Assistant Professor
Department of Soil Science and Agricultural Chemistry
College of Agriculture, Vellayani
Thiruvananthapuram

29.9.18

EXTERNAL EXAMINER

Dr. J. Prem Joshua, Ph.D.,
PROFESSOR & HEAD
FLORICULTURE RESEARCH STATION
TAMIL... ...CULTURAL UNIVERSITY
...AI - 629 302

ACKNOWLEDGEMENT

I humbly bow my head before God Almighty for all the blessings showered upon me to complete the thesis work successfully.

I am pleased to place my profound etiquette to major advisor ***Dr. G. S. Sreekala****, Assistant Professor, Department of Plantation Crops and Spices, College of Agriculture, Vellayani for her meticulous guidance, constructive suggestions, constant encouragement, affectionate advice and extreme patience right from conceptualization of the research work to preparation of the thesis.*

I express my deep-felt gratitude to ***Dr. Deepa. S. Nair****, Assistant Professor & Head, Department of Plantation Crops and Spices, College of Agriculture, Vellayani for her unambiguous advices, support and valuable suggestions throughout my research work.*

I consider it my honor in expressing my loyality to the member of my advisory committee ***Dr. Shalini Pillai, P****. Professor, Department of Agronomy, College of Agriculture, Vellayani for help, well timed support and worthy suggestions throughout my study.*

I sincerely express my profound gratitude to member of my advisory committee ***Dr. Biju Joseph****, Assistant Professor, Department of Soil science and Agricultural chemistry, College of Agriculture, Vellayani for the affectionate advise and support rendered in all phases of my thesis work.*

I thankfully acknowledge ***Dr. P. C. Jessykutty*** *(Retd) for her assistance and well timed support throughout my course programme.*

*My special thanks for **Dr. P. Babu Mathew**, Professor, Department of Agronomy, College of Agriculture, Vellayani for his help, motivation and support in the course of work.*

I express my immense gratitude to farm manager and all labourers for their timely help and support.

My special thanks goes to my classmates Avinash and Ajil for their help and support during the entire period of study.

I am indebted to my dear friends Sree, Daly, Anju, RA, Shamsi, Sooryaja and Reshu for their company, help, support and motivation. I accord my sincere thanks to my batchmates Divya, Shahiba, Geethu and Nagamani for their help. .

I express my gratitude to my seniors Sandra chechi, Aparna chechi, Afnatha, Ishratha, Nibinchettan for their help and support. It is my pleasure to express my special thanks to my dear juniors Anargha, Pooja, Nivya and Krishnaveni.

I am greatful to the KAU for awarding the KAU fellowship during my study.

Words are not enough to express my whole hearted and affectionate gratitude to my Uppa and Umma for their love. I express my love to my dear sister and my niece fidha mol who was there for me always. I also wish to express my warm gratitude to, ummamma, aunties, kakkus and other family members. I acknowledge with high sense of regards to my fiance Shebi for great support and love.

At the end. I felt elated to express my special thanks to those people who made this thesis possible.

FARHANA. C

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LIST OF ABBREVIATIONS

%	Per cent
@	At the rate of
µm	Micrometer
Al	Aluminium
AMF	Arbuscular Mycorrhizal Fungi
BCR	Benefit Cost Ratio
Ca	Calcium
CD	Critical Difference
cfu	Colony forming units
cm	Centimeter
cm^3	Centimeter cube
CRD	Completely Randomized Design
$dS\ m^{-1}$	deci Siemens per meter
EC	Electrical Conductivity
et al.	And others
Fe	Iron
Fig.	Figure
FYM	Farm Yard Manure
g	Gram
$g\ bush^{-1}$	Gram per bush
$g\ kg^{-1}$	Gram per kilogram
$g\ plant^{-1}$	Gram per plant
$g\ plant^{-1}$ year	Gram per plant per year
$g\ pot^{-1}$	Gram per pot

g $vine^{-1}$ $year^{-1}$	Gram per vine per year
ha	Hectare
i.e.	That is
IPC	International Pepper Community
IRR	Internal Rate of Return
K	Potassium
K_2O	Potash
KAU	Kerala Agricultural University
kg	Kilogram
kg ha^{-1}	Kilogram per hectare
kg pot^{-1}	Kilogram per pot
kg $vine^{-1}$	Kilogram per vine
MAP	Months After Planting
m^2	Square meter
meq	Milliequivalents
mg	Milligram
Mg	Magnesium
mg	Milli gram
mg m^{-2}	Milligram per meter square
Mg SO_4	Magnesium sulphate
ml	Millilitre
Mn	Manganese
MOP	Murate of potash
MSL	Mean Sea Level
N	Nitrogen
Na	Sodium

NHI	Nitrogen Harvest Index
No.	Number
NPW	Net Present Worth
NS	Non Significant
^oC	Degree Celsius
P	Phosphorus
P_2O_5	Phosphate
PGPR	Plant Growth Promoting Rhizobacteria
pH	Power of hydrogen
PHI	Phosphorus Harvest Index
$plant^{-1}year^{-1}$	Per plant per year
RUBP	Ribulose 1,5-bisphosphate
S	Sulphur
SE_m	Standard Error of mean
SOP	Sulphate of potash
t ha^{-1}	Tonnes per hectare
TNAU	Tamil Nadu Agricultural University
v/v	Volume by volume
vines ha^{-1}	Vines per hectare
Zn	Zinc

INTRODUCTION

1. INTRODUCTION

Black pepper, (*Piper nigrum* L.) christened as "King of spices" and "Black gold" is the most important and widely used spice in the world which originated from the tropical evergreen forest of Western Ghats. The black pepper of commerce is the dried mature fruits of the tropical climbing plant *Piper nigrum* L. Vietnam is the largest producer of pepper in the world accounting for about 41 per cent of total world production followed by Indonesia, India and Brazil (IPC, 2016). In India, black pepper is grown in about 1.29 lakh ha of land with production of 48500 tonnes (Spice Board, 2016). The black pepper is cultivated to a large extent in Kerala, Karnataka, Tamil Nadu and to a little extend in Goa, Orissa, Assam and Andaman Islands

The productivity of black pepper in Kerala is 2.5 times lower than that of Karnataka. The low productivity in Kerala is due to poor genetic potential of the vines, high population of senile and unproductive vines, losses caused by pests, diseases and soil constraints. An immediate improvement of productivity can be attained only by better agronomic practices. Thus nutrient management is one of the aspects that need to address immediately since it can increase the productivity as well as improve the general health of the plant and reduce pests and diseases.

The trailing nature of the black pepper limits its cultivation in rural areas only. Nowadays bush pepper raised from the plagiotropic shoots of pepper grown in pots is gaining momentum in urban horticulture. Growing bush pepper is one of the important suggestions to bridge the gap between demand and supply of black pepper (Madhura and Chandini, 2000). Since bush pepper does not need any standards for trailing, harvesting is quite easy and manageable. Raising bush pepper in 3-4 pots in households can thus meet the demand of the homes in urban areas (Lakshmana *et al.*, 2016).

Potting medium directly influence the growth, yield and quality of black pepper grown in pots. A conducive medium is thus necessary for better productivity.

Traditional potting mixture with soil, sand and farm yard manure needs to be replaced due to less availability of sand. Moreover the medium needs to be supplemented with fertilizers for increased growth and yield. Nutrient management is a complex process and to understand which nutrients and at what time these nutrients are to be applied, an analysis of plant nutrient status is required. This understanding will provide opportunity to optimize fertilizer rates and application timings.

The evaluation of nutrient uptake and partitioning can provide the foundation for fine-tuning nutrient management practices as producers aim for increased yields and profitability. Key nutrients for high yield in the production of bush pepper can be identified based on nutrient harvest index values and removal of a given nutrient. Hence the present investigation on "Nutrient scheduling in bush pepper (*Piper nigrum* L.)" was taken up with the objective of standardization of potting media and nutrient level in bush pepper for yield.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The investigation on "Nutrient scheduling in bush pepper (*Piper nigrum* L.)" was taken up with the objective to standardize potting media and nutrient level in bush pepper for yield. Growing bush pepper is one of the important alternatives to the vine pepper due to its potential for cultivation in urban households. The relevant literature on effect of potting media and nutrients on growth, yield, root, physiology, quality parameters and uptake of nutrients on black pepper are reviewed.

2.1 Influence of potting media on growth, yield, root, physiological and quality parameters of crops.

Bush pepper is the black pepper (*Piper nigrum* L.) plant in the shape of a bush grown with decorative and economic value which is raised from lateral branches or plagiotrops of yielding vines (Mol *et al*., 2017).

Growing of plants in pots restricts the roots and the demand made on the potting media for water, air and nutrients becomes much more intense than those made by plants grown in field which have greater volume of soil to grow (Bunt, 1988). Potting media is the substrate which provides physical support, moisture and aeration to the growing plants and plays a vital role in growth and development of plants. The important components of potting media are soil, sand, compost, FYM, vermiculite, peat, coco peat and perlite (Kala, 2017).

A study conducted by Bayu *et al.* (2012) revealed increased content of soil N, P and K on application of FYM. Khan *et al.* (2010) reported that FYM improved soil physical, chemical and biological properties. Sharangi (2011) reported that in the cultivation of black pepper variety Panniyur 1, organic matter supplementation by 25 per cent FYM along with 75 per cent urea was the best nutrient schedule under West Bengal climatic condition and the highest response of growth parameters was noticed in plant height (269.37 cm), plant fresh weight (533.80 g), plant dry weight (178.01 g) and relative growth rate (5.10 g $g^{-1}day^{-1}$) after 36 months of planting.

Edwards and Burrows (1988) reported that vermicompost is finely divided peat-like material with high porosity, aeration, drainage and water-holding capacity. Vermicomposting is the result of bio-oxidation and stabilization process of organic materials which involves action of both earthworms and bacteria without undergoing a thermophilic stage. The earthworms turn, fragment and aerate the composting materials (Dominguez *et al.*, 1997). The organic macro molecules are broken down by the action of several enzymes, intestinal mucous and antibiotics in the earthworm's intestinal tract (Doube and Brown, 1998). The excellent aeration, structure, porosity, drainage and moisture holding capacity of worm castings as well as the variety of essential plant nutrients in a readily available form make vermicompost a good potting media (Dominguez *et al.*, 1997; Metzger, 1998 and Atiyeh *et al.*, 2000). According to Winsome and Coll (1998) about 90 per cent of worm casting aggregates are water stable. Sinha *et al.* (2010) reported vermicompost as a slow release organic fertilizer. Vermicompost releases organic nitrogen and other nutrients in compost at constant rate from the accumulated humus. According to them, net overall efficiency of NPK of vermicompost over a period of years was significantly greater than 50 per cent of that of chemical fertilizers.

Composted coir pith resembles peat and has characteristics similar to that of sphagnum peat, the most commonly used rooting medium in horticulture and hence it is commercially known as coco peat (Bavappa and Gurusinghe, 1978; Karon *et al.*, 1999 and Rao, 1999). Coir pith compost has low bulk and particle density and the low particle density is due to high specific surface which gives high cation exchange capacity (Mapa and Kumara, 1995). It has high moisture retention capacity of 500–600 per cent and cation exchange capacity varies from 38.9 to 60 m eq/100 g (Evans *et al.*, 1996) which enables it to retain large amount of nitrogen and the absorption complex has high content of exchangeable K, Na, Ca and Mg (Verhagen and Papadopoulos, 1997). Srinivasan *et al.* (2005) found that application of composted coir pith @ 2.5 t ha^{-1} with full recommended dose of NPK (100:40:140 kg ha^{-1} of N, P_2O_5 and K_2O) resulted in highest yield in the third year (4.18 kg $vine^{-1}$) which was 21 per cent higher than the recommended NPK in black pepper.

Neem seed cake is the residue obtained after the extraction of oil from neem seed. It contains more nitrogen (2-5 %), phosphorus (0.5-1.0 %), calcium (0.5 -3 %), magnesium (0.3-1 %) and potassium (1 - 2 %) than farm yard manure or sewage sludge (Radwanksi and Wickens, 1981). Loss of nitrogen was prevented by the use of azadirachtin by preventing the activity of nitrifiers like *Nitrosomonas* and *Nitrobacter* (Usha and Patra, 2003; Gopal *et al.*, 2007).

Experiments conducted to evaluate the effects of neem seed cake on the main groups of soil microflora and some soil properties revealed that neem seed cake increased the population of organic nitrogen users and actinomycetes and reduced the population of fungi, *Nocardia, Bactoderma* and the whole population of inorganic nitrogen users which include nitrifying bacteria. Fluctuating effects on *Mycobacterium*, *Micromonospora* and *Arthrobacter* were noticed. Neem seed cake also significantly increased electrical conductivity, exchangeable calcium, iron, manganese, copper and zinc content (Elnasikh *et al.*, 2011). Neemcake helps to increase the nitrogen and phosphorous content in the soil. It is rich in sulphur, potassium, calcium, nitrogen thus nourishing the soil and plants by providing all the macro and micro-nutrients (Lokanadhan *et al.*, 2012).

Balanced use of nutrients through organic sources like farm yard manure, poultry manure, vermicompost, green manuring, neem cake and biofertilizers are prerequisites for sustaining soil fertility and producing maximal crop yield with optimal input levels (Dahiphale *et al.*, 2003).

Rooting and establishment of lateral cuttings of black pepper is rather less compared to the runner shoot. A success rate of 35 per cent was reported in bush pepper by Lakshmana *et al.* (2016) while the rate fluctuated between 10 to 40 per cent in farmer's nursery (Prakash *et al.*, 2016). Experiments conducted by Mol *et al.* (2017) to standardize potting mixture and humidity conditions for rooting and establishment of bush pepper cuttings of Panniyur 1 revealed that potting mixture containing coir pith compost kept in 8 x 5 cm black nursery bags under the humid chamber made by covering with thin white plastic sheet (200 μm) recorded the highest establishment (63.3 %).

Thankamani *et al.* (1996) noticed that in black pepper, vermicompost had a positive and significant effect on height and number of leaves after 3 and 6 months of growth. The height of cutting raised in vermicompost and in potting mixture containing soil, sand and farmyard manure (3:1:1 proportion) was 137.63 and 51.50 cm, respectively, after 6 months of growth. The number of leaves produced was higher in cuttings raised in vermicompost (20.07) compared to those raised in potting mixture (8.10) after 6 months. Prasath *et al.* (2014) revealed that composted coir pith with vermicompost in 3:1 proportion and *Trichoderma* @ 10 g kg^{-1} of potting mixture as an ideal potting medium for black pepper nursery. Maximum plant growth characteristics like plant height (13.28 cm), number of leaves (3.50), number of roots (20.88), root length (18.28 cm) and root:shoot ratio (0.42) was recorded in plants grown in the above media.

Thankamani *et al.* (2007) reported that black pepper cuttings raised in solarized potting mixture containing soil, sand, and farm yard manure in the proportion 2:1:1with recommended nutrients (urea, superphosphate, potash and magnesium sulphate 4:3:2:1) produced significant increase in number of leaves(5.3), length of roots (20 cm), leaf area (177 cm^2), nutrient content of leaves (N- 3.1 %, P-

0.21 % and K- 1.36 %) in the above treatment and 20 per cent increase in biomass production compared to non solarized potting mixture + recommended nutrients.

Application of decomposed coir pith, sand and farmyard manure increased dry matter production in black pepper (Srinivasan and Hamza, 2000). Akshay *et al.* (2014) worked on effect of media on black pepper cuttings and observed that the cuttings raised in the media comprising soil + sand + FYM + vermicompost (1:1:1:1 v/v) significantly increased days to sprout (15.93 days), number of leaves per cutting (6.70), length of shoot (20.26 cm) , percentage of sprouting (85.33 %), fresh weight (17.47 g), dry weight (6.65 g), minimum days to rooting (33.07 days), percentage of rooting (80 %), number of primary roots (11.07), fresh and dry weight of roots (5.08 g and 1.96 g respectively) whereas, the maximum root length (26.79 cm) was noticed in the media containing soil + sand + FYM + coir dust (1:1:1:1 v/v).

2.2 Influence of potting media on uptake of primary and secondary nutrients

Kayalvizhi *et al.* (2013) reported that media consisting of soil + sand + FYM + vermicompost (2:1:1:0.5 – 670 g + 335 g + 335 g + 165 g) significantly increased the leaf nutrient content of N, P and K in *Asparagus densiflorus* 'Meyersii'. Application of organic amendments (poultry droppings, goat droppings and cow dung) resulted in higher nutrient uptake (Ca, Mg, K and P) by maize plant relative to control (Nwokocha *et al.*, 2016). Ofosu *et al.* (2018) reported that total N, P, K and Mg uptake by oil palm seedlings was significantly influenced by the growing media. Nutrient uptake analysis of seedlings showed that growing media which included soil + rice husk biochar + compost (1:1:2) recorded the highest N uptake (1.29 g plant^{-1}), P uptake (0.15 g plant^{-1}) K uptake (0.70 g plant^{-1}) and Mg uptake (0.24 g plant^{-1}).

Diby *et al.* (2005) reported significant uptake of nitrogen (N) and phosphorus (P) and enhanced vigour of black pepper when inoculated with *Pseudomonas fluorescens* strains, due to higher root proliferation and nutrient mobilization especially that of P in the rhizosphere. *P. fluorescens* strains enhanced the P uptake by 122 per cent over control (non bacterised plants) and N uptake by 65 per cent over control resulting in increased root growth and biomass production.

In an experiment conducted at Peruvannamuzhi (Kerala), to study the feasibility of using soil-less medium containing coir pith compost and granite powder for raising black pepper (*Piper nigrum*) cuttings in the nursery, dry matter production and total uptake of nitrogen in the plant was comparatively higher for the treatment coir pith compost: granite powder (1:1) along with *Azospirillum* and phosphobacter (10^8 cfu ml^{-1} applied @ 50 ml bag^{-1}) followed by the treatment coir pith compost: granite powder: FYM (2:1:1). Higher uptake of phosphorous, potassium, calcium and magnesium was observed for the treatment coir pith compost: granite powder: FYM (2:1:1) followed by coirpith compost: granite powder (1:1) along with *Azospirillum* and phosphobacter (10^8cfu ml^{-1} applied @ 50ml bag^{-1}) and these values were on par with conventional potting mixture (Thankamani *et al*., 2007)

2.3 Influence of inorganic fertilizers on growth, yield, root, physiological and quality parameters.

Major nutrients N, P, K, secondary nutrients Ca, Mg and micronutrients especially Zn are the most important nutrients essential for black pepper growth, development and yield and their influence depend on their ratios in the soil as well as in the plant (Srinivasan *et al*., 2007).

A field experiment was conducted with organics and biofertilizers (*Azospirillum,* phosphobacteria and arbuscular mycorrhizal fungi) along with inorganic fertilizers in black pepper varieties Panniyur 1 and Panniyur 2. Treatment with 50 per cent N as FYM + 50 per cent N as inorganic along with 100 per cent P and K as inorganic in Panniyur 2 recorded higher yield while treatment with 50 % N as FYM + 50 % N and P as inorganic + *Azospirillum* + P solubilizers + AMF + 100 % K as inorganic recorded maximum yield in Panniyur 1 (Stephen and Nybe, 2003).

An experiment was conducted at Horticultural Research Station, Pechiparai to evaluate the performance of bush pepper variety Panniyur 1 both under the pot and field condition. The bush pepper grown in the field and pots were properly nourished with FYM, 5 Kg per bush along with 100 g of N, 140 g of P and 100 g of K. The bush pepper grown in pot had longer spike length and grains per spike but whereas the bush pepper grown in the field condition had more number of spikes bush^{-1}, green pepper yield and dry pepper yield. This practice of growing bush pepper in the field would reduce the cost of plucking and also the standard maintenance cost (Swaminathan, 2000).

Pillai *et al*. (1979) reported that an optimum ratio of 5:5:10 for N, P and K for obtaining maximum yield. Nybe and Nair (1986) observed a reduction in vegetative growth due to deficiency of N and P. The reduction in shoot growth and leaf area index was maximum in the case of deficiency of N (56 % and 63 %) followed by P (32 % and 2 %). Deficiency of P resulted in the highest reduction in root growth (45 %) followed by N (39 %). Deficiency of K however did not affect the growth of black pepper. Geetha and Aravindakshan (1992) reported that number of leaves, total leaf area, total and aerial biomass production differed significantly between vines and bush pepper and were dependent on nitrogen levels. Devadas and Chandini (2000) studied the influence of nutrients under different light intensities on growth of bush pepper (*Piper nigrum* L.) plants. Three levels of N, P (25.0, 37.5, 50.0 g bush^{-1}) and K (50, 75 and 100 g bush^{-1}) at three levels of shade intensity (50 %, 75 % and 100%) revealed better growth characters at 50 per cent light intensity and 37.5 g each of N and P and 50.0 g of K year^{-1}pot^{-1}.They reported that N and P had a significant effect on number and length of primary and secondary branches as well as on the number of leaves and leaf area. K had significant effect on number of primary branch, length of secondary branch, number of leaves and total leaf area.

Waard and Sutton (1960) reported that pepper applied with 240 kg N, 120 kg P_2O_5, 340 kg K_2O per ha produced the highest yield. Mohankumaran and Cheeran (1981) conducted a study on the nutrient requirement of pepper vines trained on dead and live standards reported that dead standards with 75 g N and 50 g K_2O vine^{-1} year^{-1} produced the highest yield of green berries per vine. Sadanandan (1993) reviewed an exhaustive series of fertilizer trials with pepper in major pepper growing countries of the world and reported that the levels of fertilizers used in India was very low and was perhaps one of the reasons for poor yield in the India. Studies conducted in farmers field over a period of four years (1979-84) showed that application of FYM, neem cake and bone meal @ 5, 1 and half kg vine^{-1} year^{-1} together with NPK fertilizer at a subdued level of 100, 40, 140 g vine^{-1} year^{-1} increased soil available K status by 45 per cent, leaf K status by 13 per cent and pepper yield by 172 per cent and there was 250 per cent increase in pepper yield.

Sadanandan and Hamza (1998) observed that application of NPK fertilizers @ 1, 0.5, 2 g plant^{-1} at bimonthly interval increased the spiking intensity and yield of bush pepper by 240 per cent over no fertilizers. Neem cake application @ 30 g pot^{-1} or ground nut cake @ 14 g pot^{-1} was equivalent to ferilizer application. Devadas (1997) found that bush pepper plants that received NPK fertilizers 37.5:37.5:50 g plant^{-1} year^{-1} at monthly interval recorded the highest number of spikes, number of developed berries, fresh weight of berries and dry weight of berries. Rao *et al.* (2010) revealed that dry spike yield was significantly increased due to integrated management of FYM and fertilizers in long pepper. Application of 40 t ha^{-1} FYM and 125:50:160 kg N, P_2O_5 and K_2O ha^{-1} gave significantly higher dry spike yield (2412 kg ha^{-1}) and also increased the piperine yield (32.3 kg ha^{-1}). Thankamani *et al.* (2011) reported that application of *Azospirillum* sp. in combination with 50 % recommended

N + Mg resulted in higher yield over application of recommended dose of fertilizer in black pepper.

Muthumanickiam (2003) reported soil application of 40 g P_2O_5 per vine as rock phosphate along with spraying of zinc sulphate 0.5% increased the dry pepper yield (9.21 kg vine^{-1}) and oleoresin content (12.34 %). Field experiments were conducted at two locations, viz., Kannur (Kerala) and Chettalli (Kodagu, Karnataka) for evaluating the efficacy of sulphate of potash (SOP) as a source of potassium (K) on black pepper. The results showed significantly higher yield, oleoresin and piperine content in the treatment recommended dose of K as SOP + SOP 2% as foliar spray (Srinivasan *et al.*, 2013).

Devadas (1997) reported that there was significant difference among dry matter production at three levels of N and P (25, 37.5 and 50 g bush^{-1}) while it was not affected by three levels of potassium (50, 75 and 100 g bush^{-1}).

Menon and Nair (1987) reported that specific leaf weight (mg m^{-2}) was higher in Karimunda than Panniyur 1. According to Geetha and Aravindakshan (1992) leaf area per plant in bush pepper depends primarily on the increasing leaf area while in vine pepper it is primarily dependent on the number of leaves produced. Increasing specific leaf weight improved apparent photosynthesis (Thomson *et al.*, 1996)

Asghar *et al.* (2010) conducted a study to investigate the effect of different NPK rates on growth and yield of maize cultivars Golden and Sultan. They observed that harvest index was markedly influenced by NPK application in different proportions.

Quantity of chlorophyll per unit area is an indication of photosynthetic capacity and productivity of a plant. The amount of chlorophyll in the leaf tissues can be influenced by nutrient availability and environmental factors (Otitoju and Onwurah, 2010).

The photosynthetic capacity of leaves is related to the nitrogen content because the protein content of the Calvin cycle and the thylakoids represent the majority of leaf nitrogen. Thylakoid nitrogen is proportional to the chlorophyll content. There are strong linear relationship between nitrogen and both RUBP carboxylase and chlorophyll. With increasing nitrogen per unit leaf area, the proportion of total leaf nitrogen in the thylakoids remains the same while the proportion in soluble protein increases (Evans, 1989). Nutrient treatments had influence on the chlorophyll content of leaves. Maximum chlorophyll content was recorded at 50g N, 50 g P and 75 g K per plant of bush pepper (Devadas, 1997).

Devadas (1997) found that N application had significant effect on the volatile oil content of berries and P application had significant effect on the oleoresin content of the berries. Manjunath *et al.* (2008) observed the highest protein content, protein yield and piperine content in long pepper plants receiving 100:40:140 kg N, P_2O_5, K_2O per hectare + 30 t FYM. Krishnamurthy *et al.* (2013) recorded the highest oleoresin content in black pepper plants receiving 0.5 % NPK (19:19:19) spray. The effect of *Azospirillum* along with nutrients influenced the yield of black pepper while no pronounced effect was noticed in the quality parameters (Thankamani *et al.*, 2014). Abhimannue (2016) reported oleoresin content was significantly influenced by fertigation levels and the highest oleoresin content of 15.10 kg ha^{-1} was noticed in water soluble NPK fertilizer + PGPR Mix 1 + fluorescent *Pseudomonas* in *Piper longum*.

2.4 Influence of inorganic fertilizers on plant uptake of primary and secondary nutrients

The critical stages of nutrient requirement are during initiation of flower primordial, flower emergence, berry formation and development (Raj, 1978). Sushama *et al.* (1989) found that first mature leaf of fruiting laterals just before flushing is ideal for foliar diagnosis.

Waard and Sutton (1960) reported that maximum uptake of NPK occurred when applied at 240 kg N, 120 kg P_2O_5 and 340 kg K_2O ha^{-1} in Malaysia. According to Waard (1964), the nutrient removal of black pepper variety Kuching with a plant population of 1729 vines ha^{-1} was 252.04 kg N, 31.75 kg P_2O_5 and 224.04 kg K_2O per hectare. Waard (1969) worked out critical levels of N, P, K, Ca and Mg as 2.7, 0.1, 2.0, 1.0 and 0.20 per cent respectively on dry weight basis below which deficiencies of the concerned element were expected to develop. Sim (1971) found that 233 kg N, 39 kg P_2O_5, 207 kg K_2O, 30 kg MgO, 105 kg CaO ha^{-1} were removed from the soil by seventeen year old vine.

Nagarajan and Pillai (1975) reported that Panniyur 1 is more nutrient exhaustive than Kalluvally for N, P, K, Ca and Mg and the order of nutrient removal was N >K>Ca> Mg> P. Geetha and Nair (1990) reported the order of nutrient removal as K>N>Ca>Mg> P>S>Fe >Mn>Zn in pepper.

Pillai and Sasikumaran (1976) observed that one hectare of pepper garden having a plant population of 1200 vines yielding on an average 1 kg dry pepper per vine removed 34 kg N, 3.5 kg P_2O_5 and 32 kg K_2O.

Nutrient uptake varies with varieties. Panniyur 1 removed higher N, P and K when compared to the Karimunda. Nutrient removal by an adult pepper vine of Panniyur 1 is 292 kg ha^{-1} N, 56 kg ha^{-1} P_2O_5, 405 kg ha^{-1} K_2O where as Karimunda removed 183 kg ha^{-1} N, 49 kg ha^{-1} P_2O_5, 376 kg ha^{-1} K_2O (Sadanandan, 1993). Ann (2012) reported that 293.08 kg of nitrogen, 46.41 kg of phosphorus, 264.95 kg of potassium, 35.4 kg of magnesium and 74.82 kg of calcium were removed by one hectare of pepper variety Semongok Aman with a population of 2000 plants per hectare.

Investigation on Panniyur 1 pepper variety in laterite soil indicated that application of 140 g N, 55 g P_2O_5 and 270 g K_2O $vine^{-1}$ $year^{-1}$ resulted in significant increase in the availability of N, P and K in the soil and resulted in higher uptake of nutrients by the pepper vine (Sivaraman *et al.*, 1987).

Azmil and Yau (1993) observed N content in various plant parts like leaves (2.30 %), branches (2.07 %), stem (1.96 %) fruit spikes (2.21 %) and flower (2.11 %) and N uptake by leaves (30 g $vine^{-1}$), branches (47.6 g $vine^{-1}$), stem (35.3 g $vine^{-1}$), spikes (0.7 g $vine^{-1}$), white pepper (36.4 g $vine^{-1}$) and flowers (2.1 g $vine^{-1}$).

According to Azmil and Yau (1993) P removed by leaves (3.64 g $vine^{-1}$) branches (2.58 g $vine^{-1}$) stem (3.96 g $vine^{-1}$), spikes (0.08 g $vine^{-1}$), white pepper (3.20 g $vine^{-1}$) and flowers (0.18 g $vine^{-1}$). K removed by various parts of pepper was worked out and the values obtained were leaves (28.73 g $vine^{-1}$), branches (28.70 g $vine^{-1}$), stem (19.60 g $vine^{-1}$), fruit spikes (0.05 g $vine^{-1}$), white pepper (42 g $vine^{-1}$) and flowers (1.40g $vine^{-1}$). Ca removal by plant parts were leaves (8.32 g $vine^{-1}$), branches (11.50 g $vine^{-1}$), stem (1.20 g $vine^{-1}$), fruit spikes (0.11 g $vine^{-1}$), white pepper (5.00 g $vine^{-1}$) and flowers (0.32 g $vine^{-1}$). Mg removed were leaves (4.55 g $vine^{-1}$), branches (5.98 g $vine^{-1}$), stem (5.04 g $vine^{-1}$), fruit spikes (0.10 g $vine^{-1}$), white pepper (5.80 g $vine^{-1}$) and flowers (0.22 g $vine^{-1}$).

Experiment conducted on evaluation of Sulphate of Potash (SOP) as potassium source on growth, yield and quality of bush pepper reported that leaf N content was the highest in treatment containing recommended K as MOP and Mg @ 25 kg ha^{-1} as Mg SO_4 (2.60 %). P content was maximum in 50 % of recommended K as SOP (0.21 %). Treatment containing 50 % of recommended K as SOP + SOP 2 % foliar Spray showed the highest K concentration of 3.62 %. Leaf calcium was maximum in recommended K as MOP, while control showed the highest content of leaf magnesium (Kandiannan and Srinivasan, 2007).

2.5 Nutrient content of organic sources

NPK content of FYM was reported to be 1 % N, 0.5 % P, 1 % K (KAU, 2016). According to TNAU (2016) on an average well decomposed FYM contains 0.5 % N, 0.2 % P_2O_5 and 0.5 % K_2O and vermicompost contains 0.5-1.50 % N, 0.1- 0.3 % P_2O_5, 0.15-0.56 % K_2O. Sadanandan (2000) reported that nutrient content of neem cake (3 % N, 0.7 % P_2O_5 and 1.6 % K_2O) and leaf litters (2 % N, 0.5 % P_2O_5 and 2.4 % K_2O). Coir board (2016) reported that nutrient status of coir pith organic manure is 1.26 % N, 0.06 % P_2O_5, and 1.20 % K_2O.

2.6 Nutrient harvest index of primary and secondary nutrients

Fageria and Baligar (2003) opined that Nitrogen Harvest Index (NHI) is very helpful in measuring N partitioning in crop plants, and it provides an evidence of how efficiently the plant utilized acquired N for grain production.

Rattunde and Frey (1986) reported that the NHI was positively associated with grain yield of oats and response of grain yields to environmental productivity but was inversely related to mean straw yield. A high NHI indicates increased partitioning of N to the grain (Bulman and Smith, 1994). According to Rao and Dao (1996) soil and crop management practices also influence NHI.

The NHI can be improved in crop plants by adopting appropriate soil and plant management practices. These practices are use of adequate N rate, source and time of application, planting efficient crop species or genotypes within species and use of legumes in the crop rotation (Fageria, 2014).

High yields would result in greater amounts of N and P in grains, but grain concentration of these nutrients would vary intricately. Harvest index was strongly related to NHI and Phosphorus Harvest Index (PHI) (Araujo and Teixeira, 2003).

The N harvest index was only slightly affected by N fertilization whereas the K harvest index tended to increase and the P harvest index increased strongly with increasing rates of N (Thiraporn *et al.*, 1992).

Accoding to Dass *et al.* (2010) the greatest values of nutrient harvest index were registered with farmers' practice, because under nutrient-stress conditions, the plant tries to extract more from the soil volume and converts maximum toward fruits for completion of its life cycle.

The impact of Arbuscular Mycorrhizal Fungi (AMF), inorganic phosphorus (P), and irrigation regimes was studied in an okra (*Abelmoschus esculentus*)–pea (*Pisum sativum*) cropping system in an acidic Alfisol. The fourteen treatments involoving AMF, inorganic phosphorus (50, 75, 100 % soil test based recommendation) and irrigation regime at 40 and 80 per cent available water capacity, generalized recommended NPK and irrigation and farmers practice revealed that N, P and K harvest index were significantly higher in farmers practice in okra while it was higher in the treatment AMF @ 12 kg ha^{-1} + 100 % P + 100 % NK + irrigation 80 % of available water capacity in pea (Kumar *et al.*, 2015).

2.7 Economics of cultivation

Mohammed *et al.* (2017) studied the financial feasibility and risk bearing ability of black pepper production. Results of economic performance indicators revealed that black pepper farming generated a total discounted revenue of birr 416,024.4 per hectare with benefit cost ratio of 5.7 and internal rate of return of 61 per cent. The finding also indicated that harvesting cost accounted for the higher share (about 51 %) of the total cost of black pepper production. The findings in general reveal that, in spite of high initial investment cost and long gestation period, black pepper farming is a financially viable and a less risky enterprise.

2.8 Incidence of pests and diseases

According to Anandaraj and Sharma (1995) leaf rot and blights of black pepper are caused by *Rhizoctonia solani*, *Pythium* sp. and *Colletotrichum* sp. In the case of *R. solani* greyish spots develop on the leaves and the infected leaves remain attached to one another. *Colletotrichum* spots are characterized by a yellowish halo surrounding the necrotic spots. These diseases can be prevented by collecting runner shoots from healthy gardens and by spraying Bordeaux mixture (1kg). Phytosanitation plays an important role in reducing the inoculum build up. The affected vines should be removed and destroyed.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The investigation on "Nutrient scheduling in bush pepper (*Piper nigrum* L.)" was undertaken in the Department of Plantation Crops and Spices, College of Agriculture, Vellayani, during the period of May 2017- May 2018, to standardize potting media and nutrient level in bush pepper for yield. The materials utilized and methods followed for the experiment are presented in this chapter.

3.1 EXPERIMENTAL SITE

The pot culture experiment was carried out at the Instructional Farm, College of Agriculture, Vellayani located at 8^{o} 42' North latitude and 76^{o} 98' East latitude at an altitude of 29m above MSL.

3.2 SEASON

The experiment was conducted from May 2017 to May 2018.

3.3 MATERIALS

3.3.1 Planting material

Rooted cuttings of bush pepper, variety "Panniyur 1" were collected from Coconut Research Station, Balaramapuram and planted in pots.

3.3.2 Pots

Mud pots of size 30cm diameter were used for the experiment.

3.3.3 Potting media

Potting media consisted of combinations of soil, FYM, Neem cake, coir pith compost, vermicompost, sand and leaf compost. Dried FYM was collected from

Department of Animal Husbandry, College of Agriculture, Vellayani. Neem cake, coir pith compost and vermicompost were purchased. Leaf compost was prepared in Department of Plantation Crops and Spices, College of Agriculture, Vellayani.

3.3.4 Fertilizers

Urea (46 per cent N), Mussooriephos (20 per cent P_2O_5) and Muriate of potash (60 per cent K_2O) were used as inorganic source of N, P, K and foliar fertilizer (13:0:45) was used in treatments where foliar application was included.

3.4 METHODS

3.4.1 Design of the experiment

Design : CRD

Treatments : 16

Replications : 3

No of pots treatment^{-1} : 2

3.4.1.1 Treatments

Potting media (P)

P_1 - soil + FYM + neem cake + coir pith compost (3:3:1:1)

P_2 - soil + FYM + vermicompost + coir pith compost (3:3:1:1)

P_3 - soil + FYM + leaf compost + coir pith compost (3:3:1:1)

Inorganic fertilizers (I)

I_1 - 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits

I_2 - 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits

I_3	-	25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits
I_4	-	25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits
I_5	-	12.5:12.5:25.0 g of NPK plant^{-1} year^{-1} as soil application at equal monthly splits up to 3 MAP and foliar application of 13:0:45 (0.5%) at fortnightly intervals from 4th MAP.

Treatment combinations:

p_1i_1	-	soil + FYM + neem cake + coir pith compost (3:3:1:1) and 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits.
p_1i_2	-	soil + FYM + neem cake + coir pith compost (3:3:1:1) and 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits.
p_1i_3	-	soil + FYM + neem cake + coir pith compost (3:3:1:1) and 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits.
p_1i_4	-	soil + FYM + neem cake + coir pith compost (3:3:1:1) and 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits.
p_1i_5	-	soil + FYM + neem cake + coir pith compost (3:3:1:1) and 12.5:12.5:25.0 g of NPK plant^{-1} year^{-1} as soil application at equal monthly splits up to 3 MAP and foliar application of 13:0:45 (0.5%) at fortnightly intervals from 4th MAP.
p_2i_1	-	soil + FYM + vermicompost + coir pith compost (3:3:1:1) and 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits.
p_2i_2	-	soil + FYM + vermicompost + coir pith compost (3:3:1:1) and 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits.

p_2i_3 - soil + FYM + vermicompost + coir pith compost (3:3:1:1) and 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits.

p_2i_4 - soil + FYM + vermicompost + coir pith compost (3:3:1:1) and 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits.

p_2i_5 - soil + FYM + vermicompost + coir pith compost (3:3:1:1) and 12.5:12.5:25.0 g of NPK plant^{-1} year^{-1} as soil application at equal monthly splits up to 3 MAP and foliar application of 13:0:45 (0.5%) at fortnightly intervals from 4th MAP.

p_3i_1 - soil + FYM + leaf compost + coir pith compost (3:3:1:1) and 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits.

p_3i_2 - soil + FYM + leaf compost + coir pith compost (3:3:1:1) and 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits.

p_3i_3 - soil + FYM + leaf compost + coir pith compost (3:3:1:1) and 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits.

p_3i_4 - soil + FYM + leaf compost + coir pith compost (3:3:1:1) and 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits.

p_3i_5 - soil + FYM + leaf compost + coir pith compost (3:3:1:1) and 12.5:12.5:25.0 g of NPK plant^{-1} year^{-1} as soil application at equal monthly splits up to 3 MAP and foliar application of 13:0:45 (0.5%) at fortnightly intervals from 4th MAP.

Control - package of practices recommendations (KAU, 2016) - potting mixture (soil + sand + FYM, 1:1:1) 1.0:0.5:2.0 g of NPK plant^{-1} at bimonthly interval.

3.4.2 Preparation of potting media

Potting media were prepared with different sources of organic manures in the following proportion.

Potting media, P_1 - soil + FYM + neem cake + coir pith compost (3:3:1:1)

Potting media, P_2 - soil + FYM + vermicompost + coir pith compost (3:3:1:1)

Potting media, P_3 - soil + FYM + leaf compost + coir pith compost (3:3:1:1)

Control - soil + sand + FYM (1:1:1).

P_1, P_2, P_3 and control were prepared separately (Plate. 1) and filled in pots @ 10 kg pot^{-1}. Trichoderma @1 g kg^{-1} was mixed with the potting media.

3.4.3 Preparation of leaf compost

Preparation of leaf compost is shown in plate. 2.

A shaded area was selected and cleaned for composting. Fallen jack leaves were collected, spread in a circle of radius 1m up to a height of 10 cm and moistened. 10 g of composting inoculum obtained from of Department of Agricultural Microbiology, College of Agriculture, Vellayani was used. Cow dung slurry was spread over the composting inoculum. This was covered with second layer of leaves to a thickness 10 cm and composting inoculums and cow dung slurry were spread. The process was repeated till it reached a height of 75cm. Then it was allowed to decompose. Water was sprinkled on alternate days. Turning of heap was done at 15 days interval. It took 2 months for complete decomposition. Leaf compost was collected and shade dried.

Plate 1a. Potting media (P_1)

Plate 1b. Potting media (P_2)

Plate 1c. Potting media (P_3)

Plate 1d. Potting media - control

Plate 1. Different types of potting media

Plate 2a. Composting inoculum

Plate 2b. Application of composting Inoculums

Plate 2c. Spresding of cowdung slurry

Plate 2d. Heap of leaf for composting

Plate 2. Preparation of leaf compost

3.4.4 Planting

The pots were filled with respective potting media to one fourth of the volume prior to planting of rooted cuttings. The rooted cuttings were removed from the polybag and transplanted into the pots. The pots were then filled with potting media upto the brim. Lime was applied @ 50 g plant $^{-1}$ to all pots.

3.4.5 Fertilizer application

Fertilizer application was done at monthly, bimonthly, quarterly intervals as per the treatments. The quantity of fertilizer applied for each treatment is given in appendix 1. Fertilizer application and foliar spraying are presented in Plate. 5 and Plate.6 respectively.

3.5 AFTER CULTIVATION

3.5.1 Weeding and Irrigation

Hand weeding was done as and when needed and timely irrigation was also given.

3.5.2 Plant protection

Leaf rot was noticed one month after planting, which was controlled by spraying of Ridomil Gold @ 0.2 % twice at one week interval

3.6 OBSERVATION

3.6.1 Growth parameters

The observations on growth parameters were taken from two plants at bimonthly intervals from 2 MAP to 12 MAP for each treatment and the mean was worked out.

Plate 3. Field overview 4 months after planting

Plate 4. Field overview 12 months after planting

Plate 5. Fertilizer application

Plate 6. Foliar spraying

3.6.1.1 Plant height

The height of the plant was taken from the base of the plant to the base of the young fully opened leaf and expressed in cm

3.6.1.2 Number of primary branches

The number of primary branches per plant was counted and recorded

3.6.1.3 Number of secondary branches

The number of secondary branches per plant was counted and recorded

3.6.1.4 Length of primary branches

The length of primary branches was measured from base of the branch to the base of the youngest fully opened leaf and expressed in cm

3.6.1.5 Length of primary branches

The length of secondary branches was taken from base of the secondary branch to the base of the youngest fully opened leaf and expressed in cm

3.6.1.6 Number of leaves

Total number of fully opened leaves per plant was counted and recorded at bimonthly interval.

3.6.1.7 Leaf length

Five leaves per plant were selected randomly and leaf length is measured and expressed in cm.

3.6.1.8 Leaf width

Leaves used for measuring the leaf length were used for recording the width of the leaves. The width was measured at the broadest part of the leaves and expressed in cm.

3.6.1.9 Leaf area

The leaf area for individual leaf was estimated using equation

$LA= L\times W\times 0.61$ (Ibrahim *et al.*, 1985)

Where,

LA= Leaf area

L= Length of leaves

W= Width of leaves

The average leaf area was worked out from the leaf length and leaf width recorded. This was multiplied with a constant and number of leaves to get total leaf area and was expressed in cm^2.

3.6.2 Yield parameters

3.6.2.1 Number of spikes per plant

The number of spikes of each plant at harvest till 12 MAP was counted and expressed as the total number of spikes per plant.

3.6.2.2 Length of spike

Five spikes were randomly selected from each plant at harvest till 12 MAP and the length was measured and the mean length worked out and recorded in cm.

3.6.2.3 Number of berries per spike

Number of berries on each spike was counted at harvest upto 12 MAP from five randomly selected spikes and the average worked out and recorded

3.6.2.4 Fresh weight of berries per plant

The berries were separated from the spikes and the fresh weight was taken using electronic balance and recorded in g.

3.6.2.5 Dry weight of berries per plant

The berries were oven dried at $70^{o}\pm5^{o}$ C until constant weight was obtained and expressed in g.

3.6.2.6 Hundred berry weight

Five spikes were selected randomly from each plant and the berries were separated. From this hundred berries were randomly selected and weighed using an electronic balance and expressed in g (Thankamani, 2000).

3.6.2.7 Hundred berry volume

Twenty ml of water was taken in a measuring cylinder and 100 berries were immersed in water for one minute. Hundred berry volume was determined by observing water displacement (Thankamani, 2000).

3.6.3 Root parameters

3.6.3.1 Fresh weight of roots

After carefully removing the plant from the pot at 12 MAP. The roots were washed gently in tap water to remove all adhering soil particles and allowed to air dry. Then roots were separated by cutting at soil level and fresh weight of the root was recorded using electronic balance and the mean was expressed in g.

3.6.3.2 Dry weight of roots

The roots were dried in a hot air oven at $70^{o}\pm5^{o}$ C till constant weight was obtained and the mean was expressed in g (Bruns and Croy, 1985).

3.6.3.3 Volume of roots

The fresh roots was harvested at 12 MAP and washed gently to remove the adhering soil particles and was air dried. The roots were then placed in measuring beaker and volume displaced was recorded and expressed in cm^3 (Bruns and Croy, 1985).

3.6.4 Physiological parameters.

3.6.4.1 Dry matter production

Leaves, stem, root, spikes and berries of the uprooted plants were separated and dried to a constant weight at $70^{o}\pm5^{o}$ C in a hot air oven. The sum of dry weight of component parts gave the total dry matter production of plant and mean value expressed as g $plant^{-1}$(Thankamani, 2000).

3.6.4.2 Specific leaf weight

From each plant, fully expanded five leaves were collected. Leaf area was measured by using the formula by (Ibrahim *et al.*, 1985). Then leaves were dried at $70^{0}\pm5^{0}$ C in a hot air oven to a constant weight. SLW was calculated using the formula.

$$\text{SLW (g m}^{-2}\text{)} = \frac{\text{Leaf dry weight}}{\text{Leaf area}}$$ (Amanullah, 2015)

3.6.4.3 Harvest index

Harvest index was calculated at final harvest as the ratio of dry weight of berries to the dry weight of whole plant.

$$\text{Harvest Index (HI)} = \frac{Y_{econ}}{Y_{bio}}$$

Y_{eco} = Total dry weight of berries

Y_{bio} = Total dry weight of plant

3.6.4.4 Moisture percentage

Fresh berries were weighed and oven dried at $70^{o}\pm5^{o}$ C till constant weight was obtained. Moisture percentage was calculated by using formula.

$$\text{Moisture percentage} = \frac{A-B}{A} \times 100$$

Where, A = Fresh weight of berries (g).

B = Dry weight of berries (g).

3.6.4.5 Drying percentage

Drying percentage was calculated at harvest. Fresh berries was weighed and kept in hot air oven at $70^{o}\pm5^{o}$ C till constant weight was obtained. The dry weight was then noted and drying percentage was expressed as given below.

Drying percentage (%) = B /A X 100

Where, A = Fresh weight of berries (g).

B = Dry weight of berries (g).

3.6.4.6 Chlorophyll content (6 MAP and at harvest)

Total chlorophyll content of the leaves were estimated at 6 MAP and 12 MAP by Spectrophotometric method (Starnes and Hardly, 1965) and expressed in mg g^{-1} of fresh leaf weight.

$$\text{Chlorophyll a} = 12.7\,(A_{663}) - 2.69\,(A_{645}) \times \frac{V}{1000 \times W}$$

$$\text{Chlorophyll b} = 22.9\,(A_{645}) - 4.68\,(A_{663}) \times \frac{V}{1000 \times W}$$

$$\text{Total chlorophyll} = 20.2\,(A_{645}) + 8.02\,(A_{663}) \times \frac{V}{1000 \times W}$$

Where,

A= Absorbance at specific wave length (645 and 663 nm)

V= final volume of 100 per cent acetone extract

W= Fresh weight of leaf tissue in g

3.6.5 Quality parameters of berries

3.6.5.1 Starch

Starch content of berries was analyzed at harvest by acid hydrolysis method (Pruthi, 1999) and expressed as percentage on dry weight basis.

3.6.5.2 Total ash

The berries were oven dried at $70^{\circ} \pm 5^{\circ}$ C and ground. 2 g of powdered sample was placed in a crucible, weighed accurately, and slowly carbonized using a muffle furnace 550±25°C until the sample turned into white ash to constant weight. The ash was weighed and the percentage of total ash was calculated (FSSAI, 2015).

3.6.5.3 Essential oil

The content of essential oil was estimated at harvest by Clevenger distillation method (Pruthi, 1999) and expressed as percentage (w/w) on dry weight basis.

3.6.5.4 Oleoresin

The oleoresin content was estimated by soxhlet extraction method using acetone as solvent and expressed as percentage on dry weight basis (Pruthi, 1999).

3.6.5.5 Piperine

The piperine content in dried berries was determined by spectrophotometric method described by Sowbhagya *et al.* (1990). Freshly powdered oven dried berries (100 mg) was transferred to a 100ml volumetric flask. The volume was made up with 100 per cent acetone. The flask was shaken well and allowed to settle for 2 h under dark condition. Then 0.5 ml of the solution was pipetted out from the volumetric flask and made upto 5 ml with acetone. The absorbance of the solution was read at 337 nm with acetone as blank. The standard values for pure piperine at different concentrations were also worked out following the same procedure and standard curve for piperine was plotted.

3.6.6 Analysis of soil and potting medium (before and after the experiment)

Potting media (P_1, P_2, P_3 and control) were collected at the time of potting media preparation were analysed for pH, EC, organic carbon, availabe N, P, K, Ca, Mg and S. Potting media were collected from each pot after the experiment and analysed for pH, EC, organic carbon, availabe N, P, K, Ca, Mg and S as detailed in table 1.

Table 1. Details of method used for chemical analysis of potting media

SI. No	Parameters	Method of estimation	Reference
1	pH	pH meter (1:2.5 soil water ratio)	Jackson (1973)
2	Electrical conductivity	Conductivity meter (1:2.5 soil water ratio)	Jackson (1973)
3	Organic carbon	Walkley and Black rapid titration method	Walkley and Black (1934)
4	Available N	Alkaline permanganate method	Subbiah and Asija (1956)
5	Available P	Bray extraction and photoelectric colorimetry	Jackson (1973)
6	Available K	Neutral normal ammonium acetate extraction and estimation using flame photometry	Jackson (1973)
7	Available Ca	Ammonium acetate method and estimation using atomic absorption Spectrophotometer	Hesse (1971)
8	Available Mg	Ammonium acetate method and estimation using atomic absorption Spectrophotometer	Hesse (1971)
9	Available S	Calcium chloride extraction and estimated by turbidimetry	Chesnin and Yien (1950)

3.6.7 Analysis of nutrient content of organic sources utilized.

Nitrogen, phosphorus, potassium content of FYM, coir pith compost, vermicompost, leaf compost, and neem cake was analyzed using the methods mentioned in table 3. The nutrient content of organic sources used are presented in table 2.

Table 2. Nutrient content of organic sources utilized

Organic sources	N (%)	P (%)	K (%)
FYM	0.50	0.41	0.64
Neem cake	1.20	0.75	0.78
Vermicompost	1.28	1.36	0.77
Leaf compost	1.18	0.95	0.68
Coir pith compost	0.45	0.46	0.18

3.6.8 Plant uptake of N, P, K, Ca, Mg and S of roots, leaves, stem and spikes at harvest stage

The plant samples were analysed for N, P, K, Ca, Mg, S by adopting standard procedure (Table 3). The plant samples were separated in to leaves, stem, root and spikes and dried in hot air oven at $70^{o}\pm5^{o}C$ till a constant weight was obtained. Dried samples were ground and used for analysis.

Table 3: Analytical methods followed in plant analysis

SI. No	Parameters	Method	Reference
1	Total N	Modified microkjeldal method	Jackson (1973)
2	Total P	Vanadomolybdate phosphoric yellow colour method	Piper (1966)
3	Total K	Flame photometry	Jackson (1973)
4	Total Ca, Mg	Diacid digestion and estimation using atomic absorption specrtrometry	Piper (1966)
5	Total S	Diacid digestion and estimation by turbidimetric method	Chesnin and Yien (1950)

The uptake of N, P, K, Ca, Mg and S by the plant was calculated by multiplying the nutrient content of the plant with respective dry weight of the plant parts and expressed as g plant^{-1}.

3.6.9 Nutrient harvest index (N, P, K, Ca, Mg and S)

Nutrient harvest index of different nutrients was computed using formula by Dass *et al*. (2010).

$$\text{Nutrient harvest index} = \frac{\text{Uptake of a particular nutrient by berries g plant}^{-1}}{\text{Total uptake of that nutrient in biomass g plant}^{-1}} \times 100$$

3.6.10 Economics of cultivation

Bush pepper requires long gestation period to generate profit. Since bush pepper is a perennial crop, fifteen years of cost of production and yield data were calculated for each treatment on per pot basis. Financial evaluation tools

(Harberger, 1972), such as net present Worth (NPW), discounted benefit cost ratio and internal rate of return (IRR) were used for the analysis.

NPW= Sum of discounted benefit stream – Sum of discounted cost stream

Discounted BCR= Sum of discounted benefit stream / Sum of discounted cost stream

$IRR = \sum (B_t - C_t) / (1+i)^t = 0$

Where B_t = Benefit in each year

C_t = Cost in each year

t = 1, 2, 3,……… N

n = number of years

i = interest (discount) rate

3.6.11 Incidence of diseases

Leaf rot was noticed one month after planting, which was controlled by spraying of Ridomil Gold @ 0.2 % twice at one week interval.

3.6.12 Incidence of pests

There was no incidence of pest during the crop period.

3.6.13 Statistical analysis

Statistical analysis was carried out for 15 treatments and 1 control (Factorial CRD) with two factors, potting media and inorganic fertilizers. Critical difference (CD) values at 5% level of significance were provided whereever the effects were found to be significant.

RESULTS

4. RESULTS

The results of the experiment conducted during 2017-2018 to standardize potting media and nutrient level in bush pepper for yield are presented in this chapter.

4.1 MORPHOLOGICAL PARAMETERS

4.1.1 Growth parameters

4.1.1.1 Plant height

The main and interaction effect of potting media and inorganic fertilizers on height of bush pepper at different periods of crop growth are furnished in table 4.

Significant variation in plant height was observed in potting media throughout the crop period. Plants which were raised in P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest plant height at all growth periods. P_3 (soil + FYM + leaf compost + coir pith compost in the ratio 3:3:1:1) was found to be on par with P_2 throughout the growth period. P_2 and P_3 recorded a plant height of 63.60 cm and 61.00 cm respectively at 12 MAP.

With regard to the effect of inorganic fertilizers, significant difference was noticed at different periods of crop growth. I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) resulted in highest plant height at 2 MAP, was on par with I_3 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits) and I_5 (12.5:12.5:25.0 g of NPK plant^{-1} year^{-1} as soil application at equal monthly splits up to 3 MAP and foliar application of 13:0:45 (0.5 %) at fortnightly intervals from 4th MAP). I_5 recorded the highest plant height from 4 MAP to 12 MAP, which was on par with I_3 and I_4. Plant height of 62.44 cm was recorded by I_5 at 12 MAP was on par with I_3, I_4 and I_2.

Interaction effect between potting media and inorganic fertilizers was nonsignificant at 2 MAP and significant from 4 MAP to 12 MAP. Treatment combination p_2i_5 (potting media- soil + FYM + vermicompost + coir pith compost in

Table 4. Effect of potting media and inorganic fertilizers on plant height, cm

Treatments	2MAP	4MAP	6MAP	8MAP	10MAP	12MAP
Potting media (P)						
P_1	31.28	42.00	44.60	46.87	47.82	49.60
P_2	42.60	54.40	57.40	59.00	60.40	63.60
P_3	37.60	50.73	53.40	56.07	58.50	61.00
SEm±	2.320	2.180	2.110	1.830	1.780	1.652
CD (0.05)	6.750	6.320	6.130	5.310	5.160	4.794
Inorganic fertilizers (I)						
I_1	30.66	44.44	45.83	47.22	48.00	50.56
I_2	33.11	44.11	47.18	50.22	53.22	56.33
I_3	42.03	52.44	56.32	57.78	59.48	60.44
I_4	42.67	49.67	53.11	55.89	57.56	60.56
I_5	37.33	54.56	56.56	58.78	59.61	62.44
SEm±	3.000	2.810	2.730	2.360	2.300	2.133
CD (0.05)	8.710	8.160	7.920	6.850	6.660	6.189
Interaction (p×i)						
p_1i_1	17.63	20.67	23.67	26.00	26.67	29.33
p_1i_2	23.33	33.67	36.33	40.67	43.33	46.33
p_1i_3	40.77	54.00	56.67	56.33	56.77	57.67
p_1i_4	36.33	46.00	49.67	53.67	54.33	57.67
p_1i_5	38.33	55.67	56.67	57.67	58.00	59.67
p_2i_1	37.67	58.33	57.17	58.00	58.33	62.33
p_2i_2	34.67	51.33	54.53	54.33	56.33	60.67
p_2i_3	42.33	52.00	57.97	60.00	62.00	62.67
p_2i_4	54.33	51.00	55.67	57.00	58.33	64.67
p_2i_5	44.00	59.33	61.67	65.67	67.00	67.67
p_3i_1	36.67	54.33	56.67	57.67	59.00	60.00
p_3i_2	41.33	47.33	50.67	55.67	60.00	62.00
p_3i_3	43.00	51.33	54.33	57.00	59.67	61.00
p_3i_4	37.33	52.00	54.00	57.00	60.00	62.00
p_3i_5	29.67	48.67	51.33	53.00	53.83	60.00
SEm±	5.200	4.870	4.730	4.090	3.980	3.694
CD (0.05)	NS	14.140	13.720	11.860	11.540	10.720
Control	17.00	28.00	30.33	34.00	36.33	38.00
Control Vs Treatment	S	S	S	S	S	S

the ratio 3:3:1:1 and inorganic fertilizers 12.5:12.5:25.0 g of NPK plant^{-1} year^{-1} as soil application at equal monthly splits up to 3 MAP and foliar application of 13:0:45 (0.5 %) at fortnightly intervals from 4th MAP) recorded the highest plant height from 4 MAP to 12 MAP. Plant height of 67.67 cm was recorded by p_2i_5 at 12 MAP. The treatment combinations p_1i_3, p_1i_4, p_1i_5, p_2i_1, p_2i_2, p_2i_3, p_2i_4, p_3i_1, p_3i_2, p_3i_3, p_3i_4 and p_3i_5 were found to be on par with p_2i_5 at 12 MAP. Significant difference in plant height in all periods of growth was recorded between treatment and control.

4.1.1.2 Number of primary branches

The main and interaction effect of potting media and inorganic fertilizers on number of primary branches of bush pepper at different growth periods are presented in table 5.

Potting media did not significantly influence the number of primary branches throughout the crop period. There was no significant variation in number of primary branches among the different inorganic fertilizers also at different growth periods of crop.

Interaction effect was not significant from 2 MAP to 10 MAP. At 12 MAP treatment combination p_2i_4 (7.33), (potting media (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) and inorganic fertilizers (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest number of primary branches, was on par with p_1i_3 (7.00) , p_1i_5 (6.67), p_3i_4 (6.67), p_2i_2 (6.33), p_2i_1 (6.00), p_3i_1 (5.67), p_3i_5(5.67), p_1i_4 (5.33) and p_2i_5 (5.33). The number of primary branches were noted non significant between treatment and control in all periods of growth.

4.1.1.3 Number of secondary branches

The effect of treatments on number of secondary branches at different periods of crop growth are shown in table 6.

Table 5. Effect of potting media and inorganic fertilizers on number of primary branches

Treatments	2MAP	4MAP	6MAP	8MAP	10MAP	12MAP
Potting media (P)						
P_1	1.87	4.53	4.67	5.00	5.27	5.40
P_2	2.20	4.13	4.13	4.47	4.80	5.87
P_3	2.07	4.53	4.73	5.00	5.07	5.20
SEm±	0.300	0.460	0.400	0.400	0.390	0.379
CD (0.05)	NS	NS	NS	NS	NS	NS
Inorganic fertilizers (I)						
I_1	1.67	3.78	4.11	4.33	4.56	5.11
I_2	2.22	3.89	3.89	4.22	4.33	4.78
I_3	2.11	4.89	4.89	5.11	5.11	5.22
I_4	2.44	5.33	5.56	5.67	5.89	6.44
I_5	1.78	4.11	4.11	4.78	5.33	5.89
SEm±	0.390	0.590	0.520	0.510	0.500	0.489
CD (0.05)	NS	NS	NS	NS	NS	NS
Interaction (p×i)						
p_1i_1	1.67	2.67	3.00	3.33	3.67	3.67
p_1i_2	1.33	3.33	3.33	3.67	3.67	4.33
p_1i_3	2.00	7.00	7.00	7.00	7.00	7.00
p_1i_4	2.00	5.00	5.33	5.33	5.33	5.33
p_1i_5	2.33	4.67	4.67	5.67	6.67	6.67
p_2i_1	1.67	4.00	4.00	4.00	4.33	6.00
p_2i_2	3.67	5.00	5.00	5.33	5.67	6.33
p_2i_3	1.67	3.67	3.67	4.00	4.00	4.33
p_2i_4	3.00	5.00	5.00	5.33	5.67	7.33
p_2i_5	1.00	3.00	3.00	3.67	4.33	5.33
p_3i_1	1.67	4.67	5.33	5.67	5.67	5.67
p_3i_2	1.67	3.33	3.33	3.67	3.67	3.67
p_3i_3	2.67	4.00	4.00	4.33	4.33	4.33
p_3i_4	2.33	6.00	6.33	6.33	6.67	6.67
p_3i_5	2.00	4.67	4.67	5.00	5.00	5.67
SEm±	0.670	1.030	0.900	0.890	0.870	0.848
CD (0.05)	NS	NS	NS	NS	NS	2.460
Control	1.66	5.00	5.00	5.33	5.33	5.33
Control Vs Treatment	NS	NS	NS	NS	NS	NS

Table 6. Effect of potting media and inorganic fertilizers on number of secondary branches

Treatments	2MAP	4MAP	6MAP	8MAP	10MAP	12MAP
Potting media (P)						
P_1	1.73	5.13	6.00	6.87	7.53	8.87
P_2	2.60	5.80	7.73	8.33	8.87	10.40
P_3	2.47	5.67	6.80	7.33	7.67	9.33
SEm±	0.390	0.196	0.185	0.204	0.200	0.211
CD (0.05)	NS	NS	0.536	0.591	0.580	0.612
Inorganic fertilizers (I)						
I_1	2.00	5.56	6.89	7.67	8.22	9.67
I_2	1.89	5.11	6.67	7.44	8.00	9.44
I_3	3.00	5.89	6.22	6.89	7.33	8.89
I_4	2.56	5.67	7.44	8.11	8.67	10.22
I_5	1.89	5.44	7.00	7.44	7.89	9.44
SEm±	0.510	0.253	0.238	0.263	0.258	0.272
CD (0.05)	NS	NS	0.692	0.763	0.749	0.790
Interaction (p×i)						
p_1i_1	1.33	4.67	5.67	6.67	7.33	8.67
p_1i_2	1.67	4.67	5.67	6.67	7.33	8.67
p_1i_3	3.67	5.67	6.67	7.67	8.33	9.67
p_1i_4	1.33	5.67	6.00	7.00	7.67	9.00
p_1i_5	0.67	5.00	6.00	6.33	7.00	8.33
p_2i_1	2.33	6.00	8.33	9.00	9.67	11.00
p_2i_2	3.33	6.33	8.00	8.67	9.33	10.67
p_2i_3	1.67	5.67	5.67	6.33	6.67	8.33
p_2i_4	3.33	5.33	9.33	10.00	10.33	12.00
p_2i_5	2.33	5.67	7.33	8.00	8.33	10.00
p_3i_1	2.33	6.00	6.67	7.33	7.67	9.33
p_3i_2	0.67	4.33	6.33	7.00	7.33	9.00
p_3i_3	3.67	6.33	6.33	6.67	7.00	8.67
p_3i_4	3.00	6.00	7.00	7.67	8.00	9.67
p_3i_5	2.67	5.67	7.67	8.00	8.33	10.00
SEm±	0.880	0.439	0.413	0.455	0.447	0.471
CD (0.05)	NS	NS	1.198	1.322	1.298	1.368
Control	1.33	2.33	5.66	5.66	7.00	8.33
Control Vs Treatment	NS	S	S	S	S	S

Potting media had no significant effect in number of secondary branches plant^{-1} from 2 MAP to 4 MAP. Potting media P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest number of secondary branches from 6 MAP to 12 MAP. Secondary branches of 7.33, 8.33, 8.87 and 10.40 were recorded by P_2 at 6 MAP, 8 MAP, 10 MAP and 12 MAP respectively.

There was no significant variation in number of secondary branches plant^{-1} between inorganic fertilizers from 2 MAP to 4 MAP. Inorganic fertilizer, I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest number of secondary branches from 6 MAP to 12 MAP. I_4 was found to be on par with I_1, I_2 and I_5 at 12 MAP.

Interaction effect was found to be non significant from 2 MAP to 4 MAP. Interaction was found significant from 6 MAP to 12 MAP. The treatment combination p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest number of secondary branches from 6 MAP to 12 MAP, was on par with p_2i_1 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1, inorganic fertilizers. 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits) and p_2i_2 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits). At 12 MAP, the highest number of secondary branches was recorded by p_2i_4 (12.00), was on par with p_2i_1 (11.00) and p_2i_2 (10.67). There was no significant difference in number of secondary branches plant^{-1} among treatments and control at 2 MAP. Subsequently significant difference was noticed between treatments and control.

4.1.1.4 Length of primary branches

The main and interaction effects of treatment on length of primary branches is provided in table 7.

Table 7. Effect of potting media and inorganic fertilizers on length of primary branches, cm

Treatments	2MAP	4MAP	6MAP	8MAP	10MAP	12MAP
Potting media (P)						
P_1	12.06	24.85	28.75	33.84	34.97	36.14
P_2	15.39	37.10	38.22	42.70	44.07	45.45
P_3	13.55	34.72	36.81	39.73	40.99	42.30
SEm±	2.080	1.421	0.923	0.499	0.495	0.497
CD (0.05)	NS	4.123	2.679	1.447	1.437	1.443
Inorganic fertilizers (I)						
I_1	11.10	26.78	31.09	38.66	39.90	41.17
I_2	9.82	31.17	33.36	38.76	40.02	41.29
I_3	15.01	32.84	34.56	36.13	37.39	38.70
I_4	18.41	36.17	38.22	40.31	41.57	42.88
I_5	13.99	34.17	35.74	39.92	41.18	42.46
SEm±	2.690	1.834	1.192	0.644	0.639	0.642
CD (0.05)	NS	5.323	3.459	1.869	1.855	1.863
Interaction (p×i)						
p_1i_1	5.33	14.00	22.80	34.00	35.10	36.27
p_1i_2	9.87	20.33	24.83	33.37	34.53	35.63
p_1i_3	15.53	27.77	30.00	33.10	34.23	35.40
p_1i_4	16.73	29.33	30.67	32.33	33.47	34.63
p_1i_5	12.82	32.83	35.43	36.40	37.53	38.77
p_2i_1	11.30	34.67	36.40	43.70	45.07	46.43
p_2i_2	12.92	36.83	37.23	42.83	44.20	45.63
p_2i_3	17.42	35.17	37.00	38.23	39.60	41.03
p_2i_4	16.32	41.00	44.67	47.60	48.97	50.40
p_2i_5	19.00	37.83	35.80	41.13	42.50	43.77
p_3i_1	16.67	31.67	34.07	38.27	39.53	40.80
p_3i_2	6.67	36.33	38.00	40.07	41.33	42.60
p_3i_3	12.08	35.60	36.67	37.07	38.33	39.67
p_3i_4	22.17	38.17	39.33	41.00	42.27	43.60
p_3i_5	10.17	31.83	36.00	42.23	43.50	44.83
SEm±	4.650	3.177	2.064	1.115	1.107	1.112
CD (0.05)	NS	NS	5.991	3.236	3.213	3.227
Control	9.16	19.50	25.33	28.90	32.06	32.33
Control Vs Treatment	NS	S	S	S	S	S

Potting media was found to have significant effect on length of primary branches from 4 MAP to 12 MAP. P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest length of primary branches from 4 MAP to 12 MAP. P_3 (soil + FYM + leaf compost + coir pith compost in the ratio 3:3:1:1) was found to be on par with P_2 during 4 MAP and 6 MAP.

Plants which received inorganic fertilizers I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) was found to produce the highest length of primary branches from 4 MAP to 12 MAP, and was found to be on par with I_5 (12.5:12.5:25.0 g of NPK plant^{-1} year^{-1} as soil application at equal monthly splits up to 3 MAP and foliar application of 13:0:45 (0.5 %) at fortnightly intervals from 4th MAP) from 4 MAP to 12 MAP.

The interaction effect between potting media and inorganic fertilizers was noted non significant during initial 4 months after planting, thereafter p_2i_4 (Potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest value. P_3i_4 (soil + FYM + leaf compost + coir pith compost in the ratio 3:3:1:1 and 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) was found to be on par with p_2i_4 at 6 MAP. Primary branches length of (50.40 cm) was recorded by p_2i_4 at 12 MAP. Significant difference in length of primary branches was noticed between treatment and control from 4 MAP to 12 MAP.

4.1.1.5 Length of secondary branches

The effect of treatments on length of secondary branches in different growth periods are presented in table 8.

Potting media significantly influenced the length of secondary branches from 4 MAP to 12 MAP. P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest length of secondary branches from 4 MAP to 12 MAP.

Table 8. Effect of potting media and inorganic fertilizers on length of secondary branches, cm

Treatments	2MAP	4MAP	6MAP	8MAP	10MAP	12MAP
Potting media (P)						
P_1	6.94	20.50	28.63	31.63	32.73	36.14
P_2	7.11	33.11	38.77	40.77	44.27	45.45
P_3	8.45	31.97	35.17	37.57	39.70	42.30
SEm±	1.050	0.860	0.468	0.468	0.491	0.497
CD (0.05)	NS	2.480	1.358	1.358	1.426	1.443
Inorganic fertilizers (I)						
I_1	6.80	25.57	34.16	36.62	39.16	41.17
I_2	6.53	25.49	33.86	36.32	39.13	41.29
I_3	9.96	28.29	31.59	34.06	36.57	38.70
I_4	7.32	33.97	35.91	38.38	40.03	42.88
I_5	6.89	29.33	35.46	37.92	39.61	42.46
SEm±	1.350	1.100	0.604	0.604	0.634	0.642
CD (0.05)	NS	3.200	1.753	1.753	1.841	1.863
Interaction (p×i)						
p_1i_1	4.33	11.67	28.83	31.83	32.93	36.27
p_1i_2	5.77	16.00	28.03	31.03	32.13	35.63
p_1i_3	11.95	23.33	27.80	30.80	31.90	35.40
p_1i_4	7.00	24.50	27.27	30.27	31.37	34.63
p_1i_5	5.67	27.00	31.23	34.23	35.33	38.77
p_2i_1	5.23	32.70	39.73	41.73	46.20	46.43
p_2i_2	6.50	32.00	39.00	41.00	45.43	45.63
p_2i_3	9.33	29.03	34.20	36.20	40.83	41.03
p_2i_4	5.83	40.00	43.73	45.73	47.67	50.40
p_2i_5	8.67	31.83	37.20	39.20	41.20	43.77
p_3i_1	10.83	32.33	33.90	36.30	38.33	40.80
p_3i_2	7.33	28.47	34.53	36.93	39.83	42.60
p_3i_3	8.60	32.50	32.77	35.17	36.97	39.67
p_3i_4	9.13	37.40	36.73	39.13	41.07	43.60
p_3i_5	6.33	29.17	37.93	40.33	42.30	44.83
SEm±	2.340	1.910	1.046	1.046	1.099	1.112
CD (0.05)	NS	5.550	3.036	3.036	3.189	3.227
Control	8.50	16.83	23.33	26.80	29.00	30.33
Control Vs Treatment	NS	S	S	S	S	S

However P_3 (soil + FYM + leaf compost + coir pith compost in the ratio 3:3:1:1) found to be on par with P_2 at 4 MAP.

Significant variation among inorganic fertilizers was noticed from 4 MAP to 12 MAP. I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest length of secondary branches from 4 MAP to 12 MAP. I_4 was found to be on par with I_5 (12.5:12.5:25.0 g of NPK plant^{-1} year^{-1} as soil application at equal monthly splits up to 3 MAP and foliar application of 13:0:45 (0.5 %) at fortnightly intervals from 4th MAP), I_2 (37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) and I_1 (37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits) at 8 MAP, 10 MAP and 12 MAP.

Interaction was significant from 4 MAP to 12 MAP and treatment combination, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest length of secondary branches from 4 MAP to 12 MAP. While at 10 MAP, treatment combination p_2i_4 was on par with p_2i_1 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) and p_2i_2 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits. Significant difference in length of secondary branches was observed between treatment and control from 4 MAP to 12 MAP.

4.1.1.6 Number of leaves

The main and interaction effect of potting media and inorganic fertilizers on number of leaves of bush pepper at different periods of crop growth are furnished in table 9.

There was significant difference in the number of leaves produced with different potting media from 4 MAP to 12 MAP. P_2 (soil + FYM + vermicompost +

Table 9. Effect of potting media and inorganic fertilizers on number of leaves

Treatments	2MAP	4MAP	6MAP	8MAP	10MAP	12MAP
Potting media (P)						
P_1	10.40	37.00	37.60	44.60	52.13	59.33
P_2	12.80	42.33	53.07	57.53	65.53	73.00
P_3	12.60	38.67	45.60	50.47	58.47	65.87
SEm±	1.180	1.900	1.919	1.294	1.230	1.186
CD (0.05)	NS	5.510	5.571	3.757	3.571	3.434
Inorganic fertilizers (I)						
I_1	9.22	36.33	43.67	49.67	57.00	63.12
I_2	11.78	36.67	43.67	48.56	56.22	64.13
I_3	14.33	37.89	44.33	48.67	57.26	64.44
I_4	10.22	37.56	48.78	56.11	63.67	70.89
I_5	14.11	39.33	46.67	51.33	59.44	66.78
SEm±	1.520	2.450	2.478	1.671	1.589	1.531
CD (0.05)	NS	NS	NS	4.850	4.610	4.443
Interaction (p×i)						
p_1i_1	6.67	23.00	28.33	37.67	44.67	51.67
p_1i_2	9.33	29.33	35.00	37.33	44.33	51.33
p_1i_3	15.33	30.33	40.67	52.33	60.67	68.00
p_1i_4	6.00	34.00	39.67	48.00	55.67	63.33
p_1i_5	14.67	37.00	44.33	47.67	55.33	62.33
p_2i_1	7.00	44.00	52.67	59.00	66.67	73.67
p_2i_2	16.67	44.67	49.67	57.67	65.00	73.00
p_2i_3	13.33	48.00	49.67	50.33	58.67	66.00
p_2i_4	10.67	40.67	64.33	67.67	75.33	82.33
p_2i_5	16.33	42.33	49.00	53.00	62.00	70.00
p_3i_1	14.00	42.00	50.00	52.33	59.67	67.00
p_3i_2	9.33	36.00	46.33	50.67	59.33	68.00
p_3i_3	14.33	35.33	42.67	43.33	52.33	59.33
p_3i_4	14.00	38.00	42.33	52.67	60.00	67.00
p_3i_5	11.33	38.67	46.67	53.33	61.00	68.00
SEm±	2.640	4.250	4.292	2.894	2.751	2.651
CD (0.05)	NS	NS	NS	8.400	7.985	7.695
Control	8.33	19.00	28.33	41.00	47.33	46.00
Control Vs Treatment	NS	S	S	S	S	S

coir pith compost in the ratio 3:3:1:1) produced the highest number of leaves from 4 MAP to 12 MAP. P_2 recorded the highest number of leaves (73.00) at 12 MAP.

Inorganic fertilizers were found to be non significant up to 6 MAP. Inorganic fertilizer I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) showed significantly high value from 8 MAP to 12 MAP. I_4 recorded the highest number of leaves (70.89) at 12 MAP.

Among the interaction, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) produced the highest number of leaves from 8 MAP to 12 MAP. Significant difference in number of leaves was noted between treatment and control from 4 MAP to 12 MAP.

4.1.1.7 Leaf length

The effects of treatments on leaf length at different growth period of crop are provided in table 10.

Potting media showed no significant difference in leaf length from 2 MAP to 6 MAP. Significant variation in leaf length was noticed among the potting media from 8 MAP to 12 MAP. P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest leaf length from 8 MAP to 12 MAP, which was on par with P_3 (soil + FYM + leaf compost + coir pith compost in the ratio 3:3:1:1).

Leaf length among inorganic fertilizers was found to be non significant throughout the period of observation.

Interaction effect was noted non significant at all periods of growth. There was no significant difference in leaf length between treatment and control throughout the period of observation.

Table 10. Effect of potting media and inorganic fertilizers on leaf length, cm

Treatments	2MAP	4MAP	6MAP	8MAP	10MAP	12MAP
Potting media (P)						
P_1	9.82	11.32	11.65	11.86	12.05	12.30
P_2	11.11	11.92	12.49	12.55	12.99	13.18
P_3	11.17	11.84	12.18	12.47	12.64	12.77
SEm±	0.470	0.368	0.280	0.190	0.230	0.240
CD (0.05)	NS	NS	NS	0.540	0.660	0.680
Inorganic fertilizers (I)						
I_1	10.07	11.14	11.70	11.88	12.28	12.60
I_2	11.11	11.53	11.83	12.00	12.32	12.43
I_3	11.08	11.71	12.40	12.60	12.76	12.83
I_4	10.07	12.38	12.51	12.70	12.76	12.89
I_5	11.18	11.71	12.09	12.29	12.68	13.00
SEm±	0.610	0.475	0.361	0.240	0.300	0.300
CD (0.05)	NS	NS	NS	NS	NS	NS
Interaction (p×i)						
p_1i_1	8.67	10.92	11.33	11.57	11.63	11.97
p_1i_2	9.83	10.17	10.67	10.83	11.23	11.23
p_1i_3	10.93	11.67	12.33	12.57	12.60	12.73
p_1i_4	8.50	12.53	12.53	12.90	12.90	13.17
p_1i_5	11.17	11.33	11.37	11.43	11.87	12.40
p_2i_1	11.20	11.67	12.00	11.73	12.37	12.67
p_2i_2	11.90	12.53	12.73	12.83	13.37	13.50
p_2i_3	10.10	11.23	12.50	12.57	12.93	12.97
p_2i_4	10.67	12.60	12.83	12.87	12.93	13.03
p_2i_5	11.67	11.57	12.40	12.73	13.33	13.73
p_3i_1	10.33	10.83	11.77	12.33	12.83	13.17
p_3i_2	11.60	11.90	12.10	12.33	12.37	12.57
p_3i_3	12.20	12.23	12.37	12.67	12.73	12.80
p_3i_4	11.03	12.00	12.17	12.33	12.43	12.47
p_3i_5	10.70	12.23	12.50	12.70	12.83	12.87
SEm±	1.050	0.822	0.625	0.420	0.510	0.530
CD (0.05)	NS	NS	NS	NS	NS	NS
Control	10.60	11.50	11.86	12.00	12.20	12.41
Control Vs Treatment	NS	NS	NS	NS	NS	NS

4.1.1.8 Leaf width

The main and interaction effects of treatment on leaf width are shown in table 11.

Potting media and inorganic fertilizers did not influence the leaf width at all periods of growth. Interaction effect was also non significant throughout the period of observation. There was no significant difference in leaf width between treatment and control from 2 MAP to 12 MAP.

4.1.1.9 Leaf area

The effects of treatments on leaf area at different periods of crop growth are provided in table 12.

Potting media had significant effect on leaf area from 4 MAP to 12 MAP. P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest leaf area from 4 MAP to 12 MAP. P_2 recorded the leaf area of 3798.07 cm^2, 4188.15 cm^2, 5057.97 cm^2 and 5823.13 cm^2 at 6 MAP, 8 MAP, 10 MAP and 12 MAP respectively.

Inorganic fertilizers did not influence the leaf area up to 6 MAP. Significant variation among inorganic fertilizers was noticed from 8 MAP to 12 MAP. I_4 (25.0: 25.0: 50.0 g of NPK $plant^{-1}$ $year^{-1}$ at quarterly splits) was found to be significant from 10 MAP to 12 MAP, which was on par with I_5 (12.5: 12.5: 25.0 g of NPK $plant^{-1}$ $year^{-1}$ as soil application at equal monthly splits up to 3 MAP and foliar application of 13:0:45 (0.5 %) at fortnightly intervals from 4^{th} MAP) and I_1 (37.5: 37.5: 50.0 g of NPK $plant^{-1}$ $year^{-1}$ at monthly splits).

The interaction effect was non significant from 2 MAP to 6 MAP. Significant difference was observed among the treatment combination from 6 MAP to 12 MAP. In the interaction effect p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 25.0: 25.0: 50.0 g of NPK $plant^{-1}$

Table 11. Effect of potting media and inorganic fertilizers on leaf width, cm

Treatments	2MAP	4MAP	6MAP	8MAP	10MAP	12MAP
Potting media (P)						
P_1	7.11	8.92	9.16	9.33	9.44	9.65
P_2	8.54	9.02	9.26	9.44	9.70	9.89
P_3	8.23	8.61	8.79	8.91	9.03	9.18
SEm±	0.490	0.320	0.290	0.272	0.240	0.240
CD (0.05)	NS	NS	NS	NS	NS	NS
Inorganic fertilizers (I)						
I_1	8.53	9.18	9.39	9.52	9.83	10.17
I_2	7.17	8.28	8.43	8.61	8.78	8.90
I_3	7.86	8.46	8.78	8.95	9.04	9.31
I_4	8.21	9.08	9.30	9.43	9.58	9.67
I_5	8.04	9.27	9.46	9.61	9.71	9.82
SEm±	0.630	0.410	0.370	0.351	0.310	0.310
CD (0.05)	NS	NS	NS	NS	NS	NS
Interaction (p×i)						
p_1i_1	7.77	9.07	9.17	9.43	9.50	9.73
p_1i_2	6.03	8.90	9.00	9.00	9.10	9.27
p_1i_3	7.27	8.70	9.10	9.40	9.60	10.03
p_1i_4	6.43	9.27	9.53	9.67	9.73	9.87
p_1i_5	8.07	8.67	9.00	9.17	9.27	9.33
p_2i_1	8.27	8.70	9.00	9.03	9.63	10.03
p_2i_2	8.17	8.17	8.47	8.90	9.23	9.27
p_2i_3	8.07	8.23	8.40	8.93	8.57	8.90
p_2i_4	10.27	10.15	10.50	10.60	10.87	10.93
p_2i_5	7.93	9.87	9.93	10.13	10.20	10.33
p_3i_1	9.57	9.77	10.00	10.10	10.37	10.73
p_3i_2	7.30	7.77	7.83	7.93	8.00	8.17
p_3i_3	8.23	8.43	8.83	8.93	8.97	9.00
p_3i_4	7.93	7.83	7.87	8.03	8.13	8.20
p_3i_5	8.13	9.27	9.43	9.53	9.67	9.80
SEm±	1.090	0.710	0.650	0.608	0.540	0.530
CD (0.05)	NS	NS	NS	NS	NS	NS
Control	6.46	8.10	8.23	8.30	8.46	8.56
Control Vs Treatment	NS	NS	NS	NS	NS	NS

Table 12. Effect of potting media and inorganic fertilizers on leaf area, cm^2

Treatments	2MAP	4MAP	6MAP	8MAP	10MAP	12MAP
Potting media (P)						
P_1	506.11	1923.32	2478.11	3056.83	3664.38	4358.72
P_2	773.06	2904.37	3798.07	4188.15	5057.97	5823.13
P_3	700.25	2382.95	2999.05	3427.32	4071.61	4713.01
SEm±	92.380	200.661	203.946	160.870	163.095	178.847
CD (0.05)	NS	582.355	591.888	466.872	473.330	519.046
Inorganic fertilizers (I)						
I_1	508.26	2358.26	3017.53	3450.65	4240.99	5060.37
I_2	608.01	2186.81	2702.40	3112.75	3758.68	4393.48
I_3	783.28	2290.07	2938.03	3347.66	4021.66	4702.72
I_4	597.20	2549.04	3514.32	4152.84	4812.46	5450.25
I_5	802.29	2633.56	3286.43	3723.27	4489.49	5217.96
SEm±	119.262	259.052	263.293	207.682	210.554	230.891
CD (0.05)	NS	NS	NS	602.730	611.066	670.086
Interaction (p×i)						
p_1i_1	300.02	1487.10	1894.51	2557.97	3063.12	3728.73
p_1i_2	334.52	1735.60	2151.97	2258.52	2799.25	3337.56
p_1i_3	794.81	1888.30	2779.56	3765.60	4470.60	5305.41
p_1i_4	279.01	2279.60	2763.89	3643.07	4266.19	5010.40
p_1i_5	822.20	2226.00	2800.63	3058.97	3722.74	4411.51
p_2i_1	411.38	2802.80	3519.80	3815.15	4840.63	5704.23
p_2i_2	1004.91	2823.40	3292.63	4039.42	4897.85	5568.20
p_2i_3	657.92	2764.60	3193.33	3287.26	3955.96	4636.81
p_2i_4	840.90	3192.70	5291.38	5630.74	6468.09	7162.73
p_2i_5	950.20	2938.30	3693.16	4168.16	5127.33	6043.68
p_3i_1	813.37	2784.90	3638.26	3978.82	4819.21	5748.15
p_3i_2	484.58	2001.40	2662.63	3040.29	3578.94	4274.67
p_3i_3	897.10	2217.30	2841.20	2990.11	3638.41	4165.93
p_3i_4	671.68	2174.80	2487.68	3184.70	3703.09	4177.63
p_3i_5	634.48	2736.30	3365.49	3942.66	4618.39	5198.68
SEm±	206.568	448.692	456.037	359.715	364.690	399.914
CD (0.05)	NS	NS	NS	1043.968	1058.407	1160.623
Control	342.33	1152.32	1739.88	2498.34	2977.00	3178.00
Control Vs Treatment	S	S	S	S	S	S

year^{-1} at quarterly splits) noted the highest leaf area from 8 MAP to 12 MAP. The treatment combination p_2i_4 recorded the highest leaf area of 5630.74 cm^2, 6468.09 cm^2 and 7162.73 cm^2 at 8 MAP, 10 MAP and 12 MAP respectively. Significant difference was noticed in leaf area between treatment and control from 2 MAP to 12 MAP.

4.1.2 Yield parameters

4.1.2.1 Number of spike plant^{-1}

The main and interaction effect of potting media and inorganic fertilizers on number of spikes plant^{-1} is furnished in table 13.

The number of spikes plant^{-1} differed significantly among potting media. P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest number of spikes (27.20) during the crop period. This was followed by P_3 (soil + FYM + leaf compost + coir pith compost in the ratio 3:3:1:1) and P_1 (soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1). P_3 and P_1 recorded 25.47 and 24.00 number of spikes plant^{-1} respectively.

In the inorganic fertilizers, I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded more number of spike (27.22), which was on par with I_1(37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits) and I_5 (12.5:12.5:25.0 g of NPK plant^{-1} year^{-1} as soil application at equal monthly splits up to 3 MAP and foliar application of 13:0:45 (0.5 %) at fortnightly intervals from 4th MAP). The number of spikes plant^{-1} recorded by I_4, I_5, I_1, I_2 and I_3 were 27.22, 25.88, 25.33, 25.22 and 24.11 respectively.

Interaction effect was significant and among interaction treatment combination, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest number of spikes plant^{-1} (32.67). This was followed by p_3i_5 (28.33) which was on par with p_2i_2 (26.67), p_2i_1 (26.33), p_2i_5 (25.33), p_3i_1 (25.33), p_3i_2 (25.33), p_3i_4 (25.33). Significant difference in number of spikes plant^{-1} was noticed between treatment and control.

4.1.2.2 Length of spike

The main and interaction effect of treatments on length of spikes are shown in table 13.

Significant variation in length of spike was noticed among different potting media. Plants raised in P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest value for length of spike. The length of spike recorded by P_2, P_3 and P_1 were 10.72 cm, 10.04 cm and 9.30 cm respectively.

Plants which received the inorganic fertilizers I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) resulted in the highest length of spike (11.01 cm), followed by I_3, I_1, I_5 and I_2.

Interaction effect was significant and among different treatment combination p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest value (12.38 cm) and was on par with p_2i_2 (P_2-soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and I_2-37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits). Significant difference in length of spike was observed between treatment and control.

4.1.2.3 Number of berries spike^{-1}

The main and interaction effects of treatment on number of berries spike^{-1} is provided in table 13.

Potting media significantly influenced the number of berries spike^{-1}. P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) produced the highest

Table 13. Effect of potting media and inorganic fertilizers on yield parameters

Treatments	Number of spikes plant^{-1}	Length of spike (cm)	Number of berries spike^{-1}	Fresh weight of berries (g plant^{-1})	Dry weight of berries (g plant^{-1})
Potting media (P)					
P_1	24.00	9.30	48.86	117.24	40.70
P_2	27.20	10.72	57.11	156.07	54.40
P_3	25.47	10.04	53.80	137.17	47.69
SEm±	0.513	0.220	0.509	3.213	1.124
CD (0.05)	1.486	0.640	1.479	9.306	3.256
Inorganic fertilizers (I)					
I_1	25.33	9.82	52.81	134.38	46.34
I_2	25.22	9.66	54.00	136.70	47.26
I_3	24.11	9.84	49.32	118.82	41.39
I_4	27.22	11.01	56.90	156.15	54.72
I_5	25.88	9.77	53.26	138.08	48.26
SEm±	0.662	0.280	0.658	4.148	1.451
CD (0.05)	1.919	0.820	1.909	12.014	4.204
Interaction (p×i)					
p_1i_1	24.33	9.00	47.20	114.79	39.11
p_1i_2	23.66	8.33	48.40	114.68	39.59
p_1i_3	24.33	9.60	46.93	114.14	40.21
p_1i_4	23.67	10.03	53.67	127.25	44.13
p_1i_5	24.00	9.53	48.10	115.35	40.47
p_2i_1	26.33	10.13	57.53	151.84	52.66
p_2i_2	26.67	11.57	58.00	154.66	53.21
p_2i_3	25.00	9.92	50.25	125.59	43.65
p_2i_4	32.67	12.38	61.12	199.49	70.92
p_2i_5	25.33	9.59	58.67	148.73	51.55
p_3i_1	25.33	10.33	53.70	136.52	47.27
p_3i_2	25.33	9.06	55.60	140.75	48.99
p_3i_3	23.00	10.02	50.77	116.72	40.30
p_3i_4	25.33	10.61	55.92	141.71	49.02
p_3i_5	28.33	10.20	53.00	150.17	52.77
SEm±	1.147	0.490	1.139	7.185	2.514
CD (0.05)	3.324	1.420	3.306	20.809	7.282
Control	21.33	8.35	49.33	104.68	35.75
Control Vs Treatment	S	S	S	S	S

number of berries spike^{-1}(57.11) and was followed by P_3 (soil + FYM + leaf compost + coir pith compost in the ratio 3:3:1:1) and P_1 (soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1).

Significant variation in the number of berries spike^{-1} was noticed among the inorganic fertilizers. I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) showed the highest number of berries spike^{-1}(56.90) and was followed by I_2, I_5, I_1 and I_3.

Significant difference in number of berries spike^{-1} was noticed among the treatment combination. The treatment combination, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizer 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) resulted in the highest number of berries spike^{-1}(61.12) which was on par with p_2i_2 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizer 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) and p_2i_5 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizer 12.5:12.5:25.0 g of NPK plant^{-1} year^{-1} as soil application at equal monthly splits up to 3 MAP and foliar application of 13:0:45 (0.5 %) at fortnightly intervals from 4th MAP) with 58.00 and 58.67 number of berries spike^{-1} respectively. Significant difference in number of berries spike^{-1} was noticed between treatment and control.

4.1.2.4 Fresh weight of berries plant^{-1}

The main and interaction effect of potting media and inorganic fertilizers on fresh weight of berries plant^{-1} are presented in table 13. The first and second harvest of fresh berries of treatment combination, p_2i_4 and control is shown in Plate 7.

Fresh weight of berries plant^{-1} differed significantly among different potting media. Potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest fresh weight of berries (156.07 g plant^{-1}). This was

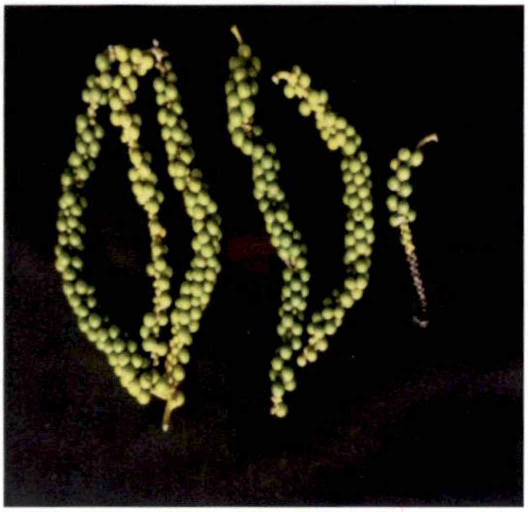

Plate 7a. First harvest of fresh berries of p_2i_4

Plate 7c. First harvest of fresh berries of control

Plate 7b. Second harvest of fresh berries of p_2i_4

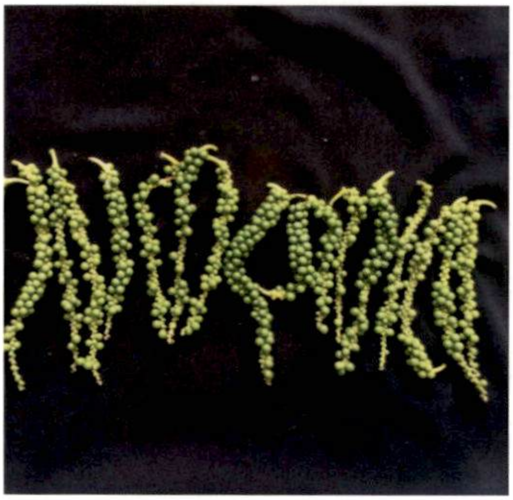

Plate 7d. Second harvest of fresh berries of control

Plate 7. Harvest of Fresh berries

followed by P_3 (soil + FYM + leaf compost + coir pith compost in the ratio 3:3:1:1) and P_1. Fresh weight of berries plant^{-1} recorded by P_3 and P_1 was 137.17 g and 117.24 g respectively.

Significant difference in fresh weight of berries plant^{-1} was noticed among the inorganic fertilizers. I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) obtained the highest fresh weight of berries plant^{-1}(156.15 g plant^{-1}) and was followed by I_5 (138.08 g plant^{-1}), I_2 (136.70 g plant^{-1}), I_1 (134.38 g plant^{-1}) and I_3 (118.82 g plant^{-1}).

The interaction were significant and the treatment combination p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizer 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) resulted in the highest fresh weight of berries plant^{-1}(199.49 g plant^{-1}). This was followed by p_2i_2 (154.66 g plant^{-1}), p_2i_1 (151.84 g plant^{-1}) p_3i_5 (150.17 g plant^{-1}) and p_2i_5 (148.73 g plant^{-1}). Significant difference in fresh weight of berries plant^{-1} was noticed between treatment and control.

4.1.2.5 Dry weight of berries plant^{-1}

The main and interaction effect of potting media and inorganic fertilizers on dry weight of berries plant^{-1} are furnished in table 13.

The dry weight of berries plant^{-1} was significantly influenced by different potting media. Potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest dry weight of berries plant^{-1} (54.40 g plant^{-1}). P_3 and P_1 produced 47.69 and 40.70 grams of dried pepper berry respectively.

Significant variation in dry weight of berries plant^{-1} between inorganic fertilizers was noticed. Inorganic fertilizer I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) exhibited the highest dry weight of berries (54.72 g plant^{-1}) which was followed by I_5, I_2, I_1 and I_3 respectively.

The interaction effect was significant and treatment combination, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizer- 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) registered the highest dry weight of berries (70.92 g plant^{-1}). This was followed by p_2i_2 (53.21 g plant^{-1}), p_3i_5 (52.77 g plant^{-1}), p_2i_1 (52.66 g plant^{-1}) and p_2i_5 (51.55 g plant^{-1}). Significant difference in dry weight of berries plant^{-1} was observed between treatment and control. The dry weight of berries recorded by control was 35.75 g plant^{-1} which was significantly lower than the treatment combinations.

4.1.2.6 Hundred berry weight

The main and interaction effect of potting media and inorganic fertilizers on hundred berry weight is shown in table 14.

Significant variation in hundred berry weight was registered among different potting media. Potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest hundred berry weight (11.13 g). The lowest value (9.65 g) for hundred berry weight was recorded by P_1 (soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1).

Hundred berry weight was not found to be influenced by inorganic fertilizers.

In interaction, p_2i_4 which is combination of potting media (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) and inorganic fertilizers (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) resulted in the highest hundred berry weight (13.03 g), which was on par with p_2i_2 (P_2- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and I_2-37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits). Hundred berry weight was found to be non significant between treatment and control.

4.1.2.7 Hundred berry volume

The main and interaction effect of potting media and inorganic fertilizers on hundred berry volume is provided in table 14.

Hundred berry volume varied significantly among different potting media. P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) reported the highest hundred berry volume (10.63 cm^3) followed by P_3 (9.31 cm^3) and P_1 (9.17 cm^3).

Hundred berry volume was found to be non significant among different inorganic fertilizers.

The interaction effect was significant and treatment combination p_2i_4 (P_2- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and I_4 -25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) resulted in the highest berry volume (12.53 cm^3), which was on par with p_2i_2 (11.70 cm^3). A non significant difference in hundred berry volume was noticed between treatment and control.

Table 14. Effect of potting media and inorganic fertilizers on hundred berry weight, g and hundred berry volume, cm^3

Treatments	Hundred berry weight (g)	Hundred berry volume (cm^3)
Potting media (P)		
P_1	9.65	9.17
P_2	11.13	10.63
P_3	9.78	9.31
SEm±	0.280	0.270
CD (0.05)	0.800	0.790
Inorganic fertilizers (I)		
I_1	10.29	9.77
I_2	10.27	9.72
I_3	10.02	9.51
I_4	10.36	9.93
I_5	10.01	9.57
SEm±	0.360	0.350
CD (0.05)	NS	NS
Interaction (p×i)		
p_1i_1	10.75	10.17
p_1i_2	9.43	8.93
p_1i_3	9.93	9.43
p_1i_4	8.97	8.57
p_1i_5	9.17	8.73
p_2i_1	9.69	9.23
p_2i_2	12.30	11.70
p_2i_3	10.73	10.10
p_2i_4	13.03	12.53
p_2i_5	9.90	9.57
p_3i_1	10.42	9.90
p_3i_2	9.07	8.53
p_3i_3	9.38	9.00
p_3i_4	9.07	8.70
p_3i_5	10.97	10.40
SEm±	0.610	0.960
CD (0.05)	1.780	1.760
Control	9.99	9.53
Control Vs Treatment	NS	NS

4.1.3 Root parameters

4.1.3.1 Fresh weight of roots

The main and interaction effect of potting media and inorganic fertilizers on fresh weight of roots are furnished in table 15.

Significant variation in fresh weight of roots was observed among different potting media and P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) resulted in highest fresh weight of roots (31.69 g plant^{-1}). The lowest fresh weight of roots (19.38 g plant^{-1}) was recorded by P_1 (soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1).

There was significant difference in fresh weight of roots among inorganic fertilizers. I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest fresh root weight (30.50 g plant^{-1}) and was on par with I_2 (37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits). This was followed by I_5 (12.5:12.5:25.0 g of NPK plant^{-1} year^{-1} as soil application at equal monthly splits up to 3 MAP and foliar application of 13:0:45 (0.5 %) at fortnightly intervals from 4th MAP), I_1 (37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits) and I_3 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits).

Among the treatment combination, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest fresh weight of roots (41.52 g plant^{-1}). p_2i_4 was followed by p_2i_2 (35.62 g plant^{-1}), p_3i_2 (34.88 g plant^{-1}), p_3i_5 (31.73 g plant^{-1}), p_2i_1 (30.04 g plant^{-1}). Root mass of p_2i_4 and control is shown in plate 8. Significant difference in fresh weight of roots was noticed between treatment and control.

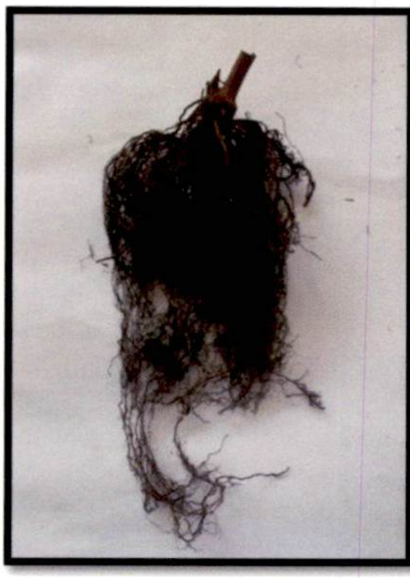

Plate 8a. Root mass of p_2i_4

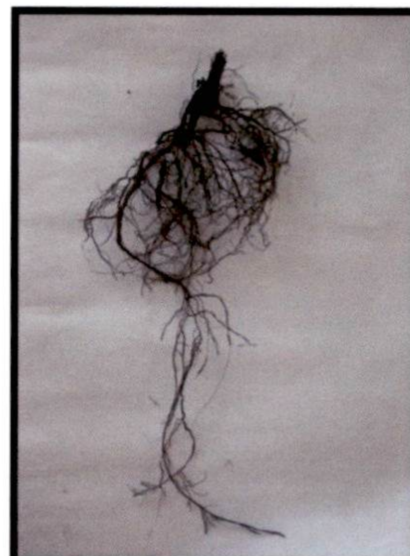

Plate 8b. Root mass of control

Plate 8. Root mass

4.1.3.2 Dry weight of roots

The main and interaction effects of treatment on dry weight of roots are provided in table 15.

Potting media significantly influenced the dry weight of roots and P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest dry weight of roots (13.78 g plant^{-1}). This was followed by P_3 (12.01 g plant^{-1}) and P_1 (8.42 g plant^{-1}).

Significant difference in dry weight of roots was noticed among inorganic fertilizers. I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) resulted in highest dry root weight (13.25 g plant^{-1}) which was on par with I_2 (37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits). The lowest dry root weight (8.42 g plant^{-1}) was recorded by I_3 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits).

Interaction effect was significant and treatment combination, p_2i_4 (Potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest dry weight of roots (18.05 g plant^{-1}), followed by p_2i_2 (15.48 g plant^{-1}), p_3i_2 (15.16 g plant^{-1}), p_3i_5 (13.79 g plant^{-1}), p_3i_5 (13.79 g plant^{-1}) and p_2i_1 (13.06 g plant^{-1}). Significant difference in dry weight of roots was observed between treatment and control.

Table 15. Effect of potting media and inorganic fertilizers on root parameters

Treatments	Fresh weight of roots (g plant^{-1})	Dry weight of roots (g plant^{-1})	Volume of roots (cm^{3}plant^{-1})
Potting media (P)			
P_1	19.38	8.42	22.38
P_2	31.69	13.78	34.75
P_3	27.62	12.01	30.55
SEm±	0.415	0.181	0.392
CD (0.05)	1.202	0.523	1.135
Inorganic fertilizers (I)			
I_1	24.57	10.68	27.57
I_2	29.91	13.00	32.79
I_3	20.34	8.84	23.54
I_4	30.50	13.25	33.49
I_5	25.84	11.23	28.73
SEm±	0.536	0.233	0.506
CD (0.05)	1.552	0.675	1.465
Interaction (p×i)			
p_1i_1	20.32	8.83	23.32
p_1i_2	19.22	8.35	22.22
p_1i_3	17.28	7.51	20.28
p_1i_4	22.59	9.82	25.59
p_1i_5	17.48	7.60	20.48
p_2i_1	30.04	13.06	33.04
p_2i_2	35.62	15.48	38.62
p_2i_3	22.98	9.99	26.58
p_2i_4	41.52	18.05	44.52
p_2i_5	28.31	12.31	30.98
p_3i_1	23.33	10.14	26.33
p_3i_2	34.88	15.16	37.54
p_3i_3	20.77	9.03	23.77
p_3i_4	27.41	11.89	30.36
p_3i_5	31.73	13.79	34.73
SEm±	0.929	0.403	0.876
CD (0.05)	2.689	1.168	2.537
Control	17.16	7.40	20.16
Control Vs Treatment	S	S	S

4.1.3.3 Volume of roots

The main and interaction effect of treatments on volume of roots is presented in table 15.

Significant variation in volume of roots was observed among different potting media. P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest volume of roots (34.75 cm^3 $plant^{-1}$). P_2 was followed by P_3 (30.55 cm^3 $plant^{-1}$) and P_1 (22.38 cm^3 $plant^{-1}$).

There was significant difference in volume of roots among inorganic fertilizers. I_4 (25.0: 25.0: 50.0 g of NPK $plant^{-1}$ $year^{-1}$ at quarterly splits) noted the highest root volume (33.49 cm^3 $plant^{-1}$) and was on par with I_2 (37.5: 37.5: 50.0 g of NPK $plant^{-1}$ $year^{-1}$ at quarterly splits) which recorded 32.79 cm^3 $plant^{-1}$ of root volume.

Among the treatment combination, p_2i_4 (P_2-soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and I_4 -25.0: 25.0: 50.0 g of NPK $plant^{-1}$ $year^{-1}$ at quarterly splits) recorded the highest root volume (44.52 cm^3 $plant^{-1}$). This was followed by p_2i_2 (38.62 cm^3 $plant^{-1}$), p_2i_2 (37.54 cm^3 $plant^{-1}$), p_3i_5 (34.73 cm^3 $plant^{-1}$), p_2i_1 (33.04 cm^3 $plant^{-1}$). Significant difference in volume of roots was found between treatment and control.

4.2 PHYSIOLOGICAL PARAMETERS

4.2.1 Dry matter production

The main and interaction effect of potting media and inorganic fertilizers on dry matter production of bush pepper at 12 MAP are furnished in table 16.

Table 16. Effect of potting media and inorganic fertilizers on the dry matter production, specific leaf weight and harvest index at 12 MAP

Treatments	Dry matter production (g plant^{-1})	Specific leaf weight (g m^{2})	Harvest index
Potting media (P)			
P_1	86.72	38.62	0.47
P_2	122.69	39.07	0.45
P_3	105.89	42.71	0.45
SEm±	1.223	1.509	0.006
CD (0.05)	3.542	NS	0.018
Inorganic fertilizers (I)			
I_1	100.76	38.44	0.47
I_2	108.47	43.05	0.44
I_3	91.90	40.34	0.45
I_4	120.33	39.64	0.45
I_5	104.03	39.20	0.46
SEm±	1.579	1.948	0.008
CD (0.05)	4.573	NS	0.023
Interaction (p×i)			
p_1i_1	81.91	45.90	0.48
p_1i_2	85.79	40.66	0.46
p_1i_3	81.79	33.08	0.49
p_1i_4	100.55	35.90	0.44
p_1i_5	83.56	37.55	0.49
p_2i_1	120.51	35.57	0.46
p_2i_2	125.75	41.47	0.42
p_2i_3	99.54	43.46	0.44
p_2i_4	150.92	36.97	0.47
p_2i_5	116.71	37.88	0.44
p_3i_1	99.87	33.83	0.47
p_3i_2	113.86	47.01	0.43
p_3i_3	94.39	44.47	0.42
p_3i_4	109.51	46.06	0.45
p_3i_5	111.82	42.17	0.47
SEm±	2.735	3.375	0.014
CD (0.05)	7.920	NS	0.040
Control	72.42	41.80	0.43
Control Vs Treatment	S	NS	S

Significant variation was observed in dry matter production among the different potting media at 12 MAP. Plants raised in P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest dry matter production (122.69 g plant^{-1}). The lowest dry matter production (86.72 g plant^{-1}) was recorded by P_1 (soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1).

With regard to the effect of inorganic fertilizers, I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) produced the highest dry matter (120.33 g plant^{-1}). This was followed by I_2, I_5, I_1 and I_3. I_2, I_5, I_1 and I_3 recorded the dry matter of 108.47, 104.03, 100.76 and 91.90 g plant^{-1} respectively.

Interaction effect between potting media and inorganic fertilizers was significant and treatment combination, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers- 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) resulted in the highest dry matter production (150.92 g plant^{-1}). This was followed by p_2i_2 (P_2- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits), which was on par with p_2i_1 (P_2- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits). Significant variation in dry matter production was noticed between treatment and control. The dry matter production recorded by the control was 72.42 g plant^{-1}.

4.2.2 Specific leaf weight

The main and interaction effect of potting media and inorganic fertilizers on specific leaf weight at 12 MAP are provided in table 16.

Potting media, inorganic fertilizers and their interaction did not influence the specific leaf weight at 12 MAP. Treatment effects also did not vary with the control.

4.2.3 Harvest index

The main and interaction effect of potting media and inorganic fertilizers on harvest index at 12 MAP are presented in table 16.

Significant difference in harvest index was noticed among different potting media used. Plants raised in potting media, P_1 (soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1) recorded the highest harvest index (0.47). P_2 and P_3 recorded the harvest index value of 0.45.

Significant variation was observed in harvest index between inorganic fertilizers. I_1 (37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits) reported the highest harvest index (0.47) and was on par with I_3 (37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits), I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) and I_5 (12.5:12.5:25.0 g of NPK plant^{-1} year^{-1} as soil application at equal monthly splits up to 3 MAP and foliar application of 13:0:45 (0.5 %) at fortnightly intervals from 4th MAP).

The interaction between potting media and inorganic fertilizers was significant. Treatment combination, p_1i_3(P_1- soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1 and I_3-37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits) and p_1i_5 (P_1- soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1 and I_5 - 12.5:12.5:25.0 g of NPK plant^{-1} year^{-1} as soil application at equal monthly splits up to 3 MAP and foliar application of 13:0:45 (0.5 %) at fortnightly intervals from 4th MAP) recorded the highest harvest index (0.49), which was on par with p_1i_1, p_1i_2, p_2i_1, p_2i_4, p_3i_1, p_3i_4 and p_3i_5. Significant difference was noticed in harvest index between treatment and control.

4.2.4 Moisture percentage

The main and interaction effect of potting media and inorganic fertilizers on moisture percentage at 12 MAP are provided in table 17.

Table 17. Effect of potting media and inorganic fertilizers on moisture percentage and drying percentage at 12 MAP

Treatments	Moisture percentage	Drying percentage
Potting media (P)		
P_1	65.28	34.65
P_2	65.17	34.78
P_3	65.25	34.74
SEm±	0.200	0.210
CD (0.05)	NS	NS
Inorganic fertilizers (I)		
I_1	65.49	34.4
I_2	65.44	34.44
I_3	65.14	34.86
I_4	65.06	34.94
I_5	65.02	34.98
SEm±	0.250	0.270
CD (0.05)	NS	NS
Interaction (p×i)		
p_1i_1	65.93	33.73
p_1i_2	65.53	34.47
p_1i_3	64.77	35.23
p_1i_4	65.27	34.73
p_1i_5	64.90	35.10
p_2i_1	65.23	34.77
p_2i_2	65.60	34.13
p_2i_3	65.23	34.77
p_2i_4	64.47	35.53
p_2i_5	65.30	34.70
p_3i_1	65.30	34.70
p_3i_2	65.20	34.73
p_3i_3	65.43	34.57
p_3i_4	65.46	34.54
p_3i_5	64.87	35.13
SEm±	0.440	0.470
CD (0.05)	NS	NS
Control	65.96	33.73
Control Vs Treatment	NS	NS

Moisture percentage was not significantly influenced by the potting media and inorganic fertilizers. The interaction effect of potting media and inorganic fertilizers also did not influence the moisture percentage. There was no significant variation in moisture percentage between treatment and control.

4.2.5 Drying percentage

The main and interaction effect of potting media and inorganic fertilizers on drying percentage at 12 MAP are presented in table 17.

Drying percentage was not affected by the potting media and inorganic fertilizers. Interaction effect between potting media and inorganic fertilizers also did not affect the drying percentage. The drying percentage was not varied between treatment and control.

4.2.6 Chlorophyll content

The main and interaction effect of potting media and inorganic fertilizers on chlorophyll content at 6 MAP and12 MAP are presented in table 18.

Significant variation in chlorophyll at 6 MAP was observed among different potting media. Potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest chlorophyll content (0.93 mg g^{-1}) at 6 MAP. This was followed by P_3 (soil + FYM + leaf compost + coir pith compost in the ratio 3:3:1:1) and P_1 (soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1) with 0.87 and 0.82 mg g^{-1} respectively.

In inorganic fertilizers, I_3 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits) resulted in the highest chlorophyll content (0.99 mg g^{-1}) which was on par with I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) (0.97 mg g^{-1}).

Interaction effect between potting media and inorganic fertilizers was significant for chlorophyll content at 6 MAP. Treatment combination, p_2i_4 (P_2- soil +

Table 18. Effect of potting media and inorganic fertilizers on chlorophyll content (mg g^{-1})

Treatments	6MAP	12MAP
Potting media (P)		
P_1	0.82	1.21
P_2	0.93	1.2
P_3	0.87	1.22
SEm±	0.020	0.050
CD (0.05)	0.057	NS
Inorganic fertilizers (I)		
I_1	0.88	1.25
I_2	0.70	1.17
I_3	0.99	1.25
I_4	0.97	1.19
I_5	0.83	1.19
SEm±	0.020	0.060
CD (0.05)	0.057	NS
Interaction (p×i)		
p_1i_1	0.96	1.38
p_1i_2	0.72	1.31
p_1i_3	0.91	1.27
p_1i_4	0.68	0.95
p_1i_5	0.83	1.16
p_2i_1	0.69	0.95
p_2i_2	0.64	0.98
p_2i_3	0.96	1.17
p_2i_4	1.22	1.41
p_2i_5	1.15	1.47
p_3i_1	1.00	1.41
p_3i_2	0.74	1.22
p_3i_3	1.11	1.31
p_3i_4	1.00	1.22
p_3i_5	0.51	0.95
SEm±	0.040	0.110
CD (0.05)	0.115	0.318
Control	1.10	1.23
Control Vs Treatment	S	NS

FYM + vermicompost + coir pith compost in the ratio 3:3:1:1and I_4- 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) showed the highest chlorophyll content (1.22 mg g^{-1}), which was on par with p_2i_5 (1.15 mg g^{-1}) and p_3i_3 (1.11 mg g^{-1}). Significant difference in chlorophyll at 6 MAP was noticed between treatment and control.

The potting media and inorganic fertilizers did not influence the chlorophyll content at 12 MAP.

Treatment combinations p_2i_5 (P_2- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and I_5 - 12.5:12.5:25.0 g of NPK plant^{-1} year^{-1} as soil application at equal monthly splits up to 3 MAP and foliar application of 13:0:45 (0.5 %) at fortnightly intervals from 4th MAP) recorded the highest chlorophyll content(1.47 mg g^{-1}) at 12 MAP and was on par with p_2i_4 (1.41 mg g^{-1}), p_3i_1 (1.41mg g^{-1}) p_1i_1 (1.38 mg g^{-1}), p_1i_2 (1.31 mg g^{-1}), p_3i_3 (1.31 mg g^{-1}), p_1i_3 (1.27 mg g^{-1}), p_3i_2 (1.22 mg g^{-1}), p_3i_4 (1.22 mg g^{-1}) and p_2i_3 (1.17 mg g^{-1}). There was no significant difference in chlorophyll content at 12 MAP among the treatments and the control.

4.3 QUALITY PARAMETERS OF BERRIES

4.3.1 Starch

The main and interaction effects of potting media and inorganic fertilizers on starch content of berries are presented in table 19.

Potting media significantly influenced the starch content and the highest starch content was produced by potting media P_1 (soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1) (36.68 %), which was followed by P_3 (soil + FYM + leaf compost + coir pith compost in the ratio 3:3:1:1) and P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1).

There was significant difference in starch content among the inorganic fertilizers. I_5 (12.5:12.5:25.0 g of NPK plant^{-1} year^{-1} as soil application at equal monthly splits up to 3 MAP and foliar application of 13:0:45 (0.5 %) at fortnightly intervals from 4th MAP) recorded the significantly higher starch content (36.74 %) in berries. This was followed by I_1, I_3, I_2 and I_4.

Interaction effects were significant and treatment combination, p_1i_5 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 12.5:12.5:25.0 g of NPK plant^{-1} year^{-1} as soil application at equal monthly splits up to 3 MAP and foliar application of 13:0:45 (0.5 %) at fortnightly intervals from 4th MAP) produced the highest starch content of (36.82%) in berries. The control did not vary with treatment combination in starch content of berries.

4.3.2 Total ash

The main and interaction effect of potting media and inorganic fertilizers on total ash of berries are presented in table 19.

The potting media and inorganic fertilizers did not influence the total as content of berries. Interaction effect between potting media and inorganic fertilizers were also non significant. The treatments combination did not show variation with the control in total ash content of berries.

4.3.3 Essential oil

The main and interaction effects of treatment on essential oil content of berries are provided in table 19.

Significant change in essential oil was noticed among different potting media. Plants raised in P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest essential oil (3.46 %), which was on par with P_3 (3.44 %) (soil + FYM + leaf compost + coir pith compost in the ratio 3:3:1:1). The lowest

Table 19. Effect of potting media and inorganic fertilizers on quality parameters of berries at 12 MAP

Treatments	Starch (%)	Total ash (%)	Essential oil (%)	Oleoresin (%)	Piperine (%)
Potting media (P)					
P_1	36.68	5.49	3.42	11.32	5.41
P_2	36.64	5.46	3.46	11.40	5.50
P_3	36.66	5.53	3.44	11.34	5.45
SEm±	0.010	0.033	0.011	0.016	0.016
CD (0.05)	0.028	NS	0.031	0.045	0.046
Inorganic fertilizers (I)					
I_1	36.69	5.45	3.42	11.33	5.39
I_2	36.62	5.52	3.48	11.38	5.49
I_3	36.68	5.47	3.42	11.32	5.43
I_4	36.58	5.49	3.52	11.46	5.57
I_5	36.74	5.53	3.36	11.26	5.37
SEm±	0.013	0.043	0.014	0.020	0.020
CD (0.05)	0.039	NS	0.040	0.058	0.059
Interaction (p×i)					
p_1i_1	36.71	5.46	3.40	11.30	5.30
p_1i_2	36.64	5.55	3.47	11.37	5.48
p_1i_3	36.65	5.42	3.46	11.36	5.47
p_1i_4	36.62	5.45	3.48	11.38	5.49
p_1i_5	36.82	5.55	3.29	11.19	5.30
p_2i_1	36.65	5.36	3.46	11.41	5.47
p_2i_2	36.6	5.53	3.51	11.41	5.52
p_2i_3	36.71	5.43	3.39	11.29	5.40
p_2i_4	36.51	5.49	3.59	11.59	5.70
p_2i_5	36.72	5.50	3.38	11.28	5.39
p_3i_1	36.71	5.53	3.40	11.30	5.41
p_3i_2	36.62	5.49	3.48	11.38	5.49
p_3i_3	36.69	5.56	3.41	11.31	5.42
p_3i_4	36.61	5.54	3.50	11.40	5.51
p_3i_5	36.68	5.55	3.43	11.33	5.44
SEm±	0.023	0.075	0.024	0.035	0.035
CD (0.05)	0.067	NS	0.069	0.101	0.102
Control	36.77	5.50	3.32	11.27	5.40
Control Vs Treatment	NS	NS	S	S	NS

essential oil content (3.42 %) was recorded by P_1 (soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1).

Significant difference in essential oil was observed between inorganic fertilizers. I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) resulted in highest essential oil content (3.52 %) and was on par with I_2 (37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits). The lowest value (3.36 %) was observed in I_5 (12.5:12.5:25.0 g of NPK plant^{-1} year^{-1} as soil application at equal monthly splits up to 3 MAP and foliar application of 13:0:45 (0.5 %) at fortnightly intervals from 4th MAP).

Interaction effect was significant and treatment combination, p_2i_4 (Potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest essential oil content in berries (3.59 %). This was followed by p_2i_2 (3.51 %), p_3i_4 (3.50 %), p_3i_2 (3.48 %) and p_1i_4 (3.48 %). Significant variation in essential oil content of berries was noticed between treatment and control.

4.3.4 Oleoresin

The main and interaction effects of treatment on oleoresin of berries are shown in table 19.

Oleoresin was significantly influenced among the potting media. The highest oleoresin content of (11.40 %) was recorded by P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1). P_3 (soil + FYM + leaf compost + coir pith compost in the ratio 3:3:1:1) was found to be on par with P_2.

There was significant difference in oleoresin among the different inorganic fertilizers. I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) indicated the highest oleoresin of (11.46 %). Treatment I_2 was on par with I_1 and I_3.

The interactions were significant and treatment combination, p_2i_4 (Potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) resulted in highest oleoresin content (11.59%). This was followed by p_2i_2 (11.41 %), p_2i_1 (11.41 %), p_3i_4 (11.40 %), p_3i_2 (11.38 %) and p_1i_4 (11.38 %). Significant change in oleoresin of berries was noticed between treatment and control.

4.3.5 Piperine

The main and interaction effect of treatments on piperine content of berries are presented in table 19.

Significant variation in piperine was noticed among different potting media. Plants raised in P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest piperine (5.50 %), which was on par with P_3 (soil + FYM + leaf compost + coir pith compost in the ratio 3:3:1:1). P_3 recorded a value of 5.45 %.

Significant variation in piperine content was noticed among different inorganic fertilizer Inorganic fertilizer, I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) resulted the highest piperine content (5.57 %). This was followed by I_2, I_3, I_1 and I_5.

Interaction effect was significant and treatment combination, p_2i_4 (Potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest piperine content in berries (5.70 %). This was followed by p_2i_2 which recorded piperine content of 5.52 %. However no variation in piperine content was noticed between treatment and control.

4.4 ANALYSIS OF POTTING MEDIUM BEFORE AND AFTER THE EXPERIMENT

The soil pH, electrical conductivity and organic carbon content of potting media before the experiment is furnished in table 20 a. Table 20 b represents the soil pH, electrical conductivity and organic carbon content of potting media after the experiment.

4.4.1 Soil pH

Soil pH value of potting media was P_2 (5.59), P_3 (5.44), P_1 (5.26) and control (5.13) before the experiment. Soil pH value found To vary significantly after the experiment. The treatment combination, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1, inorganic fertilizers- 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest pH (5.47) which was on par with p_2i_1 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1, inorganic fertilizers- 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits) and p_2i_2 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1, inorganic fertilizers- 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits). There was no significant difference in soil pH between treatment and control.

4.4.2 Electrical conductivity

EC value of different potting media was 0.73 dSm^{-1} in P_1, 0.70 dSm^{-1} in P_3, 0.67 dSm^{-1} in control and 0.57 in dSm^{-1} in P_2 before the experiment. Analysis of potting media after the experiment revealed that significant variation existed between treatment combinations. The treatment combination, p_3i_1 (potting media- soil + FYM + leaf compost + coir pith compost in the ratio 3:3:1:1, inorganic fertilizers- 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits) recorded the highest EC value of 0.96 dSm^{-1}. EC found to be non significant between treatment and control.

Table 20 a. pH, EC, organic carbon content of potting media before the experiment

Potting media	pH	EC (dSm^{-1})	Organic carbon (%)
P_1	5.26	0.73	2.31
P_2	5.59	0.57	2.58
P_3	5.44	0.7	2.37
Control	5.13	0.67	2.05

Table 20 b. pH, EC, organic carbon content of potting media after the experiment

Interaction (p×i)	pH	EC (dSm^{-1})	Organic carbon (%)
p_1i_1	5.09	0.66	2.88
p_1i_2	5.07	0.69	2.88
p_1i_3	5.10	0.50	2.80
p_1i_4	5.14	0.48	2.81
p_1i_5	5.10	0.35	2.73
p_2i_1	5.40	0.50	2.95
p_2i_2	5.37	0.41	2.89
p_2i_3	5.18	0.57	2.88
p_2i_4	5.47	0.35	2.91
p_2i_5	5.25	0.27	2.76
p_3i_1	5.15	0.96	3.06
p_3i_2	5.20	0.44	2.82
p_3i_3	5.04	0.74	2.89
p_3i_4	5.25	0.36	2.80
p_3i_5	5.27	0.30	2.79
SEm±	0.045	0.031	0.022
CD (0.05)	0.129	0.090	0.064
Control	5.00	0.56	2.17
Control Vs Treatment	NS	NS	S

4.4.3 Organic carbon

Potting media analysis before the experiment showed that potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest organic carbon of (2.58 %), followed by P_3 (2.37 %), P_1 (2.31 %) and control (2.05%). Organic carbon showed significant variation among treatment combinations. The treatment combination, p_3i_1 (potting media- soil + FYM + leaf compost + coir pith compost in the ratio 3:3:1:1, inorganic fertilizers. 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits) noted the highest organic carbon (3.06 %) after the experiment. After the experiment, Significant change in organic carbon was noticed between treatment and control.

4.4.4 Primary nutrients (N, P and K)

The available N, P and K of potting media before the experiment is given in table 21 a. The data on available N, P and K of potting media after the experiment is presented in table 21 b.

Available nitrogen of potting media before the experiment ranged from 0.490 g kg^{-1} to 0.597 g kg^{-1}. Potting media (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest value of 0.597 g kg^{-1}, which is followed by P_3 (0.553 g kg^{-1}), P_1 (0.542 g kg^{-1}) and control potting media (0.490 g kg^{-1}). Available nitrogen noted significant change after the experiment. The treatment combination, p_1i_1 (potting media- soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1, inorganic fertilizers. 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits) recorded the highest available nitrogen of 0.834 g kg^{-1}. Significant difference in available N was noticed betweentreatment and control.

Soil chemical analysis before the experiment revealed that, available phosphorus varied among different potting media from 36.45 mg kg^{-1} to 37.83 mg kg^{-1}. P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded

Table 21 a. Available N, P and K content of potting media before the experiment

Potting media	Nitrogen (g kg^{-1})	Phosphorus (mg kg^{-1})	Potassium (mg kg^{-1})
P_1	0.542	36.89	384.82
P_2	0.597	37.83	382.00
P_3	0.553	37.63	378.35
Control	0.490	36.45	363.17

Table 21 b. Available N, P and K content of potting media after the experiment

Interaction (p×i)	Nitrogen (g kg^{-1})	Phosphorus (mg kg^{-1})	Potassium (mg kg^{-1})
p_1i_1	0.834	48.30	393.70
p_1i_2	0.762	47.11	394.50
p_1i_3	0.509	46.74	393.00
p_1i_4	0.521	45.54	394.20
p_1i_5	0.501	44.04	362.30
p_2i_1	0.775	47.69	399.30
p_2i_2	0.695	46.65	382.30
p_2i_3	0.559	46.84	399.00
p_2i_4	0.521	46.17	380.00
p_2i_5	0.533	46.36	371.70
p_3i_1	0.746	48.29	395.70
p_3i_2	0.725	47.74	396.70
p_3i_3	0.561	47.27	396.00
p_3i_4	0.560	47.72	397.00
p_3i_5	0.521	45.32	365.00
SEm±	0.0121	0.303	0.120
CD (0.05)	0.0350	0.877	0.347
Control	0.492	44.81	350.40
Control Vs Treatment	S	S	S

the highest available P of 37.83 mg kg^{-1}. Available P after the experiment was significantly influenced by the interaction of potting media and inorganic fertilizers. The treatment combination, p_1i_1 (potting media- soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1, inorganic fertilizers- 37.5: 37.5: 50.0 g of NPK $plant^{-1}$ $year^{-1}$ at monthly splits) recorded available P value of 48.30 mg kg^{-1}, which was on par with p_3i_1 (48.29 mg kg^{-1}), p_3i_2 (47.74 mg kg^{-1}), p_3i_4 (47.72 mg kg^{-1}) and p_2i_1 (47.69 mg kg^{-1}). There is significant difference in available P after the experiment between treatment and control.

Available K of potting medium varied from 363.17 mg kg^{-1} to 384.82 mg kg^{-1}. Potting media, P_1 (soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1) noted the highest available K of 384.82 mg kg^{-1}, followed by P_2 (382.00 mg kg^{-1}), P_3 (378.35mg kg^{-1}), and control (363.17 mg kg^{-1}). Available K was significantly different in different treatment combinations. The treatment combination, p_2i_1 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1, inorganic fertilizers- 37.5: 37.5: 50.0 g of NPK $plant^{-1}$ $year^{-1}$ at monthly splits recorded the highest available K (399.30 mg kg^{-1}) and on par with p_2i_3 (399.00 mg kg^{-1}). There is significant variation in available K between treatment and control after the experiment.

4.4.5 Secondary nutrients (Ca, Mg and S)

The data on available Ca, Mg and S of potting media before the experiment is presented in table 22 a. Table 22 b provides the data on available Ca, Mg and S of potting media after the experiment.

Soil chemical analysis before the experiment exhibited that available Ca ranged from 325.75 mg kg^{-1} to 343.75 mg kg^{-1}. Potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) registered the highest value (343.75 mg kg^{-1}) followed by P_3 (339.75 mg kg^{-1}), P_1 (338.25 mg kg^{-1}) and control potting media (325.75 mg kg^{-1}). Available Ca showed significant variation among the

Table 22 a. Available Ca, Mg and S content of potting media before the experiment

Potting media	Calcium (mg kg^{-1})	Magnesium (mg kg^{-1})	Sulphur (mg kg^{-1})
P_1	338.25	140.75	22.02
P_2	343.75	144.50	24.51
P_3	339.75	142.40	23.02
Control	325.75	140.98	21.76

Table 22 b. Available Ca, Mg and S content of potting media after the experiment

Interaction (p×i)	Calcium (mg kg^{-1})	Magnesium (mg kg^{-1})	Sulphur (mg kg^{-1})
p_1i_1	355.50	120.64	21.99
p_1i_2	356.50	121.27	22.99
p_1i_3	356.50	120.59	23.22
p_1i_4	353.50	115.46	23.31
p_1i_5	356.13	120.51	24.31
p_2i_1	348.58	113.94	22.57
p_2i_2	348.50	109.17	22.37
p_2i_3	353.10	118.41	22.76
p_2i_4	346.50	106.98	22.57
p_2i_5	350.00	117.51	22.45
p_3i_1	352.50	116.06	22.44
p_3i_2	348.50	113.86	22.53
p_3i_3	354.30	115.57	21.21
p_3i_4	351.00	112.69	23.76
p_3i_5	347.06	114.62	22.54
SEm±	0.398	0.763	0.536
CD (0.05)	1.153	2.211	NS
Control	358.50	126.00	21.66
Control Vs Treatment	NS	NS	NS

treatment combinations after the experiment. The treatment combinations, p_1i_2 (potting media- soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1, inorganic fertilizers. 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) and p_1i_3 (potting media- soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1, inorganic fertilizers. 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits) recorded the highest value of 356.50 mg kg^{-1}, which was on par with p_1i_5 and p_1i_1. Available Ca was found to be non significant among the treatments and control.

Available Mg of potting media differed before the experiment. P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest available Mg of 144.50 mg kg^{-1}, followed by P_3 (142.40 mg kg^{-1}), control potting media (140.98 mg kg^{-1}) and P_1 (140.75 mg kg^{-1}). After the experiment, available Mg varied significantly among different treatment combinations. The treatment combinations, p_1i_2 (potting media- soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1, inorganic fertilizers. 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) registered the highest value of 121.27 mg kg^{-1} and was on par with p_1i_1 (120.64 mg kg^{-1}), p_1i_3 (120.59 mg kg^{-1}) and p_1i_5 (120.51 mg kg^{-1}). There is no significant variation in available Mg between treatment and control after the experiment.

Soil analysis before the experiment showed that available S was 24.51 mg kg^{-1} in P_2, 23.02 mg kg^{-1} in P_3, 22.02 mg kg^{-1} in P_1 and 21.76 mg kg^{-1} in control. After the experiment, the available S was found to be non significant among the different treatment combinations. Available S was noticed non significant among the treatments and the control after the experiment.

4.5 PLANT UPTAKE OF PRIMARY AND SECONDARY NUTRIENT BY ROOTS, LEAVES, STEMS, BERRIES AND SPIKES

Uptake of primary and secondary nutrients viz., N, P, K, Ca, Mg and S were estimated from roots, leaves, stem, berries, spikes and total uptake at 12 MAP.

4.5.1 N uptake

The main and interaction effect of potting media and inorganic fertilizers on the uptake of N by roots, leaves, stem, berries, spikes and total uptake are presented in the Table 23.

The nitrogen uptake by roots, leaves, stem, berries and spike were significantly influenced by the different potting media. P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) indicated the highest nitrogen uptake in these plant parts. P_3 found to be on par with P_2 in N uptake by leaves. P_2 recorded the highest total uptake of nitrogen (1.860 g plant^{-1}), followed by P_3 (soil + FYM + leaf compost + coir pith compost in the ratio 3:3:1:1) and P_1 (soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1).

The plants which received inorganic fertilizer, I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) resulted in highest nitrogen uptake in different plant parts viz., roots, leaves, stem and berries and was on par with I_5 (12.5:12.5:25.0 g of NPK plant^{-1} year^{-1} as soil application at equal monthly splits up to 3 MAP and foliar application of 13:0:45 (0.5 %) at fortnightly intervals from 4th MAP) in leaves. The total N uptake also found to be highest for the I_4 (1.870 g plant^{-1}). This was followed by I_2 (1.686 g plant^{-1}), I_5 (1.675 g plant^{-1}), I_1 (1.498 g plant^{-1}) and I_3 (1.435g plant^{-1}).

In interaction, treatment combination, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest N uptake in all plant parts. With regard to uptake of N in roots, leaves, stem and berries the treatment combination p_2i_4 was on par with p_2i_2 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits). With respect to N uptake of spike, p_2i_4 was on par with p_2i_1 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 37.5: 37.5: 50.0 g of NPK

Table 23. Effect of potting media and inorganic feriltizers on plant uptake of nitrogen, g plant^{-1}

Treatments	Roots	Leaves	Stem	Berries	Spikes	Total
Potting media (P)						
P_1	0.126	0.315	0.378	0.414	0.102	1.334
P_2	0.200	0.453	0.514	0.576	0.118	1.860
P_3	0.176	0.442	0.478	0.504	0.104	1.704
SEm±	0.003	0.006	0.006	0.013	0.002	0.018
CD (0.05)	0.008	0.018	0.017	0.036	0.006	0.052
Inorganic fertilizers (I)						
I_1	0.160	0.358	0.406	0.463	0.111	1.498
I_2	0.181	0.395	0.485	0.514	0.111	1.686
I_3	0.137	0.383	0.406	0.410	0.099	1.435
I_4	0.197	0.451	0.523	0.590	0.106	1.870
I_5	0.161	0.429	0.464	0.511	0.110	1.675
SEm±	0.004	0.008	0.007	0.016	0.002	0.023
CD (0.05)	0.011	0.024	0.021	0.047	0.008	0.066
Interaction (p×i)						
p_1i_1	0.129	0.272	0.338	0.375	0.099	1.213
p_1i_2	0.110	0.257	0.386	0.371	0.110	1.233
p_1i_3	0.115	0.292	0.342	0.370	0.099	1.217
p_1i_4	0.154	0.417	0.477	0.518	0.092	1.658
p_1i_5	0.120	0.337	0.349	0.434	0.108	1.348
p_2i_1	0.188	0.397	0.458	0.554	0.128	1.724
p_2i_2	0.224	0.483	0.560	0.635	0.116	2.018
p_2i_3	0.159	0.425	0.466	0.444	0.105	1.599
p_2i_4	0.242	0.492	0.573	0.716	0.132	2.159
p_2i_5	0.185	0.465	0.516	0.529	0.107	1.802
p_3i_1	0.162	0.405	0.423	0.459	0.108	1.556
p_3i_2	0.208	0.444	0.509	0.537	0.108	1.806
p_3i_3	0.136	0.431	0.411	0.416	0.094	1.489
p_3i_4	0.195	0.444	0.519	0.534	0.093	1.792
p_3i_5	0.176	0.485	0.528	0.571	0.115	1.875
SEm±	0.006	0.014	0.013	0.028	0.003	0.040
CD (0.05)	0.019	0.041	0.037	0.081	0.01	0.115
Control	0.109	0.270	0.274	0.330	0.086	1.069
Control Vs Treatment	S	S	S	S	S	S

plant^{-1} year^{-1} at monthly splits). The total uptake was also superior for treatment combination p_2i_4 (2.159g plant^{-1}) followed by p_2i_2 (2.018 g plant^{-1}) and p_3i_5 (1.875 g plant^{-1}). Significant variation in N uptake of different plant parts and total N uptake was noticed between the treatment and control.

4.5.2 P uptake

The main and interaction effect of potting media and inorganic fertilizers on the P uptake by roots, leaves, stem, berries, spikes and total uptake are furnished in the Table 24.

Uptake of P in different plant parts was significantly influenced by the potting media. Plants grown in potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) registered highest P uptake in roots, leaves, stem, berries and spike. P_2 recorded the highest total P uptake of 126.76 mg plant^{-1}, followed by P_1 (109.06 mg plant^{-1}) and P_3 (90.73 mg plant^{-1}).

Significant variation in P uptake of different plant parts was noticed among the inorganic fertilizers. Plants of treatment I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) registered the highest P uptake in all parts. With respect to uptake of P in leaves I_4 was on par with I_2 (37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) and I_5. I_4 recorded the highest P uptake of 125.79 mg plant^{-1}. The lowest P uptake was recorded by I_3 (92.70 mg plant^{-1}).

The treatment combination, p_2i_4 recorded the highest P uptake in different plant parts like roots, leaves, stem and berries. There was no significant variation of P uptake by spikes among the treatment combination. With respect to uptake of P by leaves the treatment combination, p_2i_4 was on par with p_2i_1, p_2i_2, p_3i_2 and p_3i_5. Treatment combination, p_2i_4 recorded the highest total P uptake of 155.17 mg plant^{-1} followed by p_2i_2 (135.33 mg plant^{-1}), p_2i_5 (125.95 mg plant-1) and p_3i_5 (124.33 mg

Table 24. Effect of potting media and inorganic feriltizers on plant uptake of phosphorus, mg plant^{-1}

Treatments	Roots	Leaves	Stem	Berries	Spikes	Total
Potting media (P)						
P_1	6.91	21.19	24.95	32.88	4.81	90.73
P_2	11.07	26.39	34.77	49.06	5.45	126.76
P_3	9.36	24.07	31.24	39.56	4.83	109.06
SEm±	0.190	0.463	0.443	0.98	0.169	1.464
CD (0.05)	0.553	1.344	1.283	2.84	0.492	4.242
Inorganic fertilizers (I)						
I_1	7.21	22.99	27.22	37.63	4.21	99.00
I_2	9.71	24.45	33.08	41.29	4.58	113.12
I_3	7.33	21.96	26.29	32.26	4.86	92.70
I_4	11.37	25.60	35.42	47.60	5.79	125.79
I_5	9.94	24.42	29.60	43.72	5.71	113.38
SEm±	0.246	0.599	0.572	1.265	0.219	1.891
CD (0.05)	0.714	1.736	1.657	3.666	0.636	5.477
Interaction (p×i)						
p_1i_1	7.03	20.85	22.39	28.61	4.70	83.59
p_1i_2	6.78	18.80	25.64	30.89	4.70	86.79
p_1i_3	5.42	19.67	21.54	30.63	4.18	81.44
p_1i_4	8.48	24.59	33.58	40.27	5.08	111.99
p_1i_5	6.83	22.04	21.60	34.01	5.39	89.88
p_2i_1	8.70	26.21	32.26	47.09	4.66	118.91
p_2i_2	11.70	27.99	38.26	52.52	4.86	135.33
p_2i_3	8.27	23.72	28.39	32.98	5.09	98.46
p_2i_4	15.59	28.69	40.21	63.69	6.99	155.17
p_2i_5	11.09	25.36	34.76	49.04	5.70	125.95
p_3i_1	5.91	21.91	27.02	37.20	3.29	95.32
p_3i_2	10.66	26.56	35.33	40.48	4.20	117.24
p_3i_3	8.29	22.48	28.96	33.17	5.32	98.22
p_3i_4	10.04	23.53	32.47	38.87	5.31	110.21
p_3i_5	11.89	25.86	32.44	48.11	6.03	124.33
SEm±	0.426	1.036	0.991	2.193	0.380	3.275
CD (0.05)	1.236	3.006	2.870	6.351	NS	9.486
Control	5.41	14.93	20.27	20.38	3.67	64.65
Control Vs Treatment	S	S	S	S	S	S

plant^{-1}).Significant change in P uptake in different plant parts and total uptake was noticed between the treatment and control.

4.5.3 K uptake

The main and interaction effect of potting media and inorganic fertilizers on the K uptake by roots, leaves, stem, berries, spikes and total uptake are provided in the Table 25.

Significant difference in uptake of K in various parts and total uptake was noticed among the different potting media. P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest total uptake of K as well as uptake of K by different plant parts. With regards to the uptake of K in leaves and spikes, P_3 (soil + FYM + leaf compost + coir pith compost in the ratio 3:3:1:1) was found on par with the P_2. A total K uptake of 2.013 g plant^{-1} was registered by P_2, followed by P_3 (1.823 g plant^{-1}) and P_1 (1.374 g plant^{-1}).

In inorganic fertilizers, uptake of K showed significant variation. I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest uptake of K in different parts like roots, leaves, stem, berries and total uptake. With respect to uptake of K in roots and stem, I_4 was on par with I_2 (37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits). With regard to K uptake of spikes, I_5(12.5:12.5:25.0 g of NPK plant^{-1} year^{-1} as soil application at equal monthly splits up to 3 MAP and foliar application of 13:0:45 (0.5 %) at fortnightly intervals from 4th MAP) recorded the highest value, which was on par with I_1, I_2 and I_4. With respect to uptake of K by berries, I_4 found to be on par with I_2 and I_5. The total K uptake was superior for I_4 (1.926 g plant^{-1}), followed by I_2 (1.811 g plant^{-1}), I_5 (1.744 g plant^{-1}), I_1 (1.677 g plant^{-1}) and I_3 (1.526 g plant^{-1}).

Interaction effect showed that, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 25.0:

Table 25. Effect of potting media and inorganic feriltizers on plant uptake of potassium, g plant^{-1}

Treatments	Roots	Leaves	Stem	Berries	Spikes	Total
Potting media (P)						
P_1	0.102	0.406	0.421	0.399	0.045	1.374
P_2	0.174	0.574	0.607	0.607	0.055	2.013
P_3	0.153	0.563	0.529	0.525	0.053	1.823
SEm±	0.002	0.008	0.007	0.014	0.001	0.02
CD (0.05)	0.007	0.023	0.020	0.041	0.004	0.058
Inorganic fertilizers (I)						
I_1	0.132	0.512	0.481	0.499	0.049	1.677
I_2	0.164	0.499	0.561	0.537	0.052	1.811
I_3	0.106	0.480	0.467	0.430	0.046	1.526
I_4	0.166	0.557	0.583	0.570	0.052	1.926
I_5	0.148	0.523	0.501	0.517	0.054	1.744
SEm±	0.003	0.01	0.009	0.018	0.002	0.026
CD (0.05)	0.009	0.029	0.026	0.053	0.005	0.074
Interaction (p×i)						
p_1i_1	0.108	0.393	0.423	0.400	0.043	1.370
p_1i_2	0.112	0.370	0.443	0.410	0.053	1.387
p_1i_3	0.098	0.389	0.403	0.383	0.050	1.323
p_1i_4	0.104	0.471	0.460	0.407	0.033	1.477
p_1i_5	0.090	0.413	0.373	0.393	0.043	1.313
p_2i_1	0.156	0.577	0.540	0.573	0.053	1.903
p_2i_2	0.189	0.584	0.690	0.647	0.050	2.153
p_2i_3	0.118	0.498	0.500	0.487	0.047	1.647
p_2i_4	0.238	0.620	0.703	0.743	0.067	2.367
p_2i_5	0.164	0.589	0.600	0.587	0.057	1.993
p_3i_1	0.130	0.569	0.480	0.523	0.050	1.757
p_3i_2	0.194	0.543	0.550	0.553	0.053	1.893
p_3i_3	0.101	0.547	0.497	0.420	0.040	1.607
p_3i_4	0.155	0.584	0.587	0.560	0.057	1.933
p_3i_5	0.187	0.572	0.530	0.570	0.063	1.927
SEm±	0.005	0.017	0.015	0.031	0.003	0.044
CD (0.05)	0.015	NS	0.045	0.091	0.009	0.129
Control	0.089	0.343	0.300	0.270	0.038	1.040
Control Vs Treatment	S	S	S	S	S	S

25.0: 50.0 g of NPK $plant^{-1}$ $year^{-1}$ at quarterly splits) recorded the highest K uptake in roots, stem, berries, spikes and total uptake. The uptake of K in leaves was non significant. With regard to uptake of K by stem p_2i_4 was on par with p_2i_2 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 37.5: 37.5: 50.0 g of NPK $plant^{-1}$ $year^{-1}$ at quarterly splits). With respect to spikes, p_2i_4 was on par with p_3i_5 (potting media- soil + FYM + leaf compost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 12.5:12.5:25.0 g of NPK $plant^{-1}$ $year^{-1}$ as soil application at equal monthly splits up to 3 MAP and foliar application of 13:0:45 (0.5 %) at fortnightly intervals from 4^{th} MAP). The treatment combination p_2i_4 recorded the highest total uptake of K (2.367 g $plant^{-1}$), followed by p_2i_2 (2.153 g $plant^{-1}$), p_2i_5 (1.993) and p_3i_4 (1.933 g $plant^{-1}$). Significant difference in K uptake in all parts and total uptake was observed between the treatment and control.

4.5.4 Ca uptake

The main and interaction effect of potting media and inorganic fertilizers on the Ca uptake by roots, leaves, stem, berries, spikes and total uptake are furnished in table 26.

Significant variation in uptake of Ca in roots, leaves, stem, berries, spikes and total uptake of Ca was noticed by the use of different potting media. Potting media P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) registered the highest Ca uptake in roots, leaves, stem, berries and spike. The total uptake of Ca was the highest for P_2 (1.332 g $plant^{-1}$), followed by P_3 (1.193 g $plant^{-1}$) and P_1 (0.919 g $plant^{-1}$).

Inorganic fertilizer I_4 (25.0: 25.0: 50.0 g of NPK $plant^{-1}$ $year^{-1}$ at quarterly splits) recorded the highest total Ca uptake and Ca in all parts and total uptake. With regards to Ca uptake in leaves, I_4 was on par with I_2 (37.5: 37.5: 50.0 g of NPK $plant^{-1}$ $year^{-1}$ at quarterly splits). I_4 recorded the highest total uptake of Ca (1.283 g $plant^{-1}$)

Table 26. Effect of potting media and inorganic feriltizers on plant uptake of calcium, g plant^{-1}

Treatments	Roots	Leaves	Stem	Berries	Spikes	Total
Potting media (P)						
P_1	0.118	0.267	0.307	0.193	0.033	0.919
P_2	0.177	0.392	0.411	0.303	0.050	1.332
P_3	0.156	0.374	0.361	0.260	0.042	1.193
SEm±	0.003	0.005	0.004	0.006	0.001	0.01
CD (0.05)	0.008	0.016	0.011	0.019	0.003	0.03
Inorganic fertilizers (I)						
I_1	0.148	0.326	0.360	0.232	0.043	1.108
I_2	0.155	0.346	0.388	0.264	0.034	1.186
I_3	0.129	0.323	0.306	0.226	0.043	1.027
I_4	0.165	0.376	0.407	0.294	0.042	1.283
I_5	0.153	0.352	0.340	0.245	0.047	1.136
SEm±	0.004	0.007	0.005	0.008	0.001	0.013
CD (0.05)	0.011	0.020	0.014	0.024	0.004	0.039
Interaction (p×i)						
p_1i_1	0.132	0.248	0.291	0.181	0.029	0.883
p_1i_2	0.101	0.237	0.304	0.181	0.032	0.857
p_1i_3	0.112	0.262	0.296	0.198	0.034	0.903
p_1i_4	0.143	0.320	0.373	0.235	0.029	1.100
p_1i_5	0.101	0.267	0.271	0.170	0.042	0.850
p_2i_1	0.179	0.375	0.428	0.286	0.055	1.323
p_2i_2	0.190	0.407	0.454	0.319	0.038	1.407
p_2i_3	0.132	0.353	0.328	0.241	0.043	1.097
p_2i_4	0.210	0.443	0.467	0.395	0.064	1.577
p_2i_5	0.172	0.381	0.379	0.275	0.049	1.257
p_3i_1	0.134	0.351	0.360	0.229	0.043	1.117
p_3i_2	0.176	0.391	0.406	0.292	0.031	1.293
p_3i_3	0.143	0.356	0.293	0.238	0.053	1.080
p_3i_4	0.141	0.365	0.380	0.252	0.033	1.173
p_3i_5	0.185	0.408	0.369	0.290	0.050	1.300
SEm±	0.006	0.012	0.009	0.014	0.002	0.023
CD (0.05)	0.018	0.035	0.025	0.042	0.006	0.067
Control	0.090	0.234	0.246	0.150	0.030	0.657
Control Vs Treatment	S	S	S	S	S	S

followed by I_5 (1.136 g plant^{-1}), I_2 (1.186 g plant^{-1}), I_1 (1.108 g plant^{-1}) and I_3 (1.027 g plant^{-1}).

Interaction effects were significant and the treatment combination, p_2i_4 (P_2- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and I_4 -25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest uptake in different parts like roots, leaves, stem, berries and spike. With respect to uptake of calcium in leaves, p_2i_4 was found to be on par with p_3i_5 (potting media- soil + FYM + leaf compost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 12.5:12.5:25.0 g of NPK plant^{-1} year^{-1} as soil application at equal monthly splits up to 3 MAP and foliar application of 13:0:45 (0.5 %) at fortnightly intervals from 4th MAP). With regards to stem p_2i_4 was on par with p_2i_2. The treatment combination, p_2i_4 recorded the highest total uptake of 1.577 g plant^{-1}, followed by p_2i_2 (1.407 g plant^{-1}), p_2i_1 (1.323 g plant^{-1}), and p_3i_5 (1.300 g plant^{-1}). Significant variation in Ca uptake in different plant parts and total uptake was noticed between treatment and control.

4.5.5 Mg uptake

The main and interaction effect of potting media and inorganic fertilizers on the Mg uptake by roots, leaves, stem, berries, spikes and total uptake are presented in table 27.

The total Mg uptake and uptake of Mg in roots, leaves, stem, berries, spikes were significantly influenced by the potting media. P_3 (soil + FYM + leaf compost + coir pith compost in the ratio 3:3:1:1) recorded the highest uptake of Mg in roots and leaves. P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) registered the superior uptake of Mg in stem, berries and spike. The total Mg uptake was the highest under P_2 (260.10 mg plant^{-1}), followed by P_3 (248.22 mg plant^{-1}) and P_1 (182.59 mg plant^{-1}).

Table 27. Effect of potting media and inorganic feriltizers on plant uptake of magnesium, mg plant^{-1}

Treatments	Roots	Leaves	Stem	Berries	Spikes	Total
Potting media (P)						
P_1	16.95	61.30	67.44	28.97	7.92	182.59
P_2	25.59	89.12	88.43	47.98	8.99	260.10
P_3	27.20	89.52	83.04	40.06	8.40	248.22
SEm±	0.705	1.114	1.219	0.926	0.159	2.464
CD (0.05)	2.045	3.234	3.536	2.688	0.462	7.151
Inorganic fertilizers (I)						
I_1	22.85	73.51	74.38	36.37	8.73	215.83
I_2	25.32	77.97	86.42	41.11	8.32	239.14
I_3	18.56	76.21	71.84	34.35	7.96	208.93
I_4	25.67	89.23	90.57	45.98	8.64	260.10
I_5	23.81	82.97	74.97	37.21	8.54	227.51
SEm±	0.911	1.439	1.573	1.196	0.205	3.181
CD (0.05)	2.641	4.175	4.565	3.471	NS	9.232
Interaction (p×i)						
p_1i_1	15.38	51.44	55.43	28.17	8.03	158.45
p_1i_2	18.12	52.29	79.55	28.45	7.81	186.22
p_1i_3	15.39	57.95	60.50	28.15	8.03	170.01
p_1i_4	19.78	78.85	81.20	31.77	7.81	219.41
p_1i_5	16.06	66.00	60.54	28.33	7.92	178.84
p_2i_1	29.01	85.50	89.55	43.53	9.79	257.38
p_2i_2	26.87	95.99	93.09	53.76	8.80	278.52
p_2i_3	19.69	79.81	76.64	39.28	8.25	223.67
p_2i_4	29.45	96.43	97.19	63.83	9.75	296.64
p_2i_5	22.92	87.86	85.67	39.46	8.36	244.27
p_3i_1	24.15	83.57	74.38	37.41	8.36	231.64
p_3i_2	30.97	85.64	86.42	41.10	8.36	252.69
p_3i_3	20.60	90.89	71.84	35.62	7.59	233.09
p_3i_4	27.79	92.43	90.57	42.35	8.36	264.24
p_3i_5	32.47	95.07	74.98	43.82	9.35	259.42
SEm±	1.576	2.492	2.725	2.071	0.356	5.521
CD (0.05)	4.574	7.232	7.907	6.011	1.032	15.99
Control	13.44	48.27	46.17	21.45	7.04	136.38
Control Vs Treatment	S	S	S	S	S	S

The uptake of Mg in roots, leaves, stem, berries spikes and total Mg uptake were significantly differed by the inorganic fertilizers. Inorganic fertilizer I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) registered the highest Mg uptake in different parts like roots, leaves, stem and berries. The uptake of Mg by spikes was non significant. The highest total Mg uptake was recorded by I_4 (260.10 mg plant^{-1}) followed by I_2 (239.14 mg plant^{-1}), I_5 (227.51 mg plant^{-1}), I_1 (215.83 mg plant^{-1}) and I_3 (208.93 mg plant^{-1}).

Interaction effects were significant and treatment combination, p_2i_4 (P_2-soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and I_4 -25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest Mg uptake in plant parts like leaves, stems, berries and spikes. With regard to roots, p_3i_5 (potting media- soil + FYM + leaf compost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 12.5:12.5:25.0 g of NPK plant^{-1} year^{-1} as soil application at equal monthly splits up to 3 MAP and foliar application of 13:0:45 (0.5 %) at fortnightly intervals from 4th MAP) recorded the highest value. Treatment combination, p_2i_4 recorded the highest total uptake of Mg (296.64 mg plant^{-1}), followed by p_2i_2 (278.52mg plant^{-1}), p_3i_4 (264.24 mg plant^{-1}), p_3i_5 (259.42 mg plant^{-1}) and p_2i_1 (257.38 mg plant^{-1}).

Significant change in Mg uptake in different plant parts and total uptake was noticed between treatments and control.

4.5.6 S uptake

The main and interaction effect of potting media and inorganic fertilizers on the S uptake by roots, leaves, stem, berries, spikes and total uptake are furnished in table 28.

Significant change in uptake of S and uptake of S in Mg in roots, leaves, stem, berries, spikes was noticed among different potting media. P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) registered the highest S uptake

Table 28. Effect of potting media and inorganic feriltizers on plant uptake of sulphur, mg plant^{-1}

Treatments	Roots	Leaves	Stem	Berries	Spikes	Total
Potting media (P)						
P_1	21.30	39.56	46.49	30.32	4.88	134.14
P_2	34.62	58.96	66.94	58.61	5.40	210.76
P_3	30.86	52.32	54.49	40.74	5.66	172.05
SEm±	0.618	0.837	1.025	2.079	0.248	2.239
CD (0.05)	1.792	2.423	2.976	6.034	NS	6.499
Inorganic fertilizers (I)						
I_1	27.50	45.84	52.04	42.19	5.82	162.71
I_2	32.12	46.00	62.57	40.80	4.80	173.30
I_3	21.66	47.29	49.82	39.38	4.30	153.60
I_4	34.33	59.45	61.58	47.44	5.74	195.30
I_5	29.03	52.82	53.87	46.30	5.90	176.66
SEm±	0.797	1.081	1.324	2.684	0.32	2.891
CD (0.05)	2.314	3.138	3.842	NS	0.928	8.372
Interaction (p×i)						
p_1i_1	22.88	35.54	41.79	32.07	5.43	128.88
p_1i_2	21.00	33.25	54.14	33.73	4.77	138.58
p_1i_3	16.94	37.66	42.35	32.17	2.97	124.59
p_1i_4	24.96	51.14	52.47	23.43	4.87	147.07
p_1i_5	20.70	40.19	41.72	30.20	6.37	131.56
p_2i_1	33.05	51.19	63.71	65.37	6.10	206.33
p_2i_2	37.46	60.20	76.51	57.57	4.63	220.87
p_2i_3	24.36	48.99	53.67	46.07	4.50	167.60
p_2i_4	46.89	73.33	70.66	74.07	6.40	253.34
p_2i_5	31.36	61.10	70.16	49.97	5.37	205.67
p_3i_1	26.58	50.79	50.61	29.13	5.93	152.91
p_3i_2	37.91	44.56	57.06	31.10	5.00	160.46
p_3i_3	23.69	55.22	53.44	39.90	5.43	168.62
p_3i_4	31.13	53.89	61.59	44.83	5.97	185.49
p_3i_5	35.02	57.16	49.74	58.73	5.97	192.76
SEm±	1.381	1.873	2.293	4.649	0.554	5.007
CD (0.05)	4.008	5.435	6.654	13.492	NS	14.532
Control	19.40	40.65	34.11	21.50	4.90	113.03
Control Vs Treatment	S	S	S	S	S	S

in roots, leaves, stem and berries. Uptake of S by spikes were found to be non significant among different potting media. P_2 registered the highest total S uptake (210.76 mg plant^{-1}), followed by P_3 (172.05 mg plant^{-1}) and P_1 (134.14 mg plant^{-1}).

Inorganic fertilizer, I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest uptake of S in different parts like roots and leaves. With regards to S uptake by stem, I_2 (37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest value and was on par with I_4. Uptake of S by berries was found to be non significant among different inorganic fertilizers. I_4 recorded the highest total S uptake of 195.30 mg plant^{-1} followed by I_5 (176.66 mg plant^{-1}), I_2 (173.30 mg plant^{-1}), I_1 (162.71 mg plant^{-1}) and I_3 (153.60 mg plant^{-1}).

Interaction effects were found to be significant. The treatment combination p_2i_4, (P_2-soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and I_4 - 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest S uptake in different plant parts like roots, leaves and berries. Regarding the uptake of S by stem, p_2i_2 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest value. The uptake of S by spikes were noted to be non significant among treatment combinations. The treatment combination, p_2i_4 recorded the highest total uptake of S (253.34 mg plant^{-1}) followed by p_2i_2 (220.87 mg plant^{-1}), p_2i_1 (206.33 mg plant^{-1}) and p_2i_5 (205.67 mg plant^{-1}). Significant variation in uptake of S by different plant parts and total uptake were noticed among the treatments and control.

4.6 NUTRIENT HARVEST INDEX OF PRIMARY AND SECONDARY NUTRIENTS

4.6.1 Nitrogen harvest index

The main and interaction effect of potting media and inorganic fertilizers on nitrogen harvest index are presented in Table 29.

Potting media significantly influenced the nitrogen harvest index. Plants raised in P_1 (soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1) recorded the highest nitrogen harvest index and was on par with P_2 (31.24 %).

Significant change in nitrogen harvest index was noticed among different inorganic fertilizers. I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) registered the highest nitrogen harvest index (31.62 %) and was on par with I_1, I_2 and I_5.

Interaction effects were found to be significant and the treatment combination, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest nitrogen harvest index (33.58 %) and was on par with p_1i_5 (32.83 %) and p_2i_1 (32.89 %) and p_1i_5 (32.83 %). Nitrogen harvest index found to be non significant between treatment and control.

4.6.2 Phosphorus harvest index

The main and interaction effect of potting media and inorganic fertilizers on phosphorus harvest index are provided in Table 29.

Phosphorus harvest index significantly varied among different potting media. Potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) registered the highest phosphorus harvest index (38.36 %). The lowest phosphorus harvest index was recorded by P_3 (36.19 %).

Table 29. Effect of potting media and inorganic feriltizers on nitrogen, phosphorus and potassium harvest index, %

Treatments	Nitrogen	Phosphorus	Potassium
Potting media (P)			
P_1	31.59	36.21	29.39
P_2	31.24	38.36	30.04
P_3	29.81	36.19	28.77
SEm±	0.276	0.552	0.247
CD (0.05)	0.802	1.601	0.716
Inorganic fertilizers (I)			
I_1	31.51	37.54	29.77
I_2	30.93	36.3	29.51
I_3	29.21	34.93	28.22
I_4	31.62	37.38	29.88
I_5	31.12	38.45	29.62
SEm±	0.357	0.712	0.319
CD (0.05)	1.036	2.067	0.925
Interaction (p×i)			
p_1i_1	31.63	34.22	29.27
p_1i_2	31.04	35.56	29.46
p_1i_3	31.15	37.57	28.86
p_1i_4	31.28	35.88	29.49
p_1i_5	32.83	37.83	29.88
p_2i_1	32.89	39.59	30.25
p_2i_2	31.72	38.79	29.87
p_2i_3	28.22	33.49	29.44
p_2i_4	33.58	41.03	31.41
p_2i_5	29.78	38.86	29.25
p_3i_1	30.01	38.8	29.79
p_3i_2	30.05	34.54	29.19
p_3i_3	28.25	33.73	26.36
p_3i_4	29.99	35.24	28.75
p_3i_5	30.74	38.64	29.73
SEm±	0.618	1.234	0.552
CD (0.05)	1.794	3.573	1.601
Control	31.34	31.49	26.02
Control Vs Treatment	S	S	S

Significant variation in phosphorus harvest index was noticed among different inorganic fertilizers. I_5 (12.5:12.5:25.0 g of NPK plant^{-1} year^{-1} as soil application at equal monthly splits up to 3 MAP and foliar application of 13:0:45 (0.5 %) at fortnightly intervals from 4th MAP) resulted in highest phosphorus harvest index (38.45 %) and was on par with I_1 and I_4.

Interaction effects were found to be significant and the treatment combination, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) resulted in highest phosphorus harvest index (41.03 %) and was on par with p_2i_1 (39.59 %), p_2i_5 (38.86 %), p_3i_1 (38.80 %), p_2i_2 (38.79 %), p_1i_5 (37.83 %), p_1i_3 (37.57 %) and p_3i_5 (38.64 %). Significant difference in phosphorus harvest index was recorded between treatment and control.

4.6.3 Potassium harvest index

The main and interaction effect of potting media and inorganic fertilizers on potassium harvest index are presented in Table 29.

Potting media significantly influenced the potassium harvest index. Plants raised in potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) registered the highest value (30.04 %). The potassium harvest index of P_1 and P_3 were (29.39 %) and (28.77 %) respectively.

Significant change in potassium harvest index was noticed among different inorganic fertilizers. I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) resulted in highest potassium harvest index (29.88 %) and was on par with I_1 (29.77 %), I_5 (29.62 %) and I_2 (29.51 %).

Interaction effects were found to be significant. Treatment combination, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest potassium harvest index (31.41 %) and was on par with p_2i_1 (30.25 %), p_1i_5 (29.88 %), and p_2i_2 (29.87 %). Significant variation in potassium harvest index was noticed between treatment and control.

4.6.4 Calcium harvest index

The main and interaction effect of potting media and inorganic fertilizers on calcium harvest index are furnished in Table 30.

Calcium harvest index significantly varied among different potting media. Potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) registered the highest calcium harvest index (22.61 %).

Significant variation in calcium harvest index was noticed among different inorganic fertilizers. I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) resulted in highest value (22.60 %) and was on par with I_2 (22.10 %) and I_3 (21.98 %).

Interaction effects were found to be significant and the treatment combination, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) resulted in highest calcium harvest index (24.97 %). The calcium harvest index of control was 20.20 %. Calcium harvest index was found to be non significant between treatment and control.

4.6.5 Magnesium harvest index

The main and interaction effect of potting media and inorganic fertilizers on magnesium harvest index are presented in Table 30.

Potting media significantly influenced the magnesium harvest index. Plants raised in potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) registered the highest value (18.28 %).

Table 30. Effect of potting media and inorganic feriltizers on calcium, magnesium and sulphur harvest index, %

Treatments	Calcium	Magnesium	Sulphur
Potting media (P)			
P_1	21.00	15.98	22.80
P_2	22.61	18.28	27.66
P_3	21.73	16.12	23.21
SEm±	0.244	0.462	0.885
CD (0.05)	0.709	0.947	2.569
Inorganic fertilizers (I)			
I_1	20.87	16.96	25.06
I_2	22.1	16.92	23.19
I_3	21.98	16.47	25.59
I_4	22.6	17.32	23.07
I_5	21.34	16.30	25.87
SEm±	0.315	0.596	1.143
CD (0.05)	0.915	NS	NS
Interaction (p×i)			
p_1i_1	20.53	17.80	24.89
p_1i_2	21.18	15.20	24.33
p_1i_3	21.94	16.59	25.88
p_1i_4	21.33	14.45	15.95
p_1i_5	20.01	15.84	22.95
p_2i_1	21.62	16.89	31.58
p_2i_2	22.62	19.29	25.86
p_2i_3	21.99	17.55	27.48
p_2i_4	24.97	21.50	29.15
p_2i_5	21.83	16.15	24.22
p_3i_1	20.47	16.18	18.71
p_3i_2	22.51	16.26	19.37
p_3i_3	22.00	15.26	23.42
p_3i_4	21.48	16.02	24.12
p_3i_5	22.18	16.91	30.43
SEm±	0.546	1.032	1.979
CD (0.05)	1.585	2.118	5.744
Control	20.2	15.63	18.86
Control Vs Treatment	NS	NS	S

Magnesium harvest index was found to be non significant among different inorganic fertilizers.

Interaction effects were found to be significant. Treatment combination, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and 25.0: 25.0: 50.0 g of NPK $plant^{-1}$ $year^{-1}$ at quarterly splits) recorded the highest value (21.50 %). There was no significant variation in magnesium harvest index between treatment and control.

4.6.6 Sulphur harvest index

The main and interaction effect of potting media and inorganic fertilizers on sulphur harvest index are presented in Table 30.

Significant difference in the sulphur harvest index was noticed among potting media. Potting media P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest sulphur harvest indices of 27.66 % followed P_3 (23.21 %) and P_1 (22.80 %).

Sulphur harvest index was found to be non significant among different inorganic fertilizers.

Interaction effects were found to be significant. Treatment combination, p_2i_1 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and 37.5: 37.5: 50.0 g of NPK $plant^{-1}$ $year^{-1}$ at monthly splits) recorded the highest sulphur harvest index (31.58 %) and was on par with p_1i_3, p_2i_2, p_2i_3, p_2i_4 and p_3i_5.

4.7 ECONOMICS OF CULTIVATION

Economics of cultivation of bush pepper for 15 years for the calculation of discounted benefit cost ratio, net present worth and internal rate of returns is shown in Appendix 2. The Discounted benefit cost ratio, net present worth and internal rate of returns for various treatments of bush pepper for 15 years is furnished in Appendix 3.

Table 31. The discounted benefit cost ratio, net present worth and internal rate of return of bush pepper

Treatments (p×i)	Discounted cost	Discounted benefit	Discounted benefit cost ratio	NPW	IRR(%)
p_1i_1	550.22	639.54	1.16	89.32	20
p_1i_2	550.22	646.43	1.18	97.21	21
p_1i_3	537.49	651.50	1.22	120.01	23
p_1i_4	537.49	722.67	1.34	184.19	28
p_1i_5	527.57	661.89	1.25	134.31	24
p_2i_1	475.65	681.28	1.81	385.63	44
p_2i_2	475.65	870.19	1.83	394.53	45
p_2i_3	462.32	713.82	1.54	251.50	34
p_2i_4	462.92	1159.89	2.51	696.97	67
p_2i_5	452.40	842.98	1.86	390.58	45
p_3i_1	475.65	773.08	1.63	297.43	38
p_3i_2	475.65	801.15	1.68	325.49	40
p_3i_3	462.32	659.14	1.43	196.82	30
p_3i_4	462.92	801.61	1.73	338.69	41
p_3i_5	452.40	863.03	1.91	410.63	47
Control	523.79	584.66	1.12	60.87	18

The discounted benefit cost ratio, net present worth and internal rate of return of bush pepper is presented in table 31. The treatment combination of potting media (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) and inorganic fertilizer (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) generated the highest discounted benefit cost ratio of 2.51. This was followed by p_3i_5 (1.91), p_2i_5 (1.86) and p_2i_2 (1.83). All the treatment combinations resulted in higher discounted benefit cost ratio than the control (1.12).

The net present worth recorded was ₹ 696.97 in p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizer (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) followed by ₹ 410.63 in p_3i_5.

Internal rate of return was the highest in the treatment combination, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizer (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) (67 %) followed by p_3i_5 (47 %).

4.8 INCIDENCE OF PESTS

There was no pest incidence in the field during the period of observation.

4.9 INCIDENCE OF DISEASES

Leaf rot was noticed 1 month after planting, which was controlled by spraying of Ridomil Gold @ 0.2 % twice at one week interval.

DISCUSSION

5. DISCUSSION

The study entitled "Nutrient scheduling in bush pepper (*Piper nigrum* L.) was undertaken in the Department of Plantation Crops and Spices in 2017- 2018. The effect of potting media and inorganic fertilizers on morphological, physiological, quality, uptake of primary and secondary nutrients and nutrient harvest indices were discussed in this chapter.

5.1 MORPHOLOGICAL PARAMETERS

5.1.1 Growth parameters

5.1.1.1 Plant height

Plant height showed significant variation among potting media and inorganic fertilizers from 2 MAP to 12 MAP (Table 4). The interaction effect of potting media and inorganic fertilizers from 6 MAP to 12 MAP are provided in Fig. 1.

The plant height was significantly higher for plants raised in P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) at all growth period. The plant height increased from 42.60 cm to 63.60 cm from 2 MAP to 12 MAP and it was least in P_1 (soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1) varied from 31.28 cm to 49.60 cm. A similar effect of vermicompost on plant height of black pepper cutting was noticed by Thankamani *et al.* (1996). Vermicompost contains nutrients essential for plant growth in readily available form (Theunissen *et al.*, 2010). Prasath *et al.* (2014) revealed that composted coir pith with vermicompost in 3: 1 proportion and *Trichoderma* @ 10 g kg^{-1} of potting mixture as an ideal potting medium for black pepper nursery and maximum plant growth characteristics like plant height (13.28 cm) was also noted in that medium. Kala (2017) observed the highest plant height in chrysanthemum cv. Pusa Sona raised in potting media composed of soil: sand: FYM: vermicompost in the ratio 2:1:0.5:0.5. Kerketa (2015) reported maximum plant height of *Populus deltoides* in potting media containing soil: sand: vermicompost in the ratio 1: 1: 1.

Inorganic fertilizers also significantly influenced the plant height of bush pepper. I_5 (12.5:12.5:25.0 g of NPK plant^{-1} year^{-1} as soil application at equal monthly splits upto 3 MAP and foliar application of 13:0:45 (0.5 %) at fortnightly intervals from 4th MAP) recorded the highest plant height from 4 MAP to 12 MAP. Chaurasia *et al.* (2005) reported that foliar application of water soluble fertilizers significantly increased the plant height of Tomato (*Lycopersicon esculentum* L.). Foliar spray enables plants to absorb the applied nutrients from the solution through their leaf surface and thus, may result in the economic use of fertilizer (Manasa *et al.,* 2015). The highest plant height in I_5 may be due to the increased absorption of nutrients due the combined application of soil and foliar fertilizers.

Interaction effect between potting media and inorganic fertilizers was non significant at 2 MAP and significant from 4 MAP to 12 MAP. Treatment combination, p_2i_5 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 12.5:12.5:25.0 g of NPK plant^{-1} year^{-1} as soil application at equal monthly splits upto 3 MAP and foliar application of 13:0:45 (0.5 %) at fortnightly intervals from 4th MAP) produced the plants with higher plant height from 4 MAP to 12 MAP. It may be due to the efficient release of nutrients from the soil during initial period upto 3 MAP and thereby absorption of nutrients through foliar application. Significant difference in plant height in all periods of growth was recorded between treatment and control. The plant height produced by the control was significantly lower compared to the treatments.

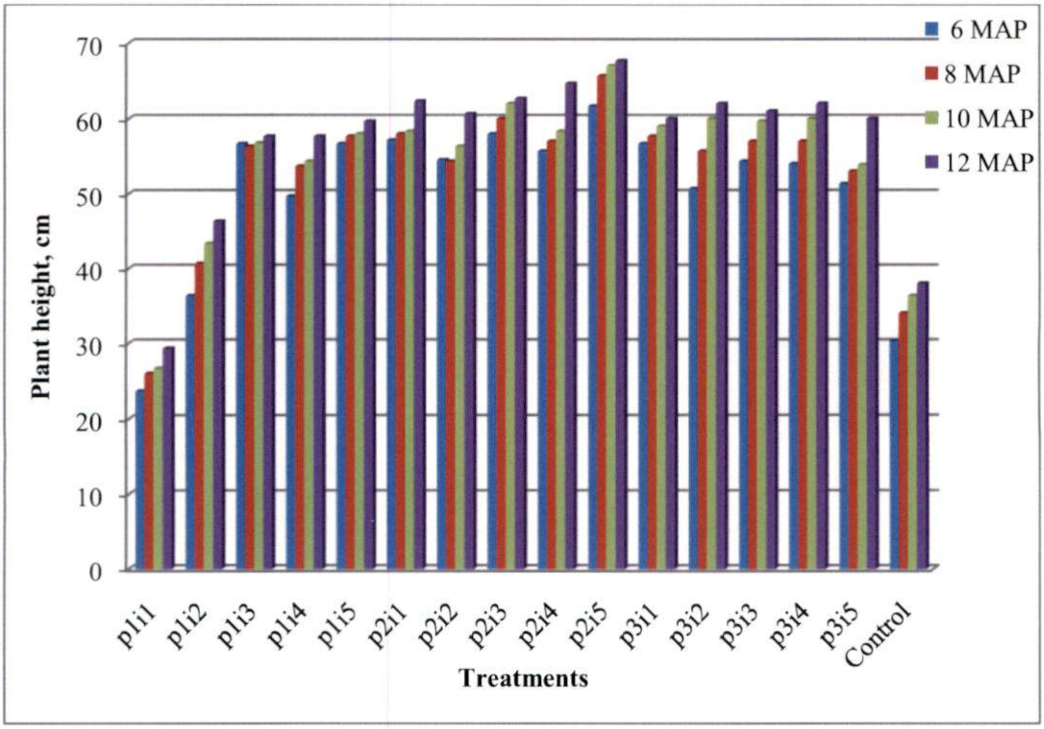

Fig. 1 Interaction effect of potting media and inorganic fertilizers on plant height (cm)

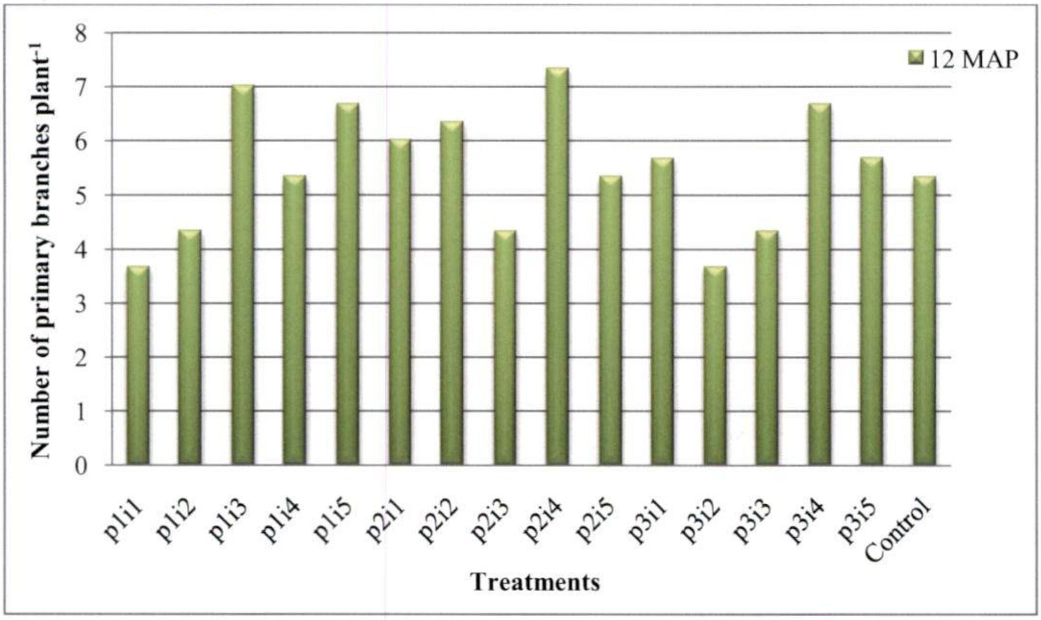

Fig. 2 Interaction effect of potting media and inorganic fertilizers on number of primary branches $plant^{-1}$

5.1.1.2 Number of primary branches

Potting media and inorganic fertilizers did not significantly influence the number of primary branches throughout the crop period from 2 MAP to 12 MAP (Table 5).

Significant difference was noticed between the interaction of potting media and inorganic fertilizers at 12 MAP and is presented in Fig. 2.

Interaction effect between potting media and inorganic fertilizers was noted to be non significant upto 10 MAP. At 12 MAP treatment combination, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers- 25.0:25.0:50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest number of primary branches was on par with p_1i_3 (7.00), p_1i_5 (6.67), p_3i_4 (6.67), p_2i_2 (6.33), p_2i_1 (6.00), p_3i_1 (5.67), p_3i_5 (5.67), p_1i_4 (5.33) and p_2i_5 (5.33). The number of primary branches also did not show any significant difference between the treatments and control.

Devadas and Chandini (2000) reported significantly higher production of primary branches in bush pepper plants grown under 50 per cent shade and applied with 37.5, 25 and 75 g of NPK plant^{-1} year^{-1}. However Abhimannue (2016) observed no significant difference in branches of *Piper longum* grown under different methods of irrigation and levels of fertigation from 7 MAP to 15 MAP.

5.1.1.3 Number of secondary branches

Number of secondary branches was influenced significantly by potting media, inorganic fertilizers from 6 MAP to 12 MAP (Table 6). The interaction effect was also significant from 6 MAP to 12 MAP and is presented in Fig. 3.

Potting media did not influence the number of secondary branches upto 4 MAP. Subsequently, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) produced the highest number of secondary branches from 6 MAP to 12 MAP. Tomati *et al.* (1987) reported that the presence of microbiota like fungi, bacteria and actinomycetes in vermicompost makes it suitable for plant growth. Thankamani *et al.* (1996) observed that when clove seedlings (*Syzygium aromaticum*) grown in potting medium (soil: vermicompost in the ratio 1:1) produced maximum number of branches. Kala (2017) found maximum number of branches plant^{-1} in potted chrysanthemum raised in the potting media composed soil: sand: FYM: vermicompost in the ratio 2:1:0.5:0.5.

There was no significant variation in the number of secondary branches among inorganic fertilizers from 2 MAP to 4 MAP. After 4 MAP inorganic fertilizer, I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest number of secondary branches from 6 MAP to 12 MAP and was on par with I_1, I_2, and I_5at 12 MAP. Devadas and Chandini (2000) observed maximum number of secondary branches in bush pepper grown in potting media containing soil: sand: FYM in the ratio 1:1:1 supplemented with 37.5: 37.5: 50 g of NPK year^{-1}at monthly splits.

Interaction effect was non significant upto 4 MAP. After that significant difference was noted among the different treatment combination. The treatment combination, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 25.0:25.0:50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) resulted in the highest value, which was on par with the p_2i_1 and p_2i_2 at 12 MAP. The increase in the number of branches may be due to increased uptake of nutrients when plants were fertilized, which resulted in stimulation in lateral meristem and which developed into branches (Tisdale *et al.*, 1995). Treatment differed significantly from the control from 4 MAP to 12 MAP. The number of

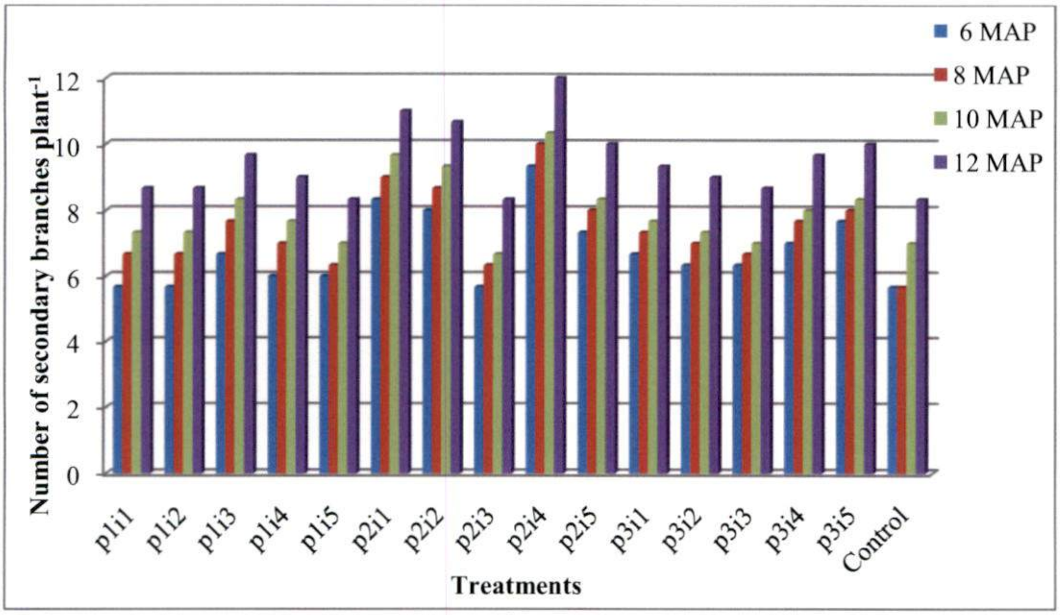

Fig. 3 Interaction effect of potting media and inorganic fertilizers on number of secondary branches plant^{-1}

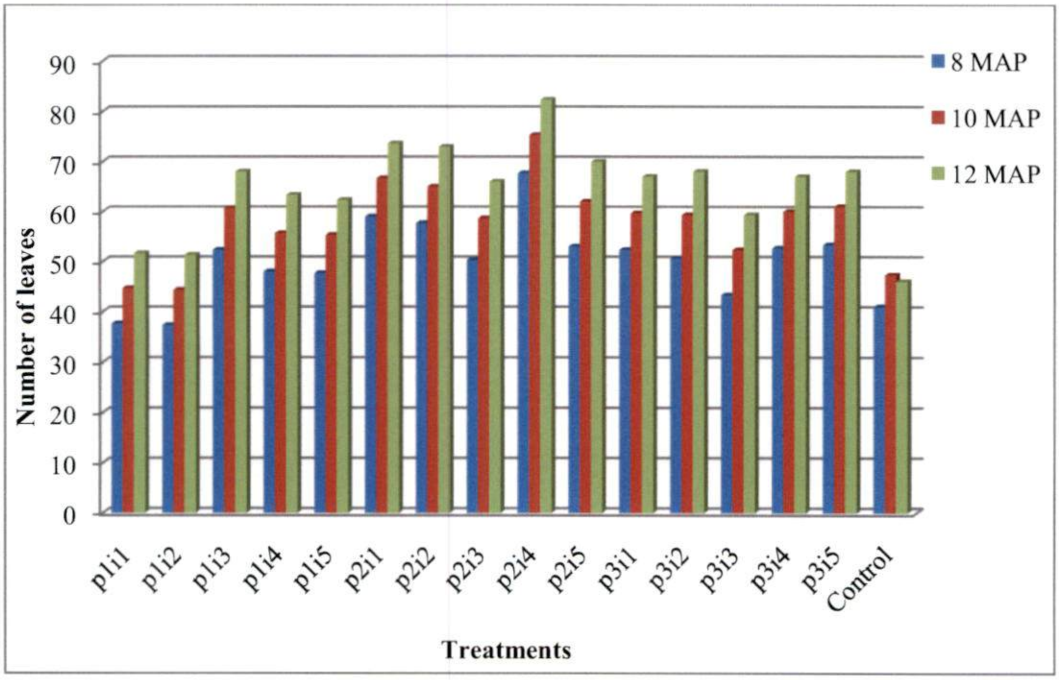

Fig. 4 Interaction effect of potting media and inorganic fertilizers on number of leaves

secondary branches was comparatively less in the control compared to treatments from 4MAP to 12 MAP.

5.1.1.4 Length of primary branches

Length of primary branches showed significant variation among potting media and inorganic fertilizers from 4 MAP to 12 MAP (Table 7).

Potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) found to produce the highest value from 4 MAP to 12 MAP. This might be due to the effect of vermicompost along with soil, FYM and coir pith compost. Vermicompost has higher nutritional value than traditional composts, due to increased rate of mineralization and degree of humification by the action of earthworms (Albanell *et al*., 1988). Akshay *et al*. (2014) viewed that the black pepper cuttings raised in the media comprising soil + sand + FYM + vermicompost (1:1:1:1 v/v) significantly increased days to sprout (15.93 days) and length of shoot (20.26 cm).

Plants which received inorganic fertilizers, I_4 (25.0:25.0:50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) produced the highest length of primary branches from 4 MAP to 12 MAP and was on par with I_5 (12.5:12.5:25.0 g of NPK plant^{-1} year^{-1} as soil application at equal monthly splits upto 3 MAP and foliar application of 13:0:45 (0.5 %) at fortnightly intervals from 4th MAP) from 4 MAP to 12 MAP. Geetha and Aravindakshan (1992) reported the importance of NPK fertilizers on length of primary and secondary branches. Devadas and Chandini (2000) reported that bush pepper plants which received 37.5 g N, 50 g P and 50 g K bush^{-1} year^{-1} in monthly splits produced the maximum length of primary branches.

The combination of potting media and inorganic fertilizers was noted non significant upto 4 MAP, thereafter p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 25.0: 25.0: 50.0 g of

NPK plant^{-1} year^{-1} at quarterly splits) recorded the significantly superior value. The treatment combination, p_2i_4 resulted in higher uptake of N, P and K which might have contributed to the superior length of primary branches. The treatment combinations differed significantly from the control during 4 MAP to 12 MAP.

5.1.1.5 Length of secondary branches

Significant difference in length of secondary branches was noticed among potting media and inorganic fertilizers and their interaction from 4 MAP to 12 MAP (Table 8).

P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest length of secondary branches from 4 MAP to 12 MAP. P_2 recorded 33.11cm, 38.77 cm, 40.77 cm, 44.27 cm and 45.45 cm length for secondary branches at 4 MAP, 6 MAP, 8 MAP, 10 MAP and 12 MAP respectively. Orozco *et al.* (1996) reported that vermicompost contains nutrients such as nitrates, phosphates, and exchangeable calcium and soluble potassium in easily available forms to the plants. The availability of the primary nutrients and calcium might have resulted in higher length of secondary branches in P_2.

Significant variation among inorganic fertilizers was noticed from 4 MAP to 12 MAP. I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest length of secondary branches from 4 MAP to 12 MAP and was on par with I_5 from 6 MAP to 12 MAP, I_2 and I_1 from 8 MAP to 12 MAP. Devadas and Chandini (2000) reported that under NPK interaction the length of secondary branches of bush pepper variety Karimunda found to be the maximum in 37.5 g N, 50 g P and 50 g K bush^{-1} year^{-1} at monthly application but 37.5 g N was found to be on par with 25 g N.

Interaction effect was significant from 4 MAP to 12 MAP and treatment combination p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest length of secondary branches from 4 MAP to 12 MAP. Significant difference in length of secondary branches was observed between treatment and control from 4 MAP to 12 MAP and the recorded length was significantly lower than the treatments.

4.1.1.5 Number of leaves

The number of leaves differed significantly between potting media from 4 MAP to 12 MAP while inorganic fertilizers (Table 9) and interaction between potting differerd significantly from 8 MAP to 12 MAP (Fig. 4).

Potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) produced the highest number of leaves from 4 MAP to 12 MAP. Available N is greater in vermicompost than conventionally composted manure (Taleshi *et al.*, 2011). Prasath *et al.* (2014) reported maximum number of leaves in black pepper raised in potting media containing composted coir pith with vermicompost in 3: 1 proportion and *Trichoderma* @ 10 g kg^{-1}. The higher number of secondary branches and length of primary and secondary branches in P_2 might have resulted in significantly higher number of leaves. The readily available nutrients in the media might have favoured the production of more number and length of primary and secondary branches.

Inorganic fertilizers were found to be non significant upto 6 MAP. Inorganic fertilizer, I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) showed significantly high value from 8 MAP to 12 MAP. I_4 produced 56.11, 63.67 and 70.89 numbers of leaves at 8 MAP, 10 MAP and 12 MAP respectively. Nybe and Nair (1986) reported the importance of N in leaf production of black pepper. Geetha and Aravindakshan (1992) reported higher number of leaves at higher level of N in bush pepper. Devadas and Chandini (2000) found that maximum number of leaves was produced when plants received 50 g N, 50 g P and 75 g K bush^{-1} year^{-1}at monthly splits.

The combination of potting media and inorganic fertilizers also influenced the leaf production. Unlike other combinations, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) produced the highest number of leaves from 8 MAP to 12 MAP. Higher number of leaves corresponded with higher number and length of primary and secondary branches in the above treatment.

The number of leaves produced by the treatments varied significantly from the control from 4 MAP to 12 MAP. The potting media and inorganic fertilizers increased the number and length of secondary branches, which resulted in the more number of leaves than in the plants grown under potting mixture (soil: sand: FYM in the ratio 1: 1: 1 and applied with NPK 1.0:0.5:2.0 g plant^{-1} at bimonthly interval.

5.1.1.7 Leaf length

Leaf length was significantly influenced by potting media from 8 MAP to 12 MAP. The inorganic fertilizers and the interaction between potting media and inorganic fertilizers could not significantly affect the leaf length from 2 MAP to 12 MAP (Table 10).

Potting media showed no significant change in leaf length from 2 MAP to 6 MAP. P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest leaf length from 8 MAP to 12 MAP, which was on par with P_3 (soil + FYM + leaf compost + coir pith compost in the ratio 3:3:1:1). Application of 15 t ha^{-1} of vermicompost and 50 % NPK in (*Allium sativum* L.) under field condition produced the highest leaf length (Suthar, 2009).

The leaf length did not vary between treatment combinations and control.

5.1.1.8 Leaf width

The effect of potting media, inorganic fertilizers and their interaction on leaf width was not significant during the growth period from 2 MAP to 12 MAP. The control also did not differ from the treatment with respect to the leaf width (Table 11).

5.1.1.9 Leaf area

Significant effect of interaction of potting media and fertilizers from 6 MAP to 12 MAP is presented in Fig.5. while the main effects are presented in Table 12.

Potting media had significant effect on leaf area from 4 MAP to 12 MAP. P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest leaf area from 4 MAP to 12 MAP. Zaman *et al.* (2015) reported that leaf area of *Stevia rebaudiana* increased with increasing levels of vermicompost application upto 7.5 t ha^{-1} and then declined with further addition. The highest number of leaves and leaf length in P_2 resulted in higher leaf area.

Significant difference in leaf area among different inorganic fertilizers was noticed from 8 MAP to 12 MAP. I_4 (25.0: 25.0: 50.0 g of NPK $plant^{-1}$ $year^{-1}$ at quarterly splits) was found to be at par with I_5 and I_1at 10 and 12 MAP. I_4 produced more number of leaves which might have resulted in highest leaf area. Devadas and Chandini (2000) reported that application of 50 g N, 25 g P and 75 g K $bush^{-1}$ $year^{-1}$ at monthly interval recorded maximum leaf area in black pepper variety Karimunda.

Significant variation was observed among the treatment combination from 8 MAP to 12 MAP. Treatment combination, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers25.0: 25.0: 50.0 g of NPK $plant^{-1}$ $year^{-1}$ at quarterly splits) produced the highest leaf area from 8 MAP to 12 MAP. p_2i_4 produced the highest number of leaves which resulted

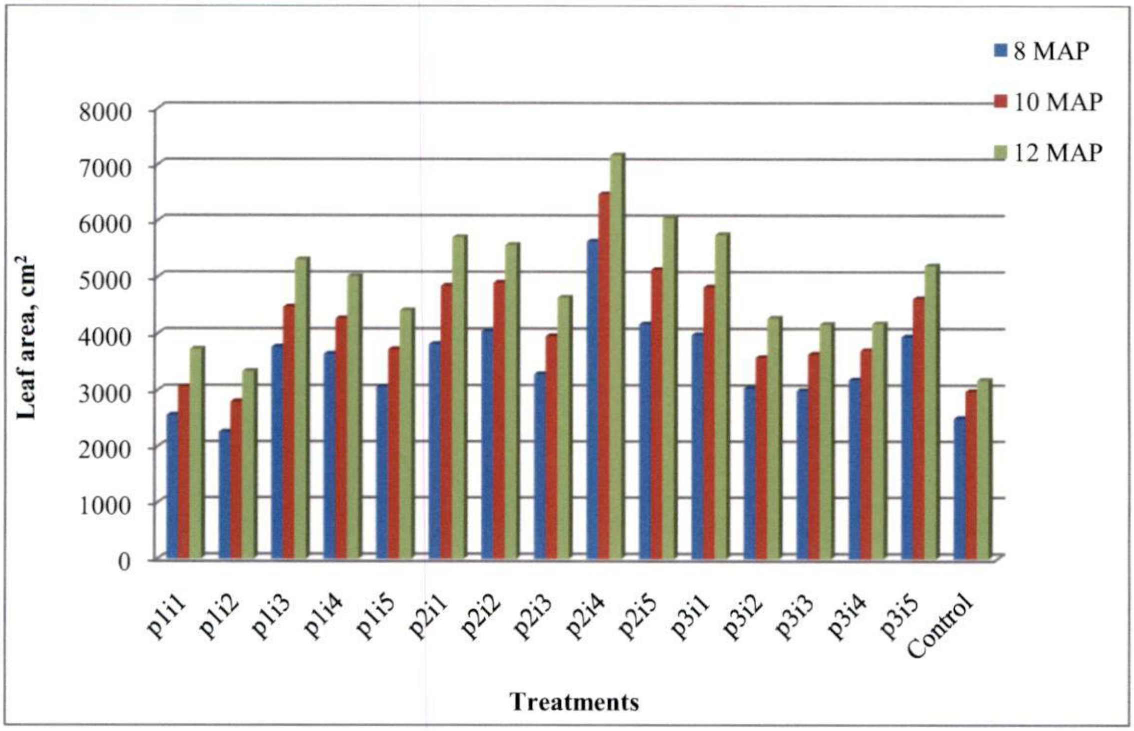

Fig. 5 Interaction effect of potting media and inorganic fertilizers on leaf area (cm^2)

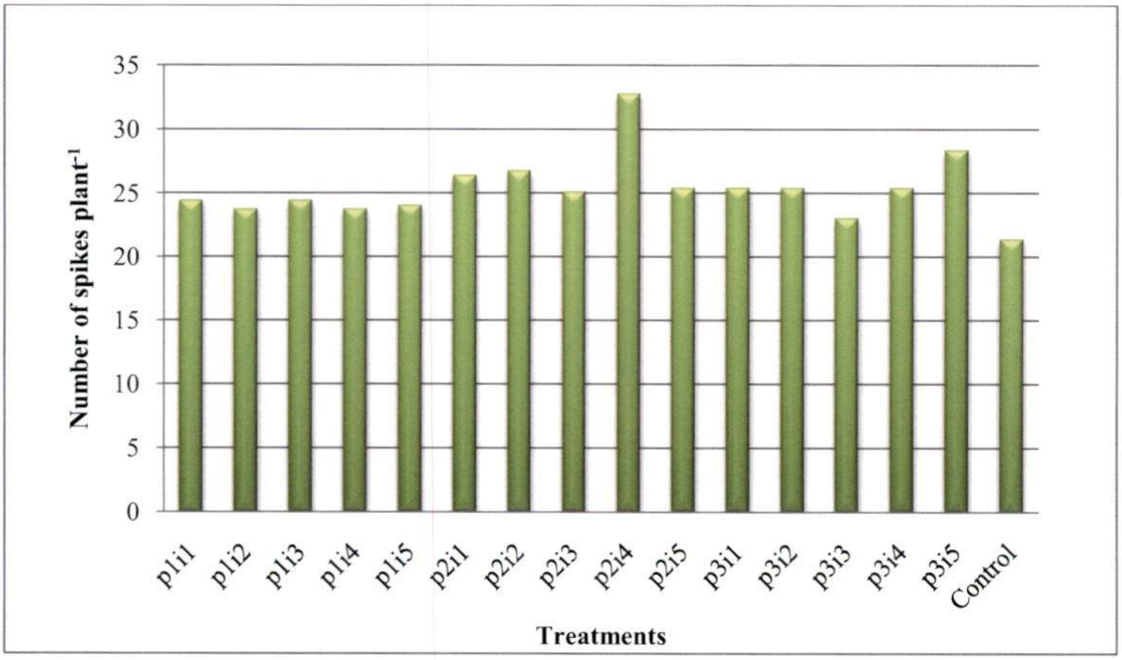

Fig. 6 Interaction effect of potting media and inorganic fertilizers on number of spikes $plant^{-1}$

in highest leaf area. Thankamani *et al.* (2007) reported that black pepper cuttings raised in solarized potting mixture containing soil, sand and farm yard manure in the proportion 2:1:1 with recommended nutrients (urea, superphosphate, potash and magnesium sulphate 4:3:2:1) produced significant increase in number of leaves (5.3), and leaf area (177 cm^2). Significant variation in leaf area was noticed among control and treatment combination throughout the growth period.

5.1.2 Yield parameters

5.1.2.1 Number of spikes plant^{-1}

Table 13 represents the effect of potting media and inorganic fertilizers on the number of spikes plant^{-1}. Fig. 6 represents the interaction effect of potting media and inorganic fertilizers on number of spikes plant^{-1} at harvest.

The number of spikes plant^{-1} differed significantly among potting media. P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest number of spikes (27.20) during the crop period followed by P_3 (25.47) and P_1 (24.00). Arancon *et al.* (2004) reported that slow increase in number of fruits in straw berry by the application of vermicompost as compared to inorganic fertilizers. Kala (2017) observed the highest number of flowers plant^{-1} in pot chrysanthemum when raised in potting media composed of soil: sand: FYM: vermicompost in the ratio 2:1:0.5:0.5.

In the inorganic fertilizers, I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded more number of spike (27.22), which was on par with I_1 (25.88) and I_5 (25.33). This was followed by I_2 (25.22) and I_3 (24.11). Sheela (1996) reported that application 30:30:60 N: P_2O_5: K_2O kg ha^{-1} along with 20 tonnes organic manure increased the number of spikes plant^{-1} in long pepper. Devadas and Chandini (2000) reported that N and P had significant effect on number of spikes where as K had no significant effect. They found that 37.5 g of N and P produced maximum number of spikes.

Interaction effect was significant and among interaction treatment combination, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest number of spikes plant^{-1} (32.67). This was followed by p_3i_5 (28.33) which was on par with p_2i_2 (26.67), p_2i_1 (26.33), p_2i_5 (25.33), p_3i_1 (25.33), p_3i_2 (25.33) and p_3i_4 (25.33). According to Thanuja and Rajendran (2003) the number of leaves per lateral and leaf area of lateral was positively correlated with the number of spikes per lateral. Treatment combination, p_2i_4 produced significantly higher number of leaves, leaf area which might have resulted in the production of more photosynthates leading to diversion to sink thus constituting more number of spikes. The treatment differed significantly from the control. The lower number of spikes in control might be because of the less production of photosynthates due to the less number of leaves and leaf area.

5.1.2.2 Length of spike

The interaction effect of potting media and inorganic fertilizers on length of spikes is furnished in Fig. 7. The main effect of potting media and inorganic fertilizers is presented in table 13.

Significant variation in length of spike was observed among different potting media. Plants raised in P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest value for length of spike (10.72 cm) followed by P_3 (10.04 cm) and P_1 (9.30 cm).

Plants which received the inorganic fertilizers, I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) resulted in the highest length of spike (11.01 cm), followed by I_3, I_1, I_5 and I_2.

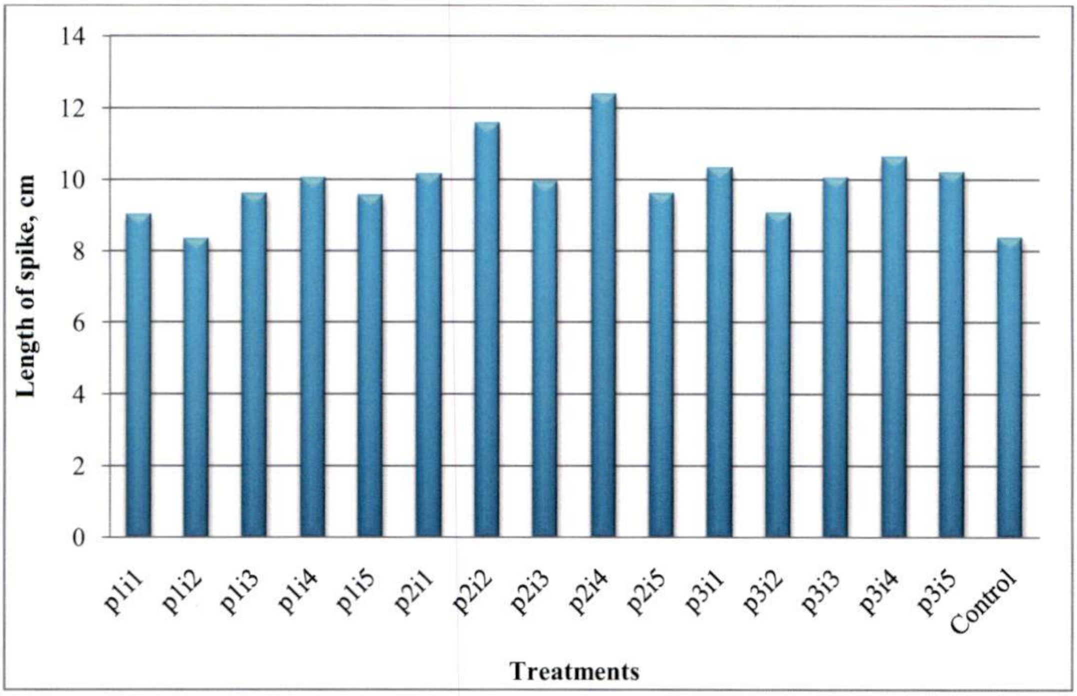

Fig. 7 Interaction effect of potting media and inorganic fertilizers on length of spike (cm)

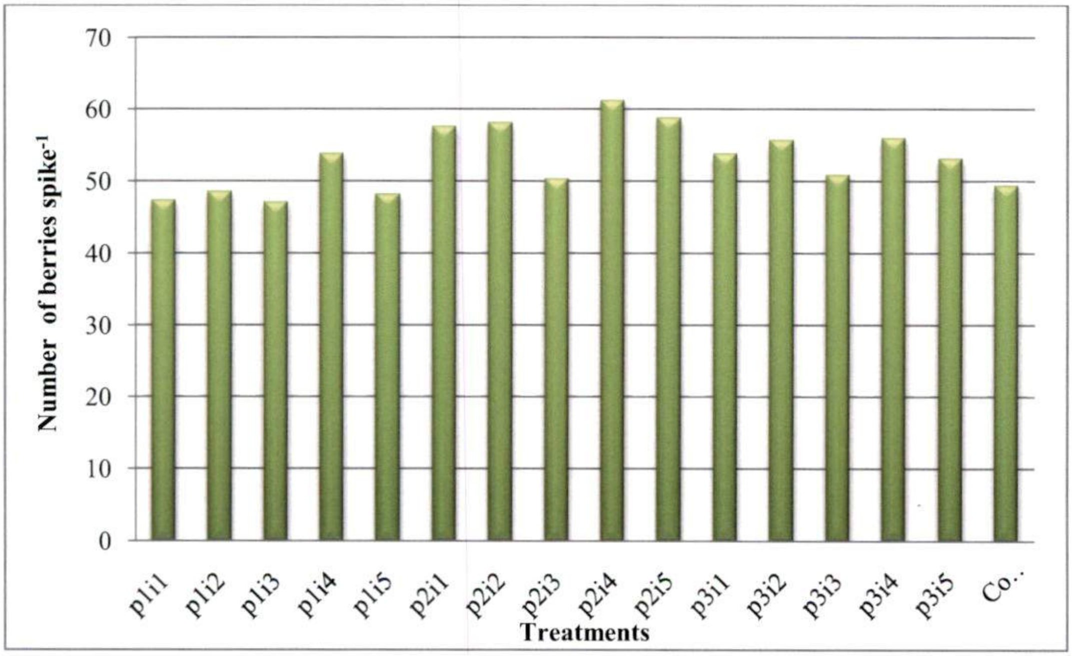

Fig. 8 Interaction effect of potting media and inorganic fertilizers on number of berries spike^{-1}

Interaction effect was significant and among different treatment combination. p_2i_4 , which contained potting media made of soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits recorded the highest value (12.38 cm) and was on par with p_2i_2.The total uptake of primary and secondary nutrients were higher in the treatment p_2i_4 compared to other treatment combinations which might have resulted in the production of more growth characters resulting in more number and length of spikes. Significant difference in length of spike was observed between treatment and control.

5.1.2.3 Number of berries spike^{-1}

The interaction effects of potting media and inorganic fertilizers on number of berries spike^{-1} is shown in Fig. 8. The main effect of potting media and inorganic fertilizers is presented in table 13.

Potting media significantly influenced the number of berries spike^{-1}. P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) produced the highest number of berries spike^{-1} (57.11) and was followed by P_3 and P_1.

Significant variation in the number of berries spike^{-1} was noticed among the inorganic fertilizers. I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) showed the highest number of berries spike^{-1}(56.90) and was followed by I_2, I_5, I_1 and I_3. Devadas and Chandini (2000) reported that application of 37.5 g each of N and P bush^{-1} year^{-1} at monthly intervals produced maximum number of developed berries. However different levels of K application did not significantly influence the number of developed berries.

Significant difference in number of berries spike^{-1} was noticed among the treatment combination. The treatment combination, p_2i_4 (61.12) resulted in the highest number of berries spike^{-1} which was on par with p_2i_2 (58.00) and p_2i_5 (58.67). Number of berries spike^{-1} is an important yield contributing character and hence the treatment combination p_2i_4, significant difference in number of berries spike^{-1} was noticed between treatment and control.

5.1.2.4 Fresh weight of berries plant^{-1}

The interaction effect of potting media and inorganic fertilizers on fresh weight of berries plant^{-1} is presented in Fig. 9

Fresh weight of berries plant^{-1} differed significantly among different potting media (table 13). Potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest fresh weight of berries (156.07 g plant^{-1}) followed by P_3 (137.17g plant^{-1}) and P_1 (117.24 g plant^{-1}). Truong (2018) revealed that the addition of vermicompost in media significantly increased the physical as well as chemical properties and resulted in substantial increase of yield in tomato. Sainamole *et al*. (2002) reported that number of berries spike^{-1} is positively correlated to fresh yield of black pepper. P_2 recorded the highest value for number of berries spike^{-1} and length of spike. This might have produced the highest fresh weight of berries.

Significant difference in fresh weight of berries plant^{-1} was noticed among the inorganic fertilizers. I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) obtained the highest fresh weight of berries plant^{-1}(156.15 g plant^{-1}) and was followed by I_5 (138.08 g plant^{-1}), I_2 (136.70 g plant^{-1}), I_1 (134.38 g plant^{-1}) and I_3 (118.82 g plant^{-1}). Devadas and Chandini (2000) reported yield reduction in bush pepper at higher level of N and 37.5 g N per plant was sufficient for getting optimum yield. They also reported that N and P had significant effect on the yield of bush pepper.

The interaction was significant and the treatment combination p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizer 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) resulted in the highest fresh weight of berries plant^{-1}(199.49 g plant^{-1}). This was followed by

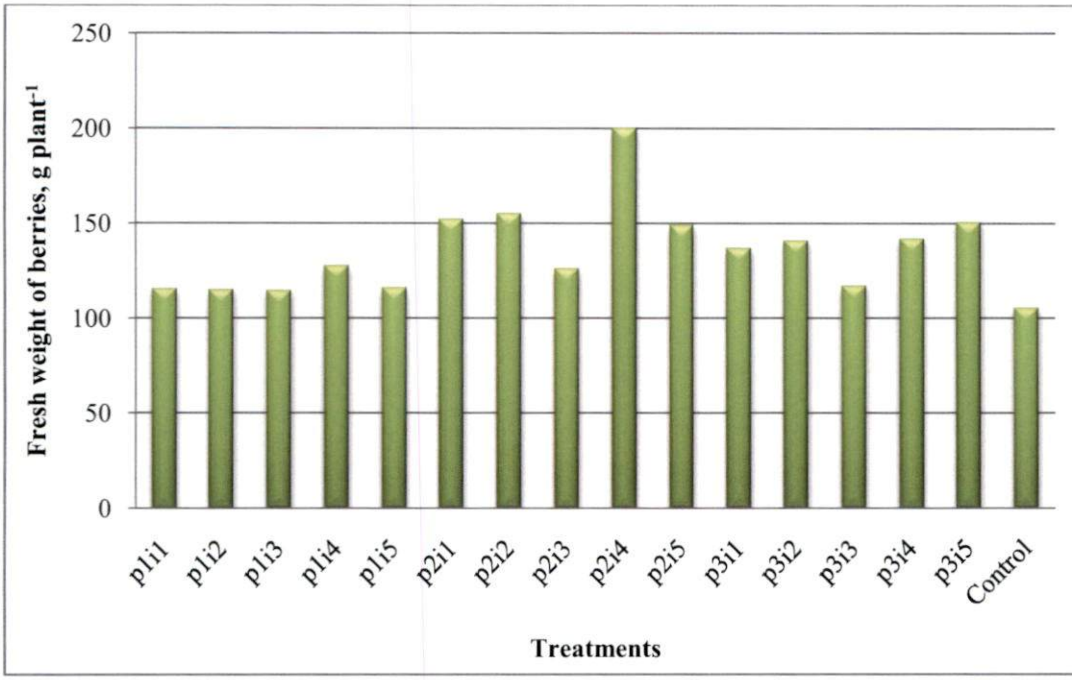

Fig. 9 Interaction effect of potting media and inorganic fertilizers on fresh weight of berries (g plant^{-1})

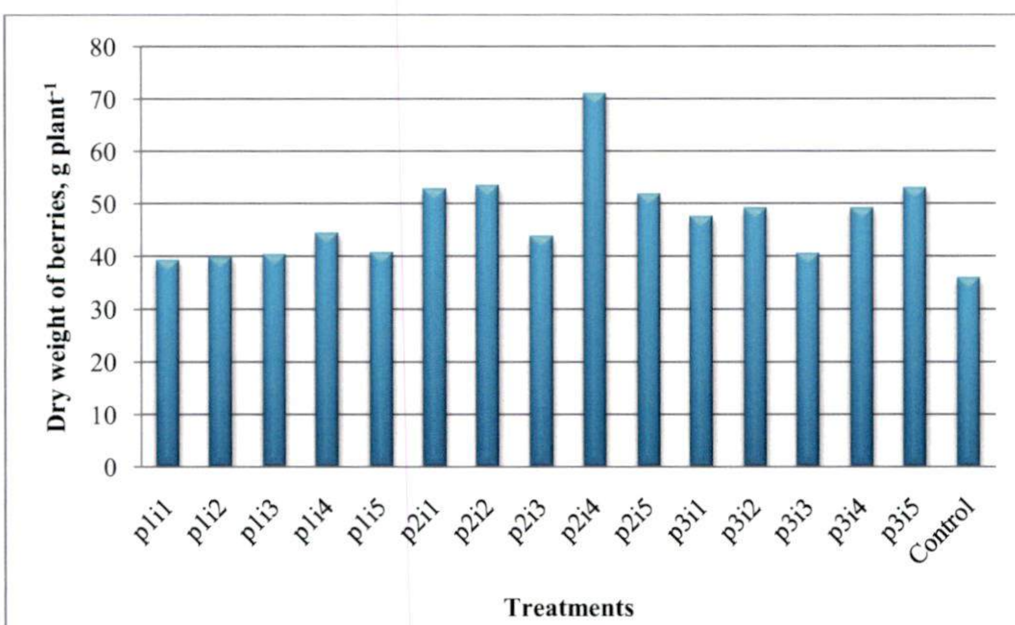

Fig. 10 Interaction effect of potting media and inorganic fertilizers on dry weight of berries (g plant^{-1})

p_2i_2 (154.66 g plant^{-1}), p_2i_1 (151.84 g plant^{-1}) p_3i_5 (150.17 g plant^{-1}) and p_2i_5 (148.73 g plant^{-1}). Experiment conducted at Horticultural Research Station, Pechiparai to evaluate the performance of bush pepper variety Panniyur 1 both under the pot and field condition revealed that bush pepper properly nourished with FYM, 5 kg per bush along with 100 g of N, 140 g of P and 100 g of K had longer spike length and grains per spike but whereas the bush pepper grown in the field condition had more number of spikes bush^{-1} and green and dry yield of pepper (Swaminathan, 2000).

The fresh weight of berries plant^{-1} recorded by control was lower than the treatments.

5.1.2.5 Dry weight of berries plant^{-1}

The interaction effect of potting media and inorganic fertilizers on dry weight of berries plant^{-1} is furnished in Fig. 10

The dry weight of berries plant^{-1} was significantly influenced by different potting media. Potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest dry weight of berries plant^{-1} (54.40 g plant^{-1}) followed by P_3 and P_1 (47.69 g plant^{-1}) and (40.70 g plant^{-1}). The higher dry weight of berries in P_2 might be due to higher number of leaves, leaf area, secondary branches, length of primary and secondary branches among potting media.

Significant variation in dry weight of berries plant^{-1} between inorganic fertilizers was noticed. Inorganic fertilizer, I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) exhibited the highest dry weight of berries (54.72 g plant^{-1}) which was followed by I_5, I_2, I_1 and I_3 respectively.

The interaction effect was significant and treatment combination, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizer- 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) registered the highest dry weight of berries (70.92 g plant^{-1}). This was followed by p_2i_2 (53.21 g plant^{-1}), p_3i_5 (52.77 g plant^{-1}), p_2i_1 (52.66 g plant^{-1}) and p_2i_5 (51.55 g plant^{-1}). Sujatha and Namboothiri (1995) reported positive and significant influence on yield with the spike length of black pepper. Number of leaves per lateral, lateral length, number of spikes per lateral, spike length and green yield registered highly significant positive correlation with the dry yield per vine (Thanuja and Rajendran, 2003). Treatment combination, p_2i_4 produced the highest number and length of primary branches, leaf area, number of spikes, number of berries spike^{-1}, spike length fresh weight, dry weight and volume of roots which might have resulted the significantly higher dry weight of berries. Treatment and control varied significantly with respect to dry weight of berries.

5.1.2.6 Hundred berry weight

Significant variation in hundred berry weight was registered among different potting media (Table 14). Potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest hundred berry weight (11.13 g).

Hundred berry weight was not found to be influenced by inorganic fertilizers.

In interaction, p_2i_4 which is combination of potting media (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) and inorganic fertilizers (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) resulted in the highest hundred berry weight (13.03 g), which was on par with p_2i_2 (12.30 g). Hundred berry weight was found to be non significant between treatment and control.

5.1.2.7 Hundred berry volume

Hundred berry volume varied significantly among different potting media (table 14). P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) reported the highest hundred berry volume (10.63 cm^3) followed by P_3 (9.31 cm^3) and P_1 (9.17 cm^3).

Hundred berry volume was found to be non significant among different inorganic fertilizers.

The interaction effect was significant and treatment combination, p_2i_4 (P_2- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and I_4 -25.0: 25.0: 50.0 g of NPK $plant^{-1}$ $year^{-1}$ at quarterly splits) resulted in the highest berry volume (12.53 cm^3), which was on par with p_2i_2 (11.70 cm^3). A non significant difference in hundred berry volume was noticed between treatment and control.

5.1.3 Root parameters

5.1.3.1 Fresh weight of roots

Significant variation in fresh weight of roots was observed among different potting media (Table 15) and P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) resulted in the highest fresh weight of roots (31.69 g $plant^{-1}$). Hormone like activity of vermicompost leads to an increase in root biomass, root initiation and better growth and development of plants (Bachman and Metzger 2007; Mycin *et al.* 2010). According to Garcia *et al.* (2014) vermicompost stimulate root growth and increases the coverage of plant nutrition. Akshay *et al.* (2014) worked on effect of media on black pepper cuttings and observed that the cuttings raised in the media comprising soil + sand + FYM + vermicompost (1:1:1:1 v/v) significantly increased percentage of rooting (80%), number of primary roots (11.07), fresh and dry weight of roots (5.08 g and 1.96 g respectively) whereas, the maximum root length (26.79 cm) was noticed in the media containing soil + sand + FYM + coir dust (1:1:1:1 v/v). The combined effect of FYM, vermicompost and coir pith compost might have produced the highest fresh weight of roots in P_2.

There was significant difference in fresh weight of roots among inorganic fertilizers. I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest fresh root weight (30.50g plant^{-1}) and was on par with I_2 (37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) which recorded a value of 29.91g plant $^{-1}$.

Among the treatment combination, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest fresh weight of roots (41.52 g plant^{-1}).

Significant difference in fresh weight of roots was noticed between treatment and control

5.1.3.2 Dry weight of roots

Potting media significantly influenced the dry weight of roots (Table 15) and P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest dry weight of roots (13.78 g plant^{-1}). This was followed by P_3 (12.01 g plant^{-1}) and P_1 (8.42 g plant^{-1}). Thankamani *et al.* (1996) reported that clove seedlings raised in potting media soil: vermicompost in the ratio 1:1 produced the maximum root dry weight. Thankamani *et al.* (2007) found that coir pith compost and granite powder in the proportion of 1:1 along with biofertilizers *Azospirillium* sp. and phosphobacteria recorded the highest root dry weight (0.89 g plant^{-1}) . Renuka *et al.* (2015) reported that carnation cuttings raised in media cocopeat and vermicompost recorded the highest percentage of rooting, cumulative root length, fresh weight of roots and percentage of establishment of rooted cuttings.

Significant difference in dry weight of roots was noticed among inorganic fertilizers. I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) resulted in highest dry root weight (13.25 g plant^{-1}) which was on par with I_2 (37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits).

Interaction effect was significant and treatment combination, p_2i_4 (Potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest dry weight of roots (18.05 g plant^{-1}). Treatment and control varied significantly with respect to dry weight of roots.

5.1.3.3 Volume of roots

Significant variation in volume of roots was observed among different potting media (Table 15). P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest volume of roots (34.75 cm^3 plant^{-1}).

There was significant difference in volume of roots among inorganic fertilizers. I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) noted the highest root volume (33.49 cm^3 plant^{-1}) and was on par with I_2.

Among the treatment combinations, p_2i_4 (P_2- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and I_4 -25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest root volume (44.52 cm^3 plant^{-1}).The higher number as well as weight of roots might have contributed to more root volume. Treatments and control varied significantly with respect to root volume.

5.2 PHYSIOLOGICAL PARAMETERS

5.2.1 Dry matter production

The interaction effect of potting media and inorganic fertilizers on dry matter production of bush pepper at 12 MAP is presented in Fig. 11

Significant variation was observed in dry matter production was among the different potting media at 12 MAP (Table 16). Potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest dry matter production (122.69 g $plant^{-1}$). The lowest dry matter production (86.72 g $plant^{-1}$) was recorded by P_1 (soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1). According to Vadiraj *et al.* (1992) growth and dry matter production of cardamom seedling enhanced with the application of vermicomposted forest litter than other media. Thankamani *et al* (2007) reported that dry matter production of black pepper cutting was significantly higher for the treatment coir pith compost: granite powder (1:1) along with *Azospirillum* and phosphobacter. The highest dry matter production in P_2 may be due to significantly higher uptake of primary and secondary nutrients, which resulted in the highest vegetative growth.

With regard to the effect of inorganic fertilizers, I_4 (25.0: 25.0: 50.0 g of NPK $plant^{-1}$ $year^{-1}$ at quarterly splits) produced the highest dry matter (120.33 g $plant^{-1}$). This was followed by I_2, I_5, I_1 and I_3. Geetha and Aravindakshan (1992) reported the beneficial effect of NPK fertilizers on the dry matter production in bush pepper. Devadas and Chandini (2000) recorded maximum dry matter production at 37.5 g N, 25 g P and 75 g K $bush^{-1}$ $year^{-1}$ at monthly splits.

Interaction effect between potting media and inorganic fertilizers was significant and treatment combination, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers- 25.0: 25.0: 50.0 g of NPK $plant^{-1}$ $year^{-1}$ at quarterly splits) resulted in the highest dry matter production (150.92 g $plant^{-1}$). Anwar *et al.* (2005) observed that combination of vermicompost at 5 t ha^{-1} and fertilizer NPK 50:25:25 kg ha^{-1} performed superior with regard to growth, herb, dry matter, oil content and oil yield. Chung *et al.* (2000) reported that compost alone can not supply enough nutrients for the growth. Compost with adequate amount of chemical fertilizers produce high dry matter yield in corn. Chand *et al.* (2011) reported that combined application of 50 Per cent NPK along with vermicompost @ 2.5 g kg^{-1} increased the dry matter in geranium.

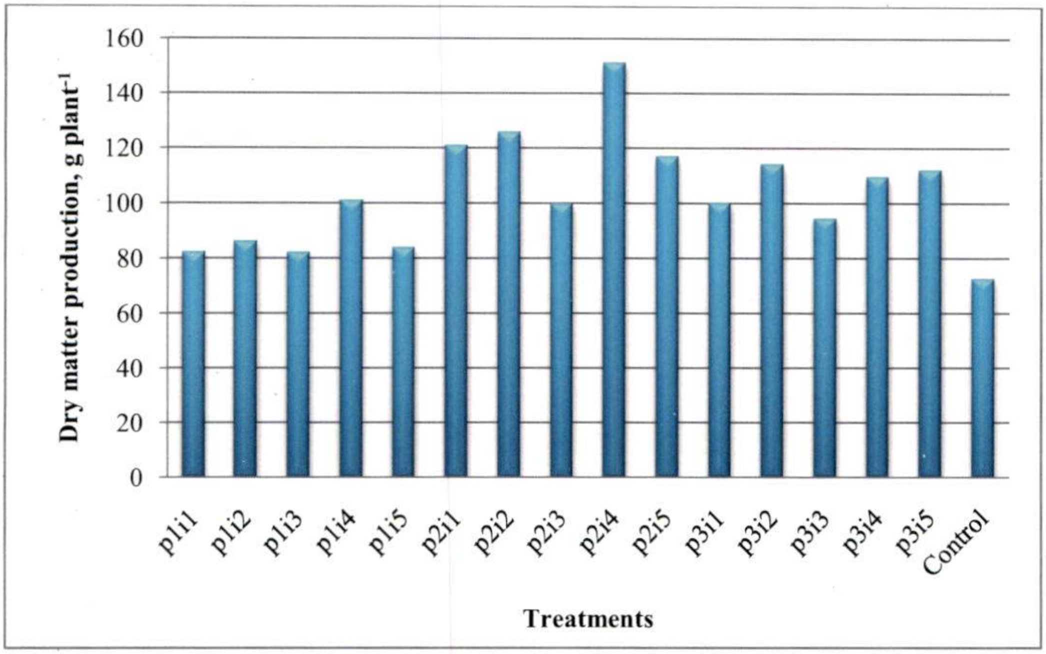

Fig. 11 Interaction effect of potting media and inorganic fertilizers on dry matter production (g plant^{-1})

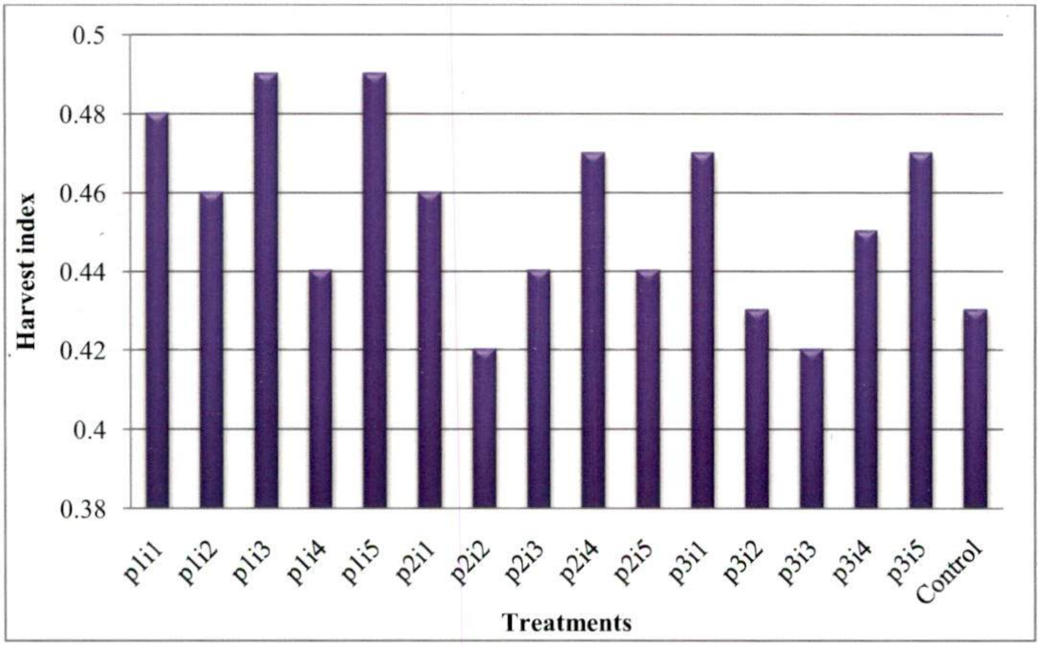

Fig. 12 Interaction effect of potting media and inorganic fertilizers on harvest index

According to Sadanandan (2000) in Panniyur 1 for a dry matter production of 15.5 kg ha^{-1} the NPK removal by the adult black pepper vine was 292, 56, 405 kg ha^{-1} while for Karimunda it was 183, 49 and 376 kg ha^{-1} respectively for dry matter production of 13.4 kg ha^{-1}. Significant variation in dry matter production was noticed between treatment and control. The dry matter production recorded by the control was 72.42 g $plant^{-1}$. Higher dry matter production in treatments might be due to the higher nutrient removal by the treatments compared to the control. The best treatment (p_2i_4) removed an NPK of 2.159 g $plant^{-1}$,155.17 mg $plant^{-1}$ and 2.367 g $plant^{-1}$ for the dry matter production of 150.92 g $plant^{-1}$ while the NPK removal by the control treatment was 1.069 g $plant^{-1}$, 64.65 mg $plant^{-1}$and 1.040 g $plant^{-1}$ for a dry matter production of 72.42 g $plant^{-1}$. Reduction in the uptake of NPK might be resulted in the decrease in the dry matter production indicating the importance of the nutrients in the dry matter production.

5.2.2 Specific leaf weight

Potting media, inorganic fertilizers and their interaction did not influence the specific leaf weight at 12 MAP (Table 16). Treatment effects also did not vary with the control.

Menon and Nair (1987) observed that the specific leaf weight of Karimunda was higher than Panniyur 1. According to Geetha and Aravindakshan (1992) leaf area per plant in bush pepper depends primarily on the increasing leaf area while in vine pepper it was primarily dependent on the number of leaves produced. Increasing specific leaf weight improves apparent photosynthesis (Thomson *et al.*, 1996). Specific leaf weight which is the leaf dry weight per unit area is correlated to photosynthesis.

5.2.3 Harvest index

The interaction effect of potting media and inorganic fertilizers on harvest index at 12 MAP is presented in Fig. 12

Significant difference in harvest index was noticed among different potting media used (Table 16). Plants raised in potting media, P_1 (soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1) recorded the highest harvest index (0.47). P_1 recorded the lowest dry matter production which might have resulted in the highest harvest index.

Significant variation was observed in harvest index between inorganic fertilizers. I_1 (37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits) reported the highest harvest index (0.47) which was on par with I_3 and I_4. Asghar *et al.* (2010) observed that harvest index was markedly influenced by NPK application in different proportions. Harvest index is the ratio of economic yield and biological yield. I_1 recorded the lowest dry matter production which resulted in the highest harvest index compared to other inorganic fertilizers.

The interaction between potting media and inorganic fertilizers was significant. Treatment combination, p_1i_3 and p_1i_5 recorded the highest harvest index (0.49). Significant difference was noticed in harvest index between treatment and control. Harvest index of control was lower than the treatments. Harvest index represents the partitioning of photosynthate between the berries and the vegetative parts since the dry weight of berries was more compared to substantial increase in dry matter production the treatments recorded the higher harvest index than control.

5.2.4 Moisture percentage

Moisture percentage was not significantly influenced by the potting media and inorganic fertilizers (Table 17). The interaction effect of potting media and inorganic fertilizers also did not influence the moisture percentage. There was no significant variation in moisture percentage between treatment and control indicating that moisture percentage of pepper berries was not influenced by different potting mixtures and inorganic fertilizers.

5.2.5 Drying percentage

Drying percentage was not affected by the potting media and inorganic fertilizers (Table 17). Interaction between potting media and inorganic fertilizers also did not affect the drying percentage. The drying percentage was also non significant between treatment and control which specifies that drying percentage was not influenced by potting mixture and inorganic fertilizers.

5.2.6 Chlorophyll content

Significant variation in chlorophyll at 6 MAP was observed among different potting media while at 12 MAP, potting media did not influence chlorophyll content (Table 18). Potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest chlorophyll content (0.93 mg g^{-1}) at 6 MAP. According to Akshay *et al.* (2014) black pepper cuttings grown in media containing soil, sand, FYM and vermicompost (1:1:1:1 v/v) recorded the maximum chlorophyll a, chlorophyll b and total chlorophyll content.

Application of inorganic fertilizers showed significant variation in chlorophyll content at 6 MAP. At 12 MAP, inorganic fertilizers did not influence chlorophyll content. Inorganic fertilizers, I_3 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits) resulted in the highest chlorophyll content at 6 MAP (0.99 mg g^{-1}) which was on par with I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) which recorded a value of 0.97 mg g^{-1}.

Interaction effect between potting media and inorganic fertilizers were significant for chlorophyll content at 6 MAP and 12 MAP. Treatment combination, p_2i_4 showed the highest chlorophyll content at 6 MAP (1.22 mg g^{-1}), which was on par with p_2i_5 and p_3i_3. .Treatment combination, p_2i_5 recorded the highest chlorophyll content (1.47 mg g^{-1}) at 12 MAP and was on par with p_2i_4, p_3i_1, p_1i_1, p_1i_2, p_3i_3, p_1i_3, p_3i_2, p_3i_4, p_1i_5 and p_2i_3. According to Devadas (1997) maximum chlorophyll content in leaf was recorded in bush pepper plant supplied with 50g N, 50 g P and 75 g K per plant.

Significant variation in chlorophyll content at 6 MAP was noticed between treatment and control while at 12 MAP, there was no significant variation between treatments and the control. Quantity of chlorophyll per unit area is an indication of photosynthetic capacity and productivity of a plant. According to Otitoju and Onwurah (2010) the amount of chlorophyll in the leaf tissues can be influenced by nutrient availability and environmental factors.

The photosynthetic capacity of leaves is related to the nitrogen content .The protein content of the Calvin cycle and the thylakoids represent the majority of leaf nitrogen. Thylakoid nitrogen is proportional to the chlorophyll content. There are strong linear relationship between nitrogen and both RUBP carboxylase and chlorophyll. With increasing nitrogen per unit leaf area, the proportion of total leaf nitrogen in the thylakoids remains the same while the proportion in soluble protein increases (Evans, 1989).Thus higher nutrient especially availability of nitrogen influences the leaf chlorophyll content.

5.3 QUALITY PARAMETERS OF BERRIES

5.3.1 Starch

The interaction effect of potting media and inorganic fertilizers on starch content of berries is presented in Fig. 13

Potting media significantly influenced the starch content and the highest starch content (36.68 %) was produced by potting media P_1 (soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1) (Table 19). However the starch content was significantly less for the potting media, P_2.

There was significant difference in starch content among the inorganic fertilizers. I_5 (12.5:12.5:25.0 g of NPK plant^{-1} year^{-1} as soil application at equal monthly splits up to 3 MAP and foliar application of 13:0:45 (0.5 %) at fortnightly intervals from 4th MAP) recorded the significantly higher starch content (36.74 %) in berries. The treatment involving foliar nutrition produced significantly higher starch content. According to Mengel (2002) the efficiency of foliar nutrition depends on the mobility of the specific nutrient throughout the entire plant, mobility comprising long distance transport especially phloem transport as well as the symplastic transport. Potassium and nitrogen are examples of nutrients showing high mobility and when taken up by leaves can be rapidly distributed throughout the entire plant. The efficient absorption of the nutrients might have taken place in foliar treatment which resulted in higher starch content.

Interaction effects were significant and treatment combination, p_1i_5 produced the highest starch content of (36.82%) in berries. The treatment having foliar nutrition resulted in higher starch content compared to other nutrients. Essential oil is negatively correlated with starch (Pruthi, 1999). Treatment combination, p_1i_5 registered the significantly lowest essential oil content which might be due to the highest starch content. The starch content of the treatment combination did not vary significantly from the control.

5.3.2 Total ash

The potting media, inorganic fertilizers and their interaction did not influence the total ash content of berries (Table 19). The treatments combination did not show variation with the control in total ash content of berries.

5.3.3 Essential oil

The interaction effect of treatment on essential oil content of berries is provided in Fig. 14

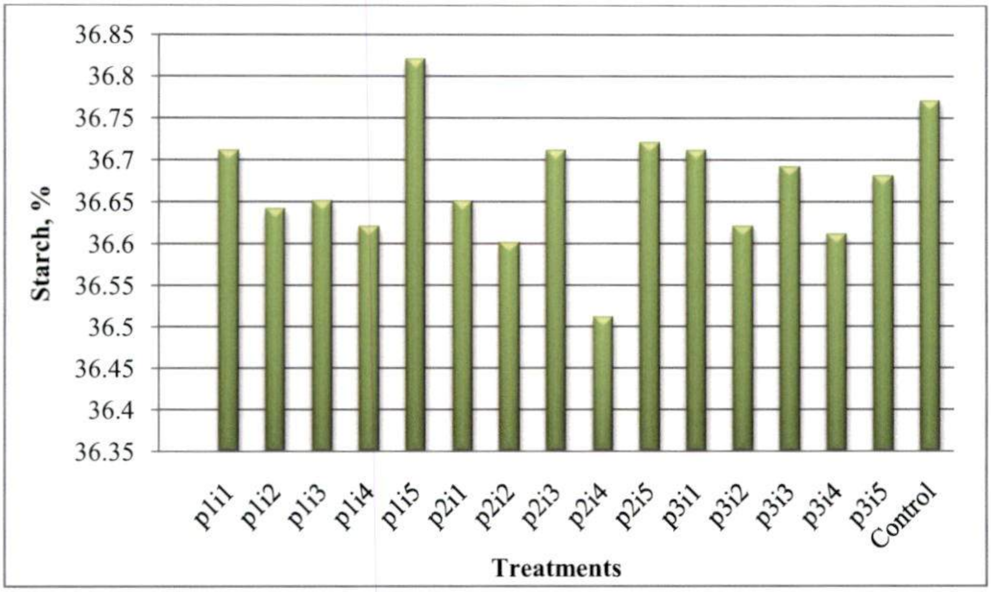

Fig. 13 Interaction effect of potting media and inorganic fertilizers on starch (%)

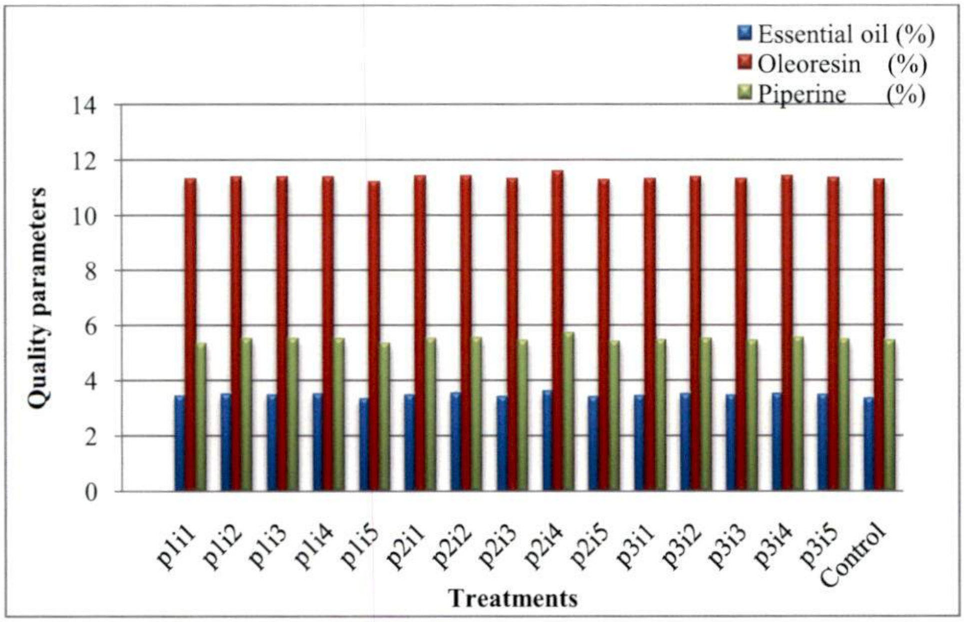

Fig. 14 Interaction effect of potting media and inorganic fertilizers on essential oil (%), oleoresin (%) and Piperine (%)

Significant change in essential oil was noticed among different potting media (Table 19). Plants raised in P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest essential oil (3.46 %) which was on par with P_3. Sruthi *et al.* (2013) reported that in black pepper total phenol, essential oil, piperine and oleoresin showed positive correlation with each other and also with crude fibre and total fat, but negatively correlated with bulk density and starch.

Significant difference in essential oil was observed between inorganic fertilizers. I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) resulted in highest essential oil content (3.52 %) and was on par with I_2 (37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits). Devadas (1997) reported that N application had significant effect on the volatile oil content of berries.

Interaction effect was significant and treatment combination, p_2i_4 recorded the highest essential oil content in berries (3.59 %). Significant variation in essential oil content of berries was noticed between treatment and control.

5.3.4 Oleoresin

The interaction effect of treatment on oleoresin content of berries is shown in Fig. 14

Oleoresin was significantly influenced among the potting media (Table 19). The highest oleoresin content of (11.40 %) was recorded by P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1). The essential oil and piperine content of P_2 was significantly high, which might be resulted the highest oleoresin content in P_2.

There was significant difference in oleoresin among the different inorganic fertilizers. I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) indicated the highest oleoresin of (11.46 %). Devadas (1997) observed that P application had significant effect on the oleoresin content of the berries. Abhimannue

(2016) reported oleoresin content was significantly influenced by fertigation levels and highest oleoresin content of 15.10 kg ha^{-1} was noticed in water soluble NPK fertilizer + PGPR Mix 1 + fluorescent Pseudomonas in *Piper longum*.

The interactions were significant and treatment combination, p_2i_4 resulted in highest oleoresin content (11.59%). The positive correlation of essential oil with oleoresin content was also reported by Pruthi (1999). Experiment conducted at IISR showed that application of NPK fertilisers increased the yield and oleoresin in bush pepper and an increase of 228 Per cent in oleoresin content was noticed compared to check (Sadanandan and Hamza, 1998). The treatment combination, p_2i_4 registered the highest essential oil content, which might be resulted the significantly highest oleoresin content. Hamsa and Sadanandan (2005) reported that application of 0.25 % of $ZnSO_4$ as foliar increased the oleoresin as well as piperine content compared to other sources and method of application of $ZnSO_4$. Significant change in oleoresin of berries was noticed between treatment and control.

5.3.5 Piperine

The interaction effect of treatments on piperine content of berries is presented in Fig. 14

Significant variation in piperine was noticed among different potting media. Plants raised in P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest piperine (5.50 %), which was on par with P_3 (Table 19). Piperine (piperinoyl- piperidine) is a nitrogenous pungent substance contained in black pepper (Capasso *et al.*, 2002). Piperine is the most pungent alkaloid of black pepper which makes it spicy. Hence the higher piperine content in the treatment can thus reduce the quantity of use.

Significant variation in piperine content was noticed among different inorganic fertilizers. Inorganic fertilizer, I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest piperine content (5.57 %).

Interaction effect was significant and treatment combination, p_2i_4 recorded the highest piperine content in berries (5.70 %). Manjunath *et al.* (2007) observed highest piperine content in long pepper plants receiving 30 t FYM along with 100: 40: 140 kg N, P_2O_5, K_2O per hectare. Treatment combination, p_2i_4 recorded the highest oleoresin content and the efficient nutrition partitioning in the treatment might have resulted in significantly higher piperine in p_2i_4.

However no variation in piperine content was noticed between treatment and control.

5.4 ANALYSIS OF POTTING MEDIUM BEFORE AND AFTER THE EXPERIMENT

5.4.1 Soil pH

The pH of the potting media before the experiment was higher compared to that after the experiment (Table 20a). Addition of inorganic fertilizers might have reduced the soil pH. A reduction in soil pH after each treatment involving interaction effect of potting media and inorganic fertilizers is presented in (Table 20b). Soil pH value was found vary significantly after the experiment. The treatment combination, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1, inorganic fertilizers. 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest pH (5.47) which was on par with p_2i_1 and p_2i_2. There was no significant difference in soil pH between treatment and control.

Fertilizer application may alter rhizosphere pH by changing the relative concentration of different ions in the soil solution. This effect is further confounded by the influence of fertilizer nutrients on ion exchange between root and soil along with root metabolic processes, which may lead to as much as a 2 to 3 unit change in rhizosphere pH compared to bulk soil (Neumann and Romheld, 2001). As pH fluctuates, the availability of different ions changes as certain ions are chemically bound (e.g., P) while others become more available (e.g., Fe and Al). This may affect root system development, as high concentrations of Al tend to be toxic to roots (Jacob and Timmer, 2005). Soils of high yielding black pepper gardens have pH ranging from acidic to near neutral (Hamza and Sadanandan, 2004). Chao *et al.* (2014) reported that low pH may directly inhibit root development and function, limit K, Ca and Mg absorption and reduce seedling growth. At pH 5.5, black pepper attained maximum growth, while the minimum growth occurred at pH 3.5.

5.4.2 Electrical conductivity

The EC of the potting media before the experiment was higher for P_1 while it was less for P_2 (Table 20a). EC value found to decreased after the experiment (Table 20b). Analysis of potting media after the experiment revealed significant variation in EC among the treatment combinations. The treatment combination, p_3i_1 (potting media- soil + FYM + leaf compost + coir pith compost in the ratio 3:3:1:1, inorganic fertilizers. 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits) recorded the highest EC value of 0.96 dS m^{-1}. EC found to be non significant between treatment and control. Electrical conductivity (EC) can provide information on the nutrient condition of the soil. Fertilizer application may change the rhizosphere chemical properties such as pH, ion availability, and electrical conductivity (EC). These changes may inhibit root system growth and function by reducing soil osmotic potential and creating specific ion toxicities (Jacob and Timmer, 2005). Since fertilizer nutrients are salts that conduct an electrical charge and act to alter the electricity of the soil solution. Understanding the relationship between rhizosphere EC and root system development is crucial for formulating successful nursery and field fertilization protocols. EC values should range between 0.63 to 1.56 dSm-2 for media used for container grown plants and EC values > 3.5 dS m^{-1} can have adverse effects on seedling growth (Bernstein, 1975; Poole *et al.*, 1978). EC levels tend to rise exponentially with increasing fertilizer inputs and decreasing soil moisture. Concurrently, when low EC levels are detected, fertilizer inputs should be increased accordingly and EC levels re-assessed thereafter to ensure optimal nutrient availability. (Bunt, 1988; Landis *et al.*, 1989).

5.4.3 Organic carbon

The organic carbon percentage of the potting mixture (Table 20a) before the experiment was comparatively lesser compared to treatment combinations involving potting mixture and inorganic fertilizers. Organic carbon value increased for each treatment after the experiment (Table 20 b). Organic carbon showed significant variation among treatment combinations. The treatment combination, p_3i_1 (potting media- soil + FYM + leaf compost + coir pith compost in the ratio 3:3:1:1, inorganic fertilizers. 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits) noted the highest organic carbon (3.06 %) after the experiment. The presence of leaf compost in the potting media might have increased the organic carbon content in the treatment. Hamza *et al.* (2007) reported that optimum value of organic carbon for black pepper cultivation was 2.00 to 7.50 Per cent. After the experiment, Significant change in organic carbon was noticed between treatment and control and organic carbon content of control was lower than the other treatments.

5.4.4 Primary nutrients (N, P and K)

The interaction effect of potting media and inorganic fertilizers on available N is furnished in the Fig. 15

The available N and P content of potting mixture (Table 21 a) was maximum in P_2. The available nitrogen content of the treatment noted significant change after the experiment. The treatment combination, p_1i_1 (potting media- soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1, inorganic fertilizers. 37.5: 37.5: 50.0 g

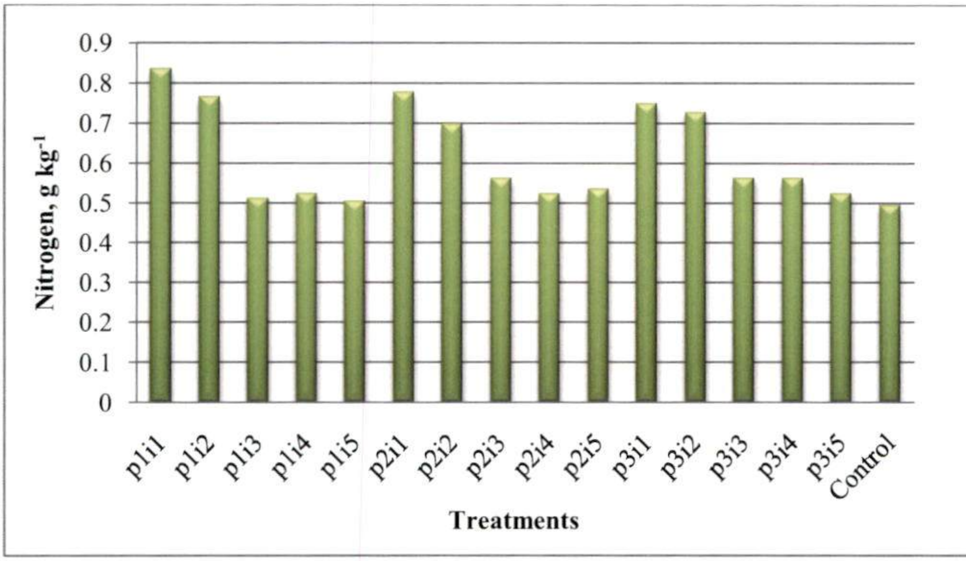

Fig. 15 Interaction effect of potting media and inorganic fertilizers on available N (g kg^{-1}) of potting media after the experiment

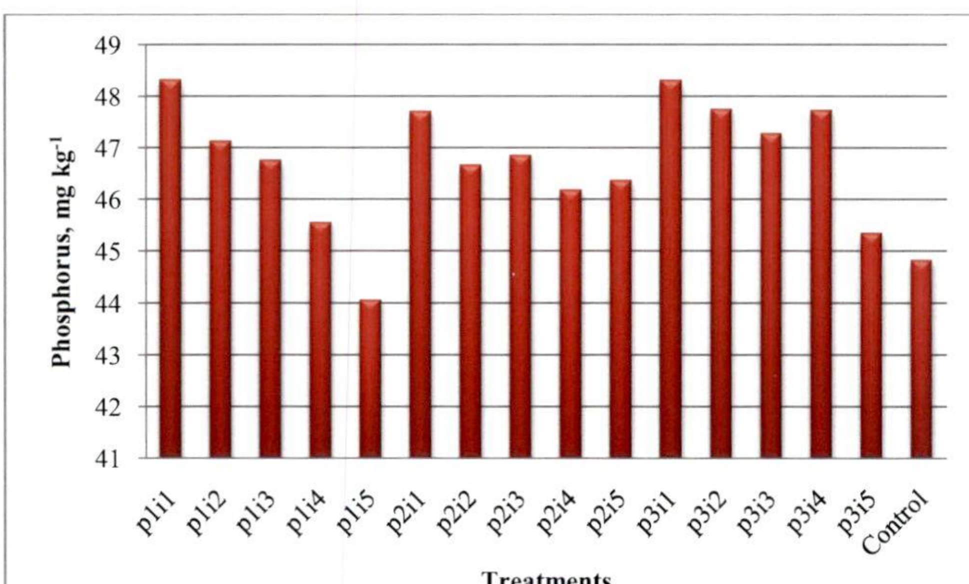

Fig. 16 Interaction effect of potting media and inorganic fertilizers on available P (mg kg^{-1}) of potting media after the experiment

of NPK plant^{-1} year^{-1} at monthly splits) recorded the highest available nitrogen of 0.834 g kg^{-1}. This might be due to the lowest uptake of nitrogen by the plants grown in treatment combination, p_1i as revealed from Table 23. Significant difference in available nitrogen was noticed between treatment and control.

The interaction effect of potting media and inorganic fertilizers on available P and K is furnished in the Fig. 16

Available P after the experiment significantly influenced by the interaction of potting media and inorganic fertilizers after the experiment. The treatment combination, p_1i_1 (potting media- soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1, inorganic fertilizers. 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits) recorded the highest available P value of 48.30 mg kg^{-1}. This also might be due to the lowest uptake of P by plants in treatment combination p_1i_1. Available P varied significantly between the treatment and control after the experiment.

The interaction effect of potting media and inorganic fertilizers on available P and K is furnished in the Fig. 17

Available K was significantly different among treatment combinations. The treatment combination, p_2i_1 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1, inorganic fertilizers. 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits) recorded the highest available K (399.30 mg kg^{-1}) and on par with p_2i_3 (399.00 mg kg^{-1}). There was significant variation in available K between treatment and control after the experiment.

5.4.5 Secondary nutrients (Ca, Mg and S)

The interaction effect of potting media and inorganic fertilizers on available Ca, Mg and S after the experiment is furnished in the Fig. 18

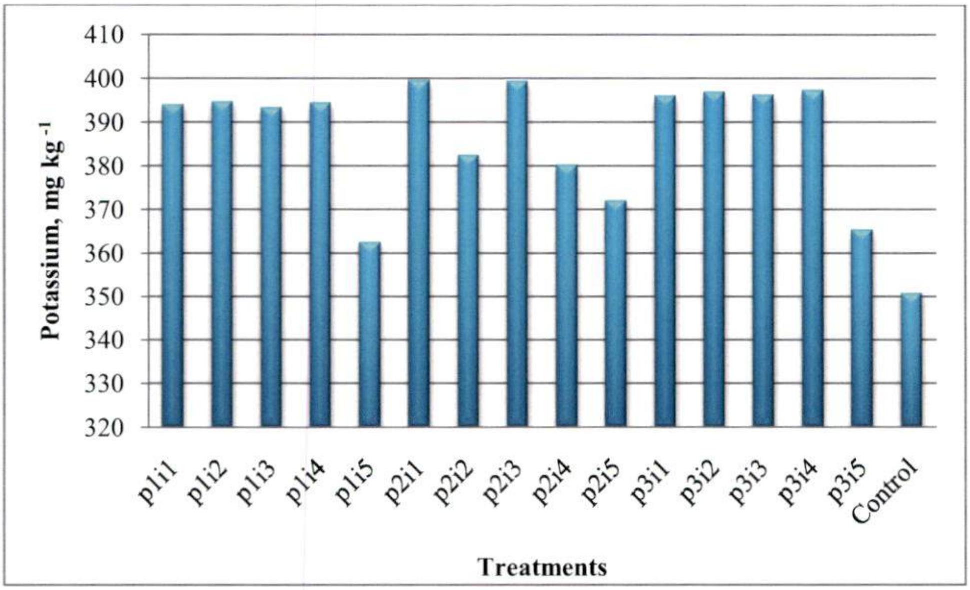

Fig. 17 Interaction effect of potting media and inorganic fertilizers on available K (mg kg^{-1}) of potting media after the experiment

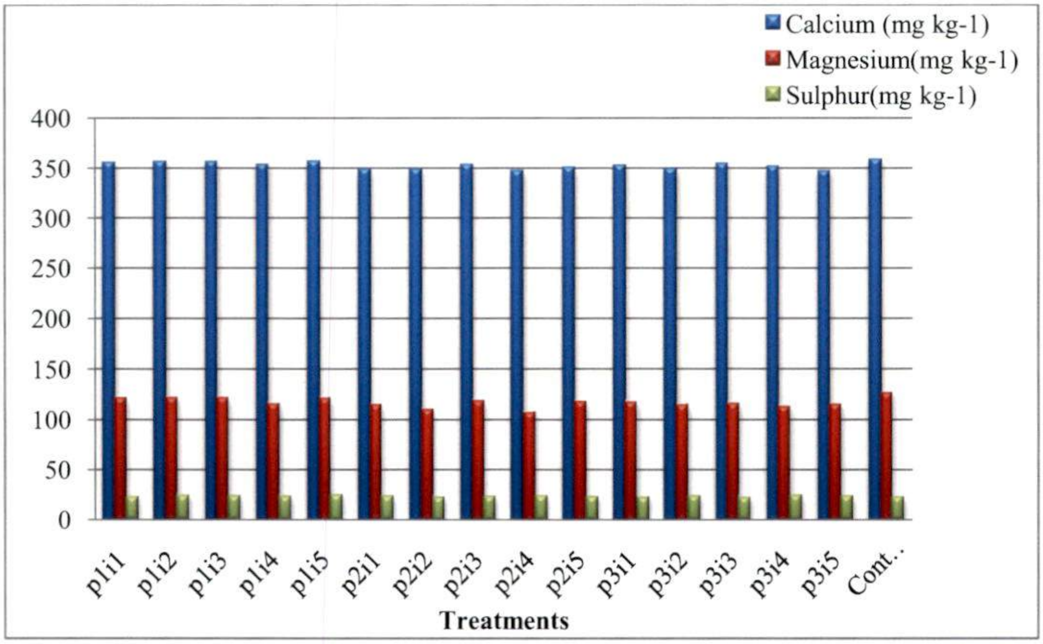

Fig. 18 Interaction effect of potting media and inorganic fertilizers on available Ca, Mg and S (mg kg^{-1}) of potting media after the experiment

Available Ca showed significant variation among the treatment combinations after the experiment. The treatment combinations, p_1i_2 (potting media- soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1, inorganic fertilizers- 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) and p_1i_3 (potting media- soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1, inorganic fertilizers- 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits) recorded the highest value of 356.50 mg kg^{-1}, which was on par with p_1i_5 and p_1i_1. Available Ca was found to be non significant among the treatments and control after the experiment.

After the experiment, available Mg varied significantly different among different treatment combinations (Table 22b). The treatment combination, p_1i_2 (potting media- soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1, inorganic fertilizers- 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) registered the highest value of 121.27 mg kg^{-1} and was on par with p_1i_1 (120.64 mg kg^{-1}), p_1i_3 (120.59 mg kg^{-1}) and p_1i_5 (120.51 mg kg^{-1}). There was no significant variation in available Mg between treatment and control after the experiment.

After the experiment, the interaction of potting media and inorganic fertilizers did not affect the available S content of the potting mixture. Available S was non significant between the treatments and the control after the experiment.

5.5 PLANT UPTAKE OF PRIMARY AND SECONDARY NUTRIENTS BY ROOTS, LEAVES, STEMS, BERRIES AND SPIKES

5.5.1 N uptake

The interaction effect of potting media and inorganic fertilizers on the uptake of N by roots, leaves, stem, berries and spikes are presented in Fig. 19

Potting media significantly influenced the uptake of nitrogen in different parts (Table 23). P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest nitrogen uptake in roots, leaves, stem, berries and spike. The total nitrogen uptake was significantly higher for P_2. The increased root intensity was accompanied with increased nutrient uptake. Kumar *et al.* (2007) reported that application of vermicompost 2.5 t ha^{-1} in maize recorded significantly higher nutrient uptake over FYM, poultry manure, green leaf manure and residues of sorghum. Vermicompost improved the microbial activity which led to greater root expansion ultimately resulting in greater uptake of nutrients and contributing increased flowering (Taleshi *et al.*, 2011).

The plants which received inorganic fertilizer, I_4 (25.0: 25.0: 50.0 g of NPK $plant^{-1}$ $year^{-1}$ at quarterly splits) resulted in significantly higher nitrogen uptake in different plant parts viz., roots, leaves, stem and berries and was on par with I_5 in leaves. The total N uptake was also found to be the highest for the I_4 (1.870 g $plant^{-1}$). Nutrient uptake is the function of dry matter production and I_4 produced significantly higher dry matter.

In interaction, treatment combination, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 25.0: 25.0: 50.0 g of NPK $plant^{-1}$ $year^{-1}$ at quarterly splits) recorded the highest N uptake in all plant parts. With regard to uptake of N in roots, leaves, stem and berries the treatment combination p_2i_4 was on par with p_2i_2. With respect to N uptake of spike, p_2i_4 was on par with p_2i_1. Treatment combination, p_2i_4 recorded the significantly higher dry matter production than other treatment combination which might have resulted in higher nutrient uptake and dry weight of berries in p_2i_4. Rajkhowa *et al.* (2003) found significant increase in nutrient uptake by combined use of fertilizer along with vermicompost. Significant variation was noticed in N uptake of different plant parts and total N uptake between treatment and control. The total nitrogen uptake by control was 1.069 g $plant^{-1}$ which was lower than treatment combinations. The lower N uptake in control resulted in lower dry matter production and yield.

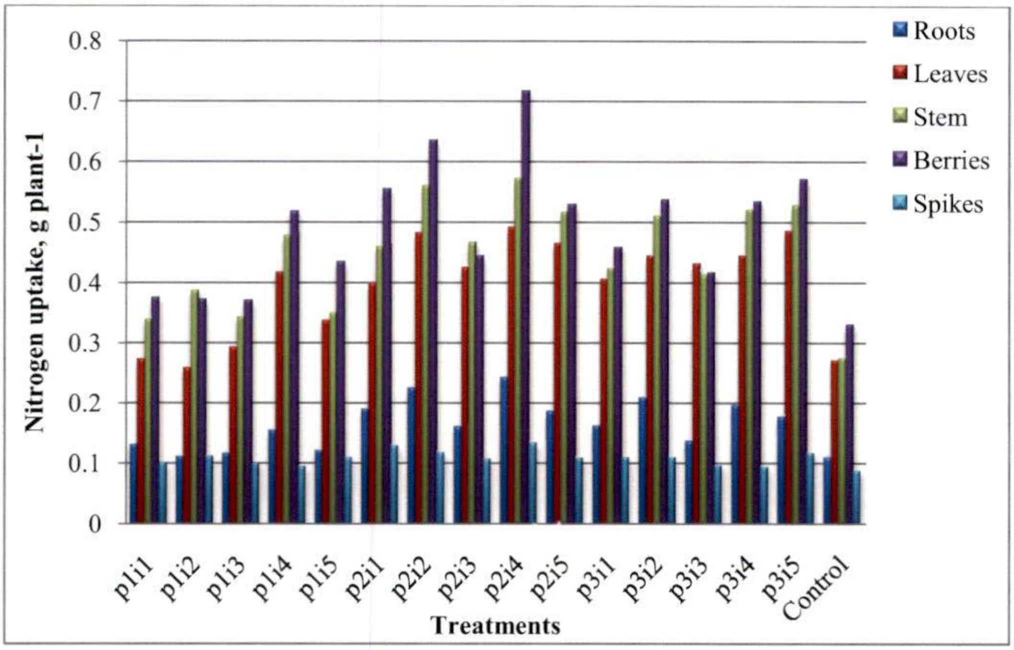

Fig. 19 Interaction effect of potting media and inorganic fertilizers on nitrogen uptake (g plant^{-1}) by roots, leaves, stem, berries and spikes

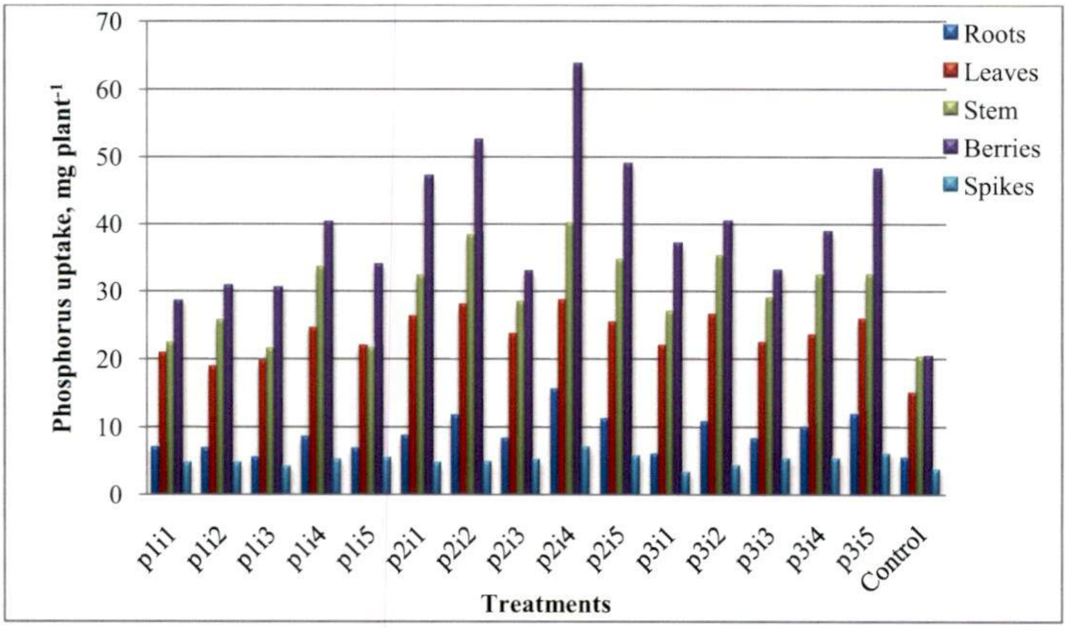

Fig. 20 Interaction effect of potting media and inorganic fertilizers on phosphorus uptake (mg plant^{-1}) by roots, leaves, stem, berries and spikes

5.5.2 P uptake

The main and interaction effect of potting media and inorganic fertilizers on the P uptake by roots, leaves, stem, berries and spikes are furnished in Fig. 20

Uptake of P in different plant parts was significantly influenced by the potting media (Table 24). Plants grown in potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) registered highest P uptake in roots, leaves, stem, berries and spike. Vermicompost increases the microorganisms in rhizosphere of plants which leads to more availability of N and P through biological fixation of N and biological solubilization of P (Mackey *et al*., 1982; Mycin *et al*., 2010). Diby *et al.* (2005) reported significant uptake of nitrogen (N) and phosphorus (P) and enhanced vigour of black pepper when inoculated with *Pseudomonas fluorescens* strains, due to higher root proliferation and nutrient mobilization especially that of P in the rhizosphere. *P. fluorescens* strains enhanced the P uptake by 122 per cent over control (non bacterised plants) and N uptake by 65 per cent over control resulting in increased root growth and biomass production. Thus the highest uptake in P_2 might be due to the more availability of the P through the biological solubilisation which had resulted the highest root growth and hence higher P uptake.

Significant variation in P uptake of different plant parts was noticed among the inorganic fertilizers. Plants of treatment, I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) registered the highest P uptake in all parts. I_4 recorded the highest total P uptake of 125.79 mg plant^{-1}. The lowest P uptake was recorded by I_3 (92.70 mg plant^{-1}). Nutrient uptake is the function of dry matter and I_4 recorded the significantly higher dry matter due to the higher uptake. The lowest dry matter production was recorded by I_3.

The treatment combination, p_2i_4 recorded the highest P uptake in different plant parts like roots, leaves, stem and berries. There was no significant variation of P uptake by spikes among the treatment combination. Treatment combination, p_2i_4 recorded the highest total P uptake of 155.17 mg plant^{-1} followed by p_2i_2 (135.33 mg plant^{-1}), p_2i_5 (125.95 mg plant^{-}1) and p_3i_5 (124.33 mg plant^{-1}). Raju *et al.* (2013) reported that 50 % N through inorganic fertilizer + 50 % N through vermicompost recorded the highest NPK uptake. This might be due to the immediate release of nutrients through inorganic fertilizers and the latter by the mineralization of nutrients through vermicompost resulting in steady supply of nutrients throughout the crop period. Phosphorus enters the plant through root hairs, root tips, and the outermost layers of root cells. Higher root mass was reported in p_2i_4 which hence had more root hairs, root tips and outer root cells which resulted in more absorption of P. Phosphorus (P) is vital to plant growth found in every living plant cell . Once inside the plant root, P may be stored in the root or transported to the upper portions of the plant. Through various chemical reactions, it is incorporated into organic compounds, including nucleic acids (DNA and RNA), phosphoproteins, phospholipids, sugar phosphates, enzymes, and energy-rich phosphate compounds. Significant change in P uptake in different plant parts and total uptake was noticed between the treatment and control

5.5.3 K uptake

The interaction effect of potting media and inorganic fertilizers on the K uptake by roots, leaves, stem, berries and spikes are provided in Fig. 21

Significant difference in uptake of K in various parts and total uptake was noticed among the different potting media (Table 25). P_2 recorded the highest total uptake of K as well as uptake of K by different plant parts. With regard to the uptake of K in leaves and spikes, P_3 was found on par with the P_2. A total K uptake of 2.013 g plant^{-1} was registered by P_2, followed by P_3 (1.823 g plant^{-1}) and P_1 (1.374 g plant^{-1}). Basker *et al.* (1992) reported that earthworms enhance the availability of K by

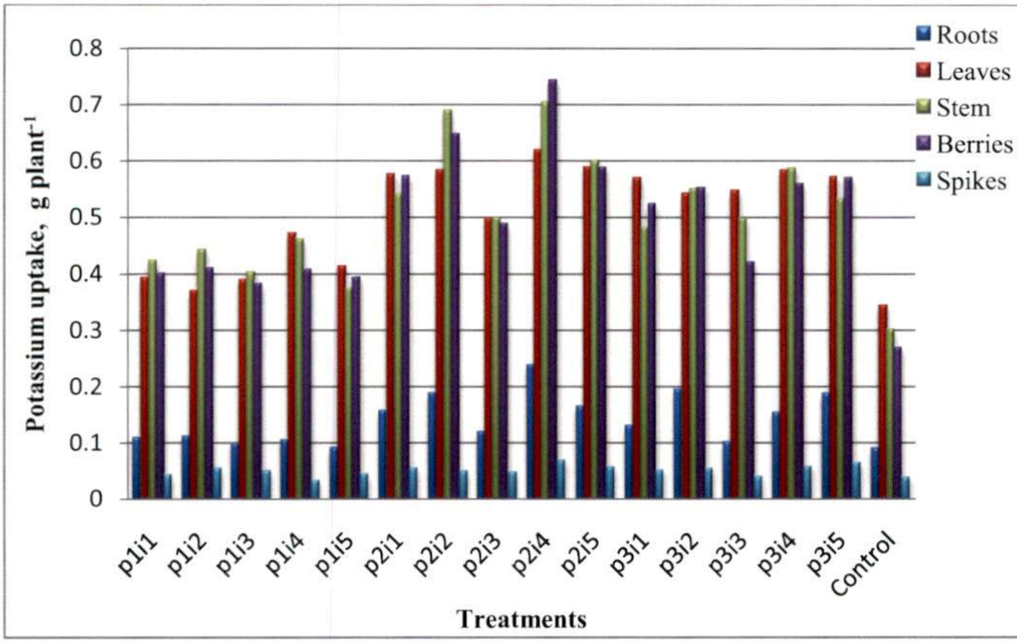

Fig. 21 Interaction effect of potting media and inorganic fertilizers on potassium uptake (g plant^{-1}) by roots, leaves, stem, berries and spikes

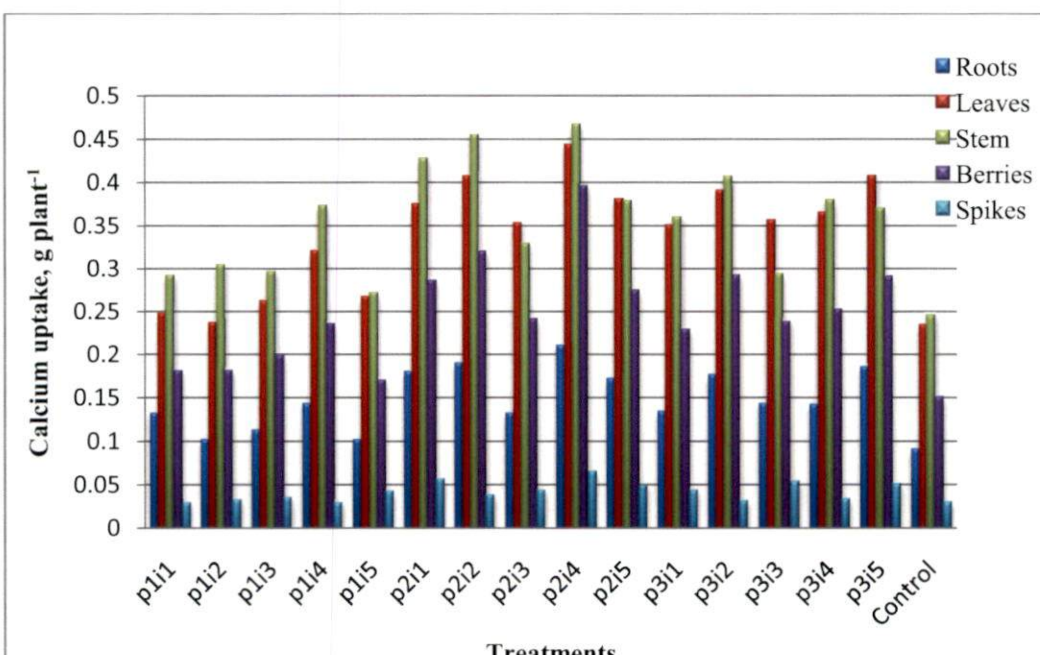

Fig. 22 Interaction effect of potting media and inorganic fertilizers on calcium uptake (g plant^{-1}) by roots, leaves, stem, berries and spikes

shifting the equilibrium between the forms of K from unavailable forms to more available forms in the soil.

In inorganic fertilizers, uptake of K showed significant variation. I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest uptake of K in different parts like roots, leaves, stem, berries and total uptake. With regard to K uptake of spikes, I_5 recorded the highest value, which was on par with I_1, I_2 and I_4. The total K uptake was superior for I_4 (1.926 g plant^{-1}), followed by I_2 (1.811 g plant^{-1}), I_5 (1.744 g plant^{-1}), I_1 (1.677 g plant^{-1}) and I_3 (1.526 g plant^{-1}). I_4 produced significantly higher dry weight of roots. Increased root surface area provides more surface area for nutrient uptake.

Interaction effect showed that, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest K uptake in roots, stem, berries, spikes and total uptake. The uptake of K in leaves was non significant. The treatment combination p_2i_4 recorded the highest total uptake of K (2.367 g plant^{-1}), followed by p_2i_2 (2.153 g plant^{-1}), p_2i_5 (1.993 g plant^{-1}) and p_3i_4 (1.933 g plant^{-1}). Geetha and Nair (1990) reported the order of nutrient removal as K>N>Ca>Mg> P>S>Fe >Mn>Zn. According to Azmil and Yau (1993), K removed by various parts of pepper was worked out and the values obtained were leaves (28.73 g vine^{-1}), branches (28.70 g vine^{-1}), stem (19.60 g vine^{-1}), fruit spikes (0.05 g vine^{-1}), white pepper (42 g vine^{-1}) and flowers (1.40g vine^{-1}).

Significant difference in K uptake in all parts and total uptake was observed between the treatment and control.

5.5.4 Ca uptake

The interaction effect of potting media and inorganic fertilizers on the Ca uptake by roots, leaves, stem, berries and spikes are furnished in Fig. 22

Significant variation in uptake of Ca in roots, leaves, stem, berries, spikes and total uptake of Ca was noticed by the use of different potting media (Table 26). Potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) registered the highest Ca uptake in roots, leaves, stem, berries and spike. The total uptake of Ca was the highest for P_2 (1.332 g plant^{-1}). Thankamani *et al.* (2007) recorded higher uptake of phosphorous, potassium, calcium and magnesium in black pepper (*Piper nigrum*) cuttings raised in coir pith compost: granite powder: FYM (2:1:1).

Inorganic fertilizer, I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest total Ca uptake and Ca uptake in all parts. I_4 recorded the highest total uptake of Ca (1.283 g plant^{-1}). According to Azmil and Yau (1993) Ca removal by different parts of black pepper was leaves (8.32 g vine^{-1}), branches (11.50 g vine^{-1}), stem (1.20 g vine^{-1}), fruit spikes (0.11 g vine^{-1}), white pepper (5.00 g vine^{-1}) and flowers (0.32 g vine^{-1}).

Interaction effects were significant and the treatment combination, p_2i_4 (P_2-soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and I_4 -25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest uptake in different parts like roots, leaves, stem, berries and spike. With respect to uptake of calcium in leaves, found to be on par with p_3i_5. With regards to stem p_2i_4 was on par with p_2i_2. The treatment combination, p_2i_4 recorded the highest total uptake of 1.577 g plant^{-1}. Significant variation in Ca uptake in different plant parts and total uptake was noticed between the treatment and control.

4.5.5 Mg uptake

The interaction effect of potting media and inorganic fertilizers on the Mg uptake by roots, leaves, stem, berries and spikes are presented in Fig. 23

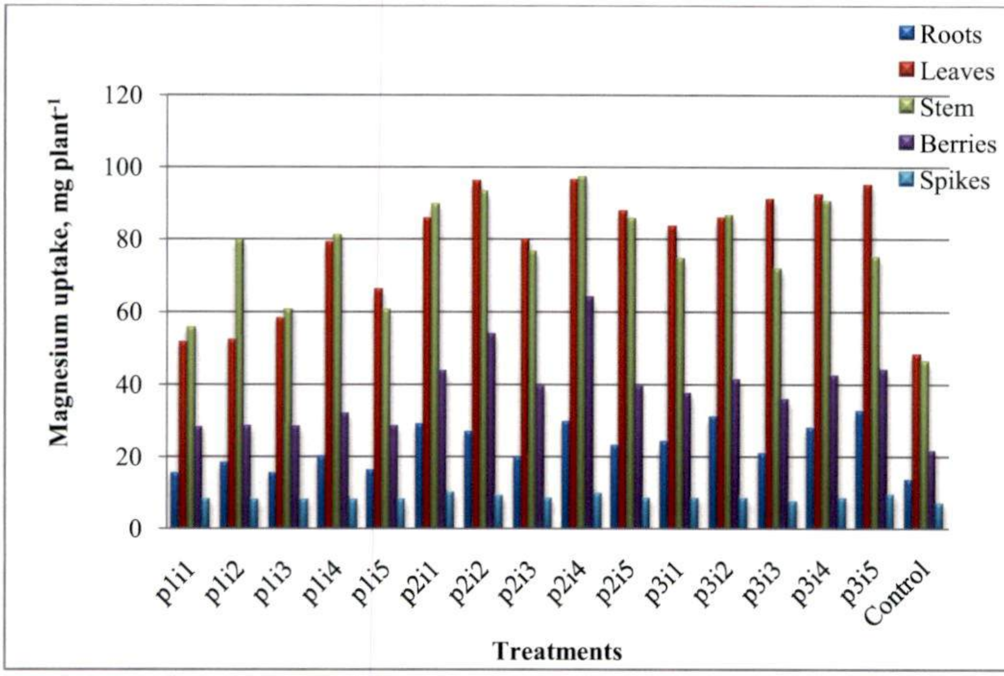

Fig. 23 Interaction effect of potting media and inorganic fertilizers on magnesium uptake (mg plant^{-1}) by roots, leaves, stem, berries and spikes

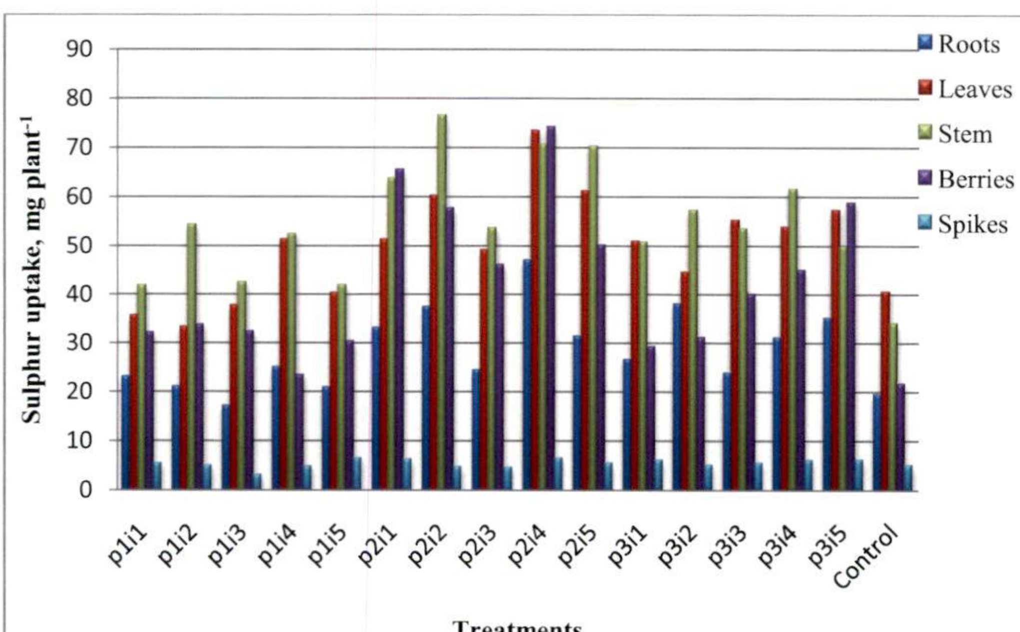

Fig. 24 Interaction effect of potting media and inorganic fertilizers on sulphur uptake (mg plant^{-1}) by roots, leaves, stem, berries and spikes

The total Mg uptake and uptake of Mg in roots, leaves, stem, berries, spikes were significantly influenced by the potting media (Table 27). P_3 (soil + FYM + leaf compost + coir pith compost in the ratio 3:3:1:1) recorded the highest uptake of Mg in roots and leaves. P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) registered the superior uptake of Mg in stem, berries and spike. The total Mg uptake was the highest under P_2 (260.10 mg plant^{-1}).

The uptake of Mg in roots, leaves, stem, berries spikes and total Mg uptake were significantly differed by the inorganic fertilizers. Inorganic fertilizer, I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) registered the highest Mg uptake in different parts like roots, leaves, stem and berries. The uptake of Mg by spikes was non significant. The highest total Mg uptake was recorded by I_4 (260.10 mg plant^{-1}). Mg removal by different parts of black pepper were leaves (4.55 g vine^{-1}), branches (5.98 g vine^{-1}), stem (5.04 g vine^{-1}), fruit spikes (0.10 g vine^{-1}), white pepper (5.80 g vine^{-1}) and flowers (0.22 g vine^{-1}) as reported by Azmil and Yau (1993).

Interaction effects were significant and treatment combination, p_2i_4 (P_2-soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and I_4 -25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest Mg uptake in plant parts like leaves, stems, berries and spikes. With regard to roots, p_3i_5 recorded the highest value. Treatment combination, p_2i_4 recorded the highest total uptake of Mg (296.64 mg plant^{-1}).

Significant change in Mg uptake in different plant parts and total uptake was noticed between treatments and control.

4.5.6 S uptake

The interaction effect of potting media and inorganic fertilizers on the S uptake by roots, leaves, stem, berries and spikes are furnished in Fig. 24

Significant change in uptake of S was noticed in roots, leaves, stem and berries among different potting media (Table 28). P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) registered the highest S uptake in roots, leaves, stem and berries. Uptake of S by spikes were found to be non significant among different potting media. P_2 registered the highest total S uptake (210.76 mg plant^{-1}).

Inorganic fertilizer, I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest uptake of S in different parts like roots and leaves. The S uptake by stem was highest foe 1_2 and was on par with I_4. Uptake of S by berries was found to be non significant among different inorganic fertilizers. I_4 recorded the highest total S uptake of 195.30 mg plant^{-1}.

Interaction effects were found to be significant. The treatment combination p_2i_4, (P_2-soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and I_4 - 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest S uptake in different plant parts like roots, leaves and berries. Regarding the uptake of S by stem, p_2i_2 recorded the highest value. The uptake of S by spikes were noted to be non significant among treatment combinations. The treatment combination, p_2i_4 recorded the highest total uptake of S (253.34 mg plant^{-1}).

Significant variation in uptake of S by different plant parts and total uptake were noticed among the treatments and control.

5.6 NUTRIENT HARVEST INDEX OF PRIMARY AND SECONDARY NUTRIENTS

5.6.1 Nitrogen harvest index

The interaction effect of potting media and inorganic fertilizers on nitrogen harvest index are presented in Fig. 25

Potting media significantly influenced the nitrogen harvest index (Table 29). Plants raised in P_1 (soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1) recorded the highest nitrogen harvest index (31.59 %) and was on par with P_2 (31.24 %).

Significant change in nitrogen harvest index was noticed among different inorganic fertilizers. I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) registered the highest nitrogen harvest index (31.62 %) and was on par with I_1, I_2 and I_5. Nitrogen harvest index (NHI) is very helpful in measuring nitrogen partitioning in crop plants and it provides an evidence of how efficiently the plant utilized acquired N for grain production (Fageria and Baligar, 2003).

Interaction effects were found to be significant and the treatment combination, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest nitrogen harvest index (33.58 %) and was on par with p_1i_5 (32.83 %) and p_2i_1 (32.89 %). Frageria, (2014) reported that NHI can be improved in crop plants by adopting appropriate soil and plant management practices. The treatment combination, p_2i_4 might be highly suitable for plant growth and yield which might have resulted in highest nitrogen harvest index. Ann (2012) reported the nitrogen removal of the seven parts of black pepper vine. The removal of nitrogen by fruits was highest contributing to 29.61 % of total annual N uptake, followed by leaves (25.20 %), stems (20.63 %), branches (15.64 %), roots (4.83 %), flowers (2.65 %) and fruit spikes (1.44 %). Nitrogen harvest index was found to be non significant between treatment and control.

5.6.2 Phosphorus harvest index

The interaction effect of potting media and inorganic fertilizers on phosphorus harvest index are provided in Fig. 25

Phosphorus harvest index significantly varied among different potting media (Table 29). Potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) registered the highest phosphorus harvest index (38.36 %). The lowest phosphorus harvest index was recorded by P_3 (36.19 %).

Significant variation in phosphorus harvest index was noticed among different inorganic fertilizers. I_5 (12.5:12.5:25.0 g of NPK plant^{-1} year^{-1} as soil application at equal monthly splits up to 3 MAP and foliar application of 13:0:45 (0.5 %) at fortnightly intervals from 4th MAP) resulted in highest phosphorus harvest index (38.45 %) and was on par with I_1 and I_4.

Interaction effects were found to be significant and the treatment combination, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) resulted in highest phosphorus harvest index (41.03 %) and was on par with p_2i_1 (39.59 %), p_2i_5 (38.86 %), p_3i_1 (38.80 %), p_2i_2 (38.79 %), p_1i_5 (37.83 %), p_1i_3 (37.57 %) and p_3i_5 (38.64 %). Ann (2012) reported that in black pepper phosphorus removal was the highest in the fruits which contributed to 39.58 % of annual P uptake followed by stem (21.93 %), leaves (16 %) and branches (14.31 %). Significant difference in phosphorus harvest index was recorded between treatment and control.

5.6.3 Potassium harvest index

The interaction effect of potting media and inorganic fertilizers on potassium harvest index are presented in Fig. 25

Potting media significantly influenced the potassium harvest index (Table 29). Plants raised in potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) registered the highest value (30.04 %). The potassium harvest index of P_1 and P_3 were (29.39 %) and (28.77 %) respectively.

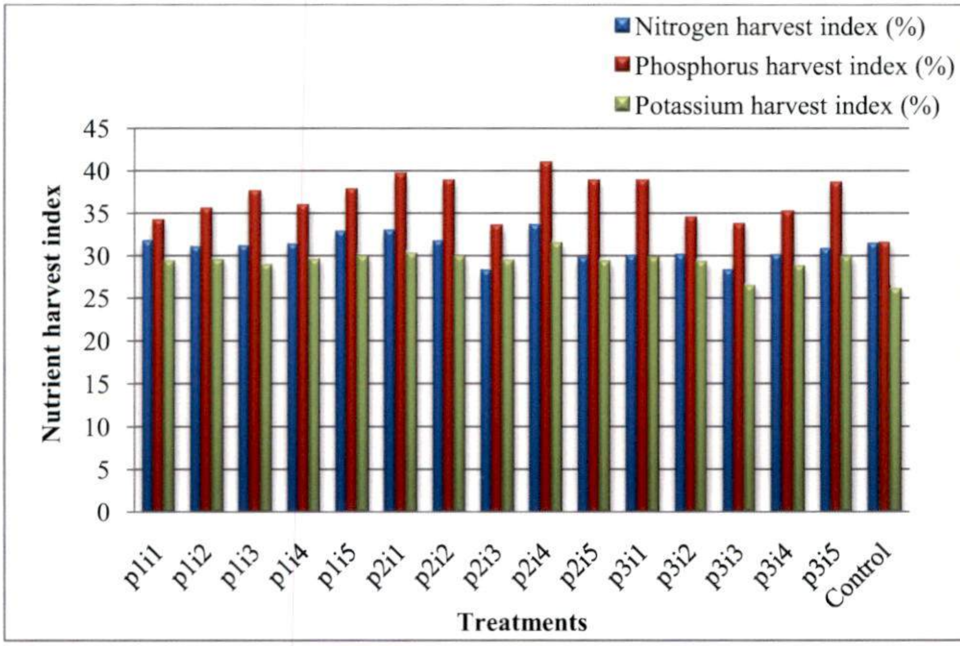

Fig. 25 Interaction effect of potting media and inorganic fertilizers on nitrogen, phosphorus and potassium harvest index (%)

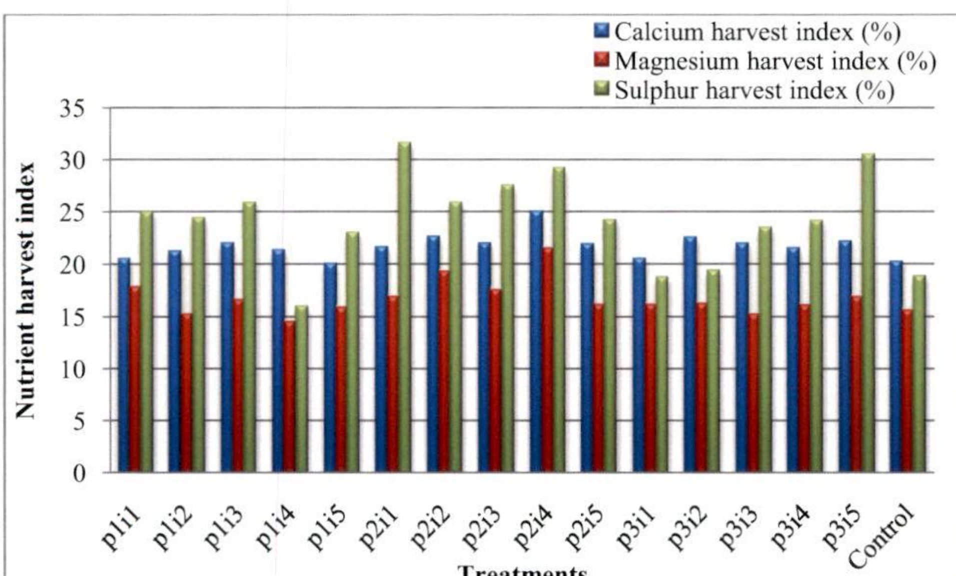

Fig. 26 Interaction effect of potting media and inorganic fertilizers on calcium, magnesium and sulphur harvest index (%)

Significant change in potassium harvest index was noticed among different inorganic fertilizers. I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) resulted in highest potassium harvest index (29.88 %) and was on par with I_1 (29.77 %), I_5 (29.62 %) and I_2 (29.51 %).

Interaction effects were found to be significant. Treatment combination, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest potassium harvest index (31.41 %) and was on par with p_2i_1 (30.25 %), p_1i_5 (29.88 %), and p_2i_2 (29.87 %). The total annual K accumulated in black pepper was mainly distributed among fruits (27.36 %), leaves (25.74 %), stems (20.49 %) and branches (18.08 %) (Ann, 2012). The higher potassium harvest index in p_2i_4 was due to the higher yield as well as higher concentration of potassium in the berries. Significant variation in potassium harvest index was noticed between treatment and control.

5.6.4 Calcium harvest index

The interaction effect of potting media and inorganic fertilizers on calcium harvest index are furnished in Fig. 26

Calcium harvest index significantly varied among different potting media (Table 30). Potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) registered the highest calcium harvest index (22.61 %).

Significant variation in calcium harvest index was noticed among different inorganic fertilizers. I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) resulted in highest value (22.60 %) and was on par with I_2 (22.10 %) and I_3 (21.98 %).

Interaction effects were found to be significant and the treatment combination, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio

3:3:1:1 and 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) resulted in highest calcium harvest index (24.97 %). The calcium harvest index of control was 20.20 %. Calcium harvest index was found to be non significant between treatment and control.

5.6.5 Magnesium harvest index

The interaction effect of potting media and inorganic fertilizers on magnesium harvest index are presented in Fig. 26

Potting media significantly influenced the magnesium harvest index (Table 30). Plants raised in potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) registered the highest value (18.28 %).

Magnesium harvest index was found to be non significant among different inorganic fertilizers.

Interaction effects were found to be significant. Treatment combination, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the highest value (21.50 %). There was no significant variation in magnesium harvest index between treatment and control.

5.6.6 Sulphur harvest index

The interaction effect of potting media and inorganic fertilizers on sulphur harvest index are presented in Fig. 26

Significant difference in the sulphur harvest index was noticed among potting media (Table 30). Potting media,P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the highest sulphur harvest indices of 27.66 % followed P_3 (23.21 %) and P_1 (22.80 %).

Sulphur harvest index was found to be non significant among different inorganic fertilizers.

Interaction effects were found to be significant. Treatment combination, p_2i_1 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits) recorded the highest sulphur harvest index (31.58 %) and was on par with p_1i_3, p_2i_2, p_2i_3, p_2i_4 and p_3i_5. There was significant variation in S harvest index between treatments and control.

5.7 ECONOMICS OF CULTIVATION

Economics of cultivation of bush pepper for 15 years for the calculation of discounted benefit cost ratio, net present worth and internal rate of returns is shown in Appendix 2. The Discounted benefit cost ratio, net present worth and internal rate of returns for various treatments of bush pepper for 15 years is furnished in Appendix 3.

The discounted benefit cost ratio, net present worth and internal rate of return of bush pepper is presented in table 31. The treatment combination of potting media (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) and inorganic fertilizer (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) generated the highest discounted benefit cost ratio of 2.51. This was followed by p_3i_5 (1.91), p_2i_5 (1.86) and p_2i_2 (1.83). All the treatment combinations resulted in higher discounted benefit cost ratio than the control (1.12).The treatment combination p_2i_4 resulted in higher yield and higher gross and net income which resulted in higher discounted benefit cost ratio. The treatments p_3i_5 and p_2i_5 are foliar treatments which resulted in less cost of cultivation and substantially higher yield contributing to better discounted benefit cost ratio.

The Net present worth recorded was ₹ 696.97 in p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizer

(25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) followed by ₹ 410.63 in p_3i_5.

Internal rate of return was the highest in the treatment combination, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizer (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) (67 %) followed by p_3i_5 (47 %). Mohammed *et al.* (2017) reported that black pepper farming generated a total discounted revenue of birr 416,024.4 per hectare with benefit cost ratio of 5.7 and internal rate of return of 61 per cent. The finding also indicated that harvesting cost accounted for higher share (about 51 %) of the total cost of black pepper production which reveal that, in spite of high initial investment cost and long gestation period, black pepper farming is a financially viable and a less risky enterprise.

The discounted benefit cost ratio of 2.51 and NPW of ₹ 696.97 with an IRR of 67 % was obtained from p_2i_4. Thus investments made in bush pepper cultivation using potting medium containing soil + FYM + vermicompost + coir pith compost (3:3:1:1) and inorganic fertilizers applied at the rate of 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits (p_2i_4) was highly profitable.

SUMMARY

6. SUMMARY

An experiment on" Nutrient scheduling in bush pepper (*Piper nigrum* L.) was carried out at Department of Plantation Crops and Spices, College of Agriculture, Vellayani 2017-2018 with the objective of standardizing potting media and nutrient level in bush pepper for yield. The experiment was laid out in completely randomized design with three different types of potting media (P_1, P_2, P_3), five inorganic fertilizer treatments (I_1, I_2, I_3, I_4, I_5) and a control in bush pepper variety Panniyur 1. The different types of potting media used were soil + FYM + neem cake + coir pith compost (P_1), soil + FYM + vermicompost + coir pith compost (P_2) and soil + FYM + leaf compost + coir pith compost (P_3) in the ratio 3:3:1:1. Inorganic fertilizers applied at different levels and intervals were I_1- 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1}at monthly splits, I_2 - 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits, I_3 - 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits, I_4 - 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits and I_5 - 12.5:12.5:25.0 g of NPK plant^{-1} year^{-1} as soil application at equal monthly splits up to 3 MAP and foliar application of 13:0:45 (0.5 %) at fortnightly intervals from 4th MAP. The control treatment contained soil + sand+ FYM, (1:1:1) as potting mixture and inorganic fertilizer applied as per package of practices recommendations of KAU (1.0, 0.5, 2 g of NPK plant^{-1} at bimonthly interval). *Trichoderma* @ 1 g kg^{-1} of potting medium and lime @ 50 g plant^{-1} were applied to all the treatments. The study was planned to standardize potting media and nutrient level based on growth, yield, quality, nutrient uptake, physiological parameters and profitability of bush pepper cultivation. The salient findings are summarized below.

Plants raised in potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) resulted in significantly superior growth parameters like plant height from 2 MAP to 12 MAP, number of secondary branches from 6 MAP to 12 MAP, length of primary, secondary branches, number of leaves and leaf area from 4 MAP to 12 MAP. Plants applied with inorganic fertilizer, I_4 (25.0: 25.0: 50.0 g of

NPK plant^{-1} year^{-1} at quarterly splits) recorded the significantly higher growth attributes like number of secondary branches from 6 MAP to 12 MAP, length of primary and secondary branches from 4 MAP to 12 MAP, number of leaves and leaf area from 8 MAP to 12 MAP. Among the interaction between potting media and inorganic fertilizers treatment combination, p_2i_4 (potting media- soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1 and inorganic fertilizers 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the significantly superior growth characters like number of primary branches at 12 MAP, number of secondary branches from 6 MAP to 12 MAP, length of primary branches from 6 MAP to 12 MAP, length of secondary branches from 4 MAP to 12 MAP, number of leaves and leaf area from 8 MAP to 12 MAP. Significant difference in growth characters like plant height, leaf area from 2 MAP to 12 MAP, number of secondary branches, length of primary branches, length of secondary branches and number of leaves was noticed between treatment and control from 4 MAP to 12 MAP.

Yield parameters differed significantly among different potting media. Potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) produced significantly superior number of spikes plant^{-1}, length of spikes, number of berries spike^{-1}, fresh and dry weight of berries plant^{-1}, hundred berry weight and hundred berry volume. Application of inorganic fertilizers showed significant variation in yield attributes and plants applied with inorganic fertilizer, I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) produced significantly higher yield attributes like number of spikes plant^{-1}, length of spikes, number of berries spike^{-1}, fresh and dry weight of berries plant^{-1}. In interaction treatment combination, p_2i_4 recorded significantly higher number of spikes plant^{-1}(32.67), length of spikes (12.38 cm), number of berries spike^{-1}(61.12), fresh and dry weight of berries plant^{-1} (199.49 and 70.92 g plant^{-1} respectively), hundred berry weight (13.03 g) and hundred berry volume (12.53 cm^3). Significant variation in yield parameters like number of spikes plant^{-1}, length of spikes, number of berries spike^{-1}, fresh and dry weight of berries plant^{-1} were recorded between control and treatment while hundred berry weight and hundred berry volume was noticed non significant between treatment and control.

Root parameters like fresh weight, dry weight and volume of roots differed significantly among potting media, inorganic fertilizers and their interaction. Plants grown in potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) produced the significantly superior value. Among the inorganic fertilizers, I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) recorded the significantly higher value and was on par with I_2 (37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) for all root parameters. Among the interaction, treatment combination, p_2i_4 produced significantly higher fresh weight (41.52 g plant^{-1}), dry weight (18.05 g plant^{-1}) and volume of roots (44.52 cm^3 plant^{-1}). A significant variation in fresh weight, dry weight and volume of roots was noticed between treatment and control.

The physiological parameters like specific leaf weight, moisture percentage and drying percentage were non significant among the potting media, inorganic fertilizers and their interaction. Plants raised in potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) recorded the significantly higher dry matter production at 12 MAP as well as chlorophyll content at 6 MAP and P_1 (soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1) recorded the highest harvest index. Plants treated with inorganic fertilizer, I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) produced significantly higher dry matter production and fertilizers I_1 (37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits) reported the highest harvest index. Significantly higher chlorophyll content at 6 MAP was noticed in I_3 and was on par with I_4. Among the interaction, treatment combination, p_2i_4 produced significantly higher dry matter production (150.92 g plant^{-1}) and chlorophyll content at 6 MAP while p_1i_3 and p_1i_5 recorded higher harvest index (0.49). A significant variation in dry matter production and harvest index was noticed among the treatment and control while specific leaf weight, moisture percentage and drying percentage were non significant between treatment and control.

Quality parameters like starch, essential oil, oleoresin and piperine content of berries were significant among potting media, inorganic fertilizers and their interaction whereas total ash was non significant. Potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) registered the significantly higher essential oil, oleoresin and piperine. Potting media, P_1 (soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1) recorded the highest starch content. Inorganic fertilizer, I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) produced the significantly higher essential oil, oleoresin and piperine content while the starch content was significantly higher in inorganic fertilizers, I_5. Among the interaction, p_2i_4 produced the significantly higher quality parameters like essential oil (3.59 %), oleoresin (11.59 %) and piperine (5.70 %). Treatment combination, p_1i_5 produced the highest starch content of (36.82 %) in berries. The essential oil and oleoresin content of berries were significant among the treatment and control while the starch, total ash and piperine content were non significant.

Analysis of potting media after the experiment revealed that pH, EC, organic carbon, primary (N, P and K) and secondary nutrients (Ca and Mg) varied significantly among the treatment combination. Available S was non significant between the treatment combination. The treatment combination, p_2i_4 registered the highest pH. EC and organic carbon value was found to be significantly higher in the treatment combination, p_3i_1. The available N and P values were significantly higher in the treatment combination, p_1i_1 whereas available K found to be significantly superior in p_2i_1. Available Ca and Mg were significantly superior in the treatment combination p_1i_2. A significant variation in organic carbon and primary nutrients was noticed among the treatment and control while pH, EC and secondary nutrient were non significant.

Uptake of primary and secondary nutrient significantly varied among potting media, inorganic fertilizers and their interaction. Potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) indicated the significantly higher total uptake of primary and secondary nutrients. Among the inorganic fertilizers, I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) produced the significantly higher value for the total uptake of primary and secondary nutrients. Treatment combination, p_2i_4 recorded significantly superior total uptake of nitrogen (2.159 g plant^{-1}), phosphorus (155.17 mg plant^{-1}), potassium (2.367 g plant^{-1}), calcium (1.577 g plant^{-1}), magnesium (296.64 mg plant^{-1}) and sulphur (253.34 mg plant^{-1}). The uptake of N, P, K, Ca, Mg and S of roots, leaves, stem, berries and spike were significantly different between treatments and control. Total uptake of primary and secondary nutrients by control was significantly lower than the treatment combinations.

Potting media, P_2 (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) registered the significantly higher phosphorus, potassium, calcium, magnesium and sulphur harvest index while the nitrogen harvest index was maximum for potting media, P_1 (soil + FYM + neem cake + coir pith compost in the ratio 3:3:1:1). Among the inorganic fertilizers, I_4 (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) registered significantly higher nitrogen, potassium, calcium while phosphorus harvest index was found to be maximum for the I_5. Magnesium and sulphur harvest index were non significant among inorganic fertilizers. Treatment combination, p_2i_4 recorded significantly superior nitrogen (33.58 %), phosphorus (41.03 %), potassium (31.41 %), calcium (24.97 %) and magnesium (21.50 %) harvest index while sulphur harvest index (31.58 %) was maximum for p_2i_1. A significant variation in N, P, K and S harvest index was noticed between treatment and control. Calcium and magnesium harvest index were non significant between treatment and control.

The treatment combination of potting media (soil + FYM + vermicompost + coir pith compost in the ratio 3:3:1:1) and inorganic fertilizer (25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits) generated the highest discounted benefit cost ratio of 2.51 with net present worth of ₹ 696.97 and Internal rate of return of 67 %. All the treatment combinations resulted in higher discounted benefit cost ratio than the control (1.12).

The results of the study indicated that growing bush pepper in potting medium containing soil + FYM + vermicompost + coir pith compost (3:3:1:1) with the application of inorganic fertilizers @ 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} scheduled at quarterly intervals improved growth, yield and quality parameters of bush pepper through higher N, P, K, Ca and Mg harvest index resulting in higher economic returns.

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ABSTRACT

NUTRIENT SCHEDULING IN BUSH PEPPER (*Piper nigrum* L.)

by

FARHANA C.

(2016-12-016)

ABSTRACT

Submitted in partial fulfilment of the

requirement for the degree of

MASTER OF SCIENCE IN HORTICULTURE

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF PLANTATION CROPS AND SPICES

COLLEGE OF AGRICULTURE

VELLAYANI, THIRUVANANTHAPURAM-695 522

KERALA, INDIA

2018

ABSTRACT

The present study entitiled "Nutrient scheduling in bush pepper *(Piper nigrum* L.) was taken up with the specific objective to standardize potting media and nutrient level in bush pepper for yield.

The pot culture experiment on bush pepper was carried in the Department of Plantation Crops and Spices, College of Agriculture, Vellayani during the period 2017-18 using variety Panniyur 1.The efficacy of different combinations of organic manures and different levels and intervals of inorganic fertilizers were evaluated. The experiment was laid out in completely randomized design with three different types of potting media (P_1, P_2, P_3), five inorganic fertilizer treatments (I_1, I_2, I_3, I_4, I_5) and a control. The different types of potting media used were soil + FYM + neem cake + coir pith compost (P_1), soil + FYM + vermicompost + coir pith compost (P_2) and soil + FYM + leaf compost + coir pith compost (P_3) in the ratio 3:3:1:1. Inorganic fertilizers applied at different levels and intervals were I_1- 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1}at monthly splits, I_2 - 37.5: 37.5: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits, I_3 - 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at monthly splits, I_4 - 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} at quarterly splits and I_5 - 12.5:12.5:25.0 g of NPK plant^{-1} year^{-1} as soil application at equal monthly splits up to 3 MAP and foliar application of 13:0:45 (0.5 %) at fortnightly intervals from 4th MAP. The control treatment contained soil + sand+ FYM, (1:1:1) as potting mixture and inorganic fertilizer applied as per package of practices recommendations of KAU (1.0, 0.5, 2 g NPK plant^{-1} at bimonthly interval). *Trichoderma* @ 1 g kg^{-1} of potting medium and lime @ 50 g plant^{-1} were applied to all the treatments.

The results of the study revealed that potting media containing soil + FYM + vermicompost + coir pith compost (3:3:1:1) and inorganic fertilizers applied at the rate of 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1}at quarterly splits (p_2i_4) recorded significantly higher plant growth characters like number of secondary branches,

length of primary branches, length of secondary branches, number of leaves and leaf area from 8MAP to 12 MAP. Fresh weight, dry weight and volume of roots at 12 MAP were also significantly higher for the treatment combination, p_2i_4

Significantly higher dry matter production (150.92 g plant^{-1}) at 12 MAP and chlorophyll content at 6 MAP was noticed in p_2i_4 while dry matter production was the least in control (72.42 g plant^{-1}). The yield attributes like number of spikes plant^{-1}, length of spike, number of berries spike^{-1}, hundred berry weight, hundred berry volume, fresh and dry weight of berries were significantly higher for p_2i_4 recording a dry yield increase of 98 per cent over the control. Quality parameters of berries revealed that essential oil, oleoresin and piperine were highest in p_2i_4 while highest starch content was obtained in p_1i_5.

. The total uptake of nitrogen, phosphorus and potassium by bush pepper was significantly superior with a higher uptake of N (2.159 g plant^{-1}), P (155.17 mg plant^{-1}), K (2.367 g plant^{-1}), Ca (1.577 g plant^{-1}), Mg (296.64 mg plant^{-1}) and S (253.34 mg plant^{-1}) in p_2i_4. Higher nitrogen harvest index (33.58 %), phosphorous harvest index (41.03 %) and potassium harvest index (31.41 %) were recorded from p_2i_4, indicating that nutrient removal in bush pepper was proportional to the yield. The discounted benefit-cost ratio was 2.51 with 67 % of Internal Rate of Return (IRR) for p_2i_4 implied that investments made in bush pepper following the above treatment was highly profitable.

The results of the study indicated that growing bush pepper in potting medium containing soil + FYM + vermicompost + coir pith compost (3:3:1:1) with the application of inorganic fertilizers @ 25.0: 25.0: 50.0 g of NPK plant^{-1} year^{-1} scheduled at quarterly intervals produced better growth characters like number of secondary branches, length of primary and secondary branches, number of leaves, total leaf area , root dry weight and yield parameters like number of spikes and number of berries spike^{-1} which ultimately doubled the yield compared to the package of practices recommendations of KAU.

APPENDICES

APPENDIX I. FERTILIZER SCHEDULE

Inorganic fertilizers (I)	Basal	1 MAP	2 MAP	3 MAP	4 MAP	5 MAP	6 MAP	7 MAP	8 MAP	9 MAP	10 MAP	11 MAP	12 MAP
I_1	Urea: 6.79 g Mussoorie phos: 15.62 g Murate of potash:6.94 g	Urea: 6.79 g Mussoorie phos: 15.62 g Murate of potash: 6.94 g	Urea: 6.79 g Mussoorie phos: 15.62 g Murate of potash: 6.94 g	Urea: 6.79 g Mussoorie phos: 15.62 g Murate of potash: 6.94 g	Urea: 6.79 g Mussoorie phos: 15.62 g Murate of potash: 6.94 g	Urea: 6.79 g Mussoorie phos: 15.62 g Murate of potash: 6.94 g	Urea: 6.79 g Mussoorie phos: 15.62 g Murate of potash: 6.94 g	Urea: 6.79 g Mussoorie phos: 15.62 g Murate of potash: 6.94 g	Urea: 6.79 g Mussoorie phos: 15.62 g Murate of potash: 6.94 g	Urea: 6.79 g Mussoorie phos: 15.62 g Murate of potash: 6.94 g	Urea: 6.79 g Mussoorie phos: 15.62 g Murate of potash: 6.94 g	Urea: 6.79 g Mussoorie phos: 15.62 g Murate of potash: 6.94 g	Urea: 6.79 g Mussoorie phos: 15.62 g Murate of potash: 6.94 g
I_2	Urea :20.38 g Mussoorie phos: 46.87 g Murate of potash:0.83 g			Urea :20.38 g Mussoorie phos: 46.87 g Murate of potash: 0.83 g			Urea :20.38 g Mussoorie phos: 46.87 g Murate of potash: 0.83 g			Urea :20.38 g Mussoorie phos: 46.87 g Murate of potash: 0.83 g			Urea :20.38 g Mussoorie phos: 46.87 g Murate of potash: 0.83 g
I_3	U rea :4.52 g Mussoorie phos: 10.41 g Murate of potash:6.94 g	U rea :4.52 g Mussoorie phos: 10.41 g Murate of potash:6.94 g	U rea :4.52 g Mussoorie phos: 10.41 g Murate of potash:6.94 g	U rea :4.52 g Mussoorie phos: 10.41 g Murate of potash:6.94 g	U rea :4.52 g Mussoorie phos: 10.41 g Murate of potash:6.94 g	U rea :4.52 g Mussoorie phos: 10.41 g Murate of potash:6.94 g	U rea :4.52 g Mussoorie phos: 10.41 g Murate of potash:6.94 g	U rea :4.52 g Mussoorie phos: 10.41 g Murate of potash:6.94 g	U rea :4.52 g Mussoorie phos: 10.41 g Murate of potash:6.94 g	U rea :4.52 g Mussoorie phos: 10.41 g Murate of potash:6.94 g	U rea :4.52 g Mussoorie phos: 10.41 g Murate of potash:6.94 g	U rea :4.52 g Mussoorie phos: 10.41 g Murate of potash:6.94 g	U rea :4.52 g Mussoorie phos: 10.41 g Murate of potash:6.94 g

Inorganic fertilizers (I)	Basal	1 MAP	2 MAP	3 MAP	4 MAP	5 MAP	6 MAP	7 MAP	8 MAP	9 MAP	10 MAP	11 MAP	12 MAP
I_4	U rea:13.58 g Mussoorie phos: 31.25 g Murate of potash:20.83 g			U rea:13.58 g Mussoorie phos: 31.25 g Murate of potash:20.83 g			U rea:13.58 g Mussoorie phos: 31.25 g Murate of potash:20.83 g			U rea:13.58 g Mussoorie phos: 31.25 g Murate of potash:20.83 g			U rea:13.58 g Mussoorie phos: 31.25 g Murate of potash:20.83 g
I_5	Urea : 6.79 g Mussoorie phos: 15.62 g Murate of potash:10.41 g	Urea : 6.79 g Mussoorie phos: 15.62 g Murate of potash:10.41 g	Urea : 6.79 g Mussoorie phos: 15.62 g Murate of potash:10.41 g	Urea : 6.79 g Mussoorie phos: 15.62 g Murate of potash:10.41 g	Foliar fertilizer (13:0:45) : 0.225g in 45 ml water twice at 15 days interval	Foliar fertilizer (13:0:45) : 0.250 g in 50 ml water at 15 days interval	Foliar fertilizer (13:0:45) : 0.275 g in 55 ml water at 15 days interval	Foliar fertilizer (13:0:45) : 0.3 g in 60 ml water at 15 days interval	Foliar fertilizer (13:0:45) : 0.325g in 65ml water at 15 days interval	Foliar fertilizer (13:0:45) : 0.350 g in 70 ml water at 15 days interval	Foliar fertilizer (13:0:45) : 0.375 g in 75 ml water at 15 days interval	Foliar fertilizer (13:0:45) : 0.4 g in 80 ml water at 15 days interval	Foliar fertilizer (13:0:45) : 0.425 g in 85 ml water at 15 days interval
Control	U rea:2.17 g Mussoorie phos: 2.5 g Murate of potash:3.33 g		U rea:2.17 g Mussoorie phos: 2.5 g Murate of potash:3.33 g		U rea:2.17 g Mussoorie phos: 2.5 g Murate of potash:3.33 g		U rea:2.17 g Mussoorie phos: 2.5 g Murate of potash:3.33 g		U rea:2.17 g Mussoorie phos: 2.5 g Murate of potash:3.33 g		U rea:2.17 g Mussoorie phos: 2.5 g Murate of potash:3.33 g		U rea:2.17 g Mussoorie phos: 2.5 g Murate of potash:3.33 g

APPENDIX II. ECONOMICS OF CULTIVATION OF BUSH PEPEPR FOR 15 YEARS FOR THE CALCULATION OF DISCOUNTED BENEFIT COST RATIO, NET PRESENT WORTH AND INTERNAL RATE OF RETURNS

First year

Treatments	Planting material (₹)	FYM (₹)	Sand (₹)	Neem cake (₹)	Vermicompost (₹)	Leaf compost (₹)	Coir pith compost (₹)	Trichoderma (₹)	Lime (₹)	Urea (₹)	Mussooriephos (₹)	MOP (₹)	Foliar fertilizer (13:0:45) (₹)	Labour charge (planting+weeding+irrigation+harvest) (₹)	Labour charge fertilizer application (₹)	Total cost of cultivation (₹)	Dry yield (g)	Price of 1 g black pepper (₹)	Gross income (₹)	Net income (₹)
p_1i_1	100	18.75		43.75			18.75	1.05	0.8	0.571	4.166	1.166		9.086	25.4	198.089	39.11	0.372	14.548	-183.541
p_1i_2	100	18.75		43.75			18.75	1.05	0.8	0.571	4.166	1.166		9.086	8.46	198.089	39.59	0.372	14.727	-183.361
p_1i_3	100	18.75		43.75			18.75	1.05	0.8	0.380	2.777	1.166		9.086	25.04	196.509	40.21	0.372	14.956	-181.553
p_1i_4	100	18.75		43.75			18.75	1.05	0.8	0.380	2.777	1.166		9.086	8.34	196.509	44.13	0.372	16.416	-180.093
p_1i_5	100	18.75		43.75			18.75	1.05	0.8	0.190	1.388	0.583	0.60	9.165	6.69	195.026	40.47	0.372	15.056	-179.970
p_2i_1	100	18.75			25		18.75	1.05	0.8	0.571	4.166	1.166		9.165	25.4	179.418	52.67	0.372	19.592	-159.826
p_2i_2	100	18.75			25		18.75	1.05	0.8	0.571	4.166	1.166		9.165	8.46	179.418	53.21	0.372	19.795	-159.623
p_2i_3	100	18.75			25		18.75	1.05	0.8	0.380	2.777	1.166		9.086	25.04	177.759	43.65	0.372	16.238	-161.522
p_2i_4	100	18.75			25		18.75	1.05	0.8	0.380	2.777	1.166		9.165	8.34	177.838	70.93	0.372	26.384	-151.454
p_2i_5	100	18.75			25		18.75	1.05	0.8	0.190	1.388	0.583	0.60	9.165	6.69	176.276	51.55	0.372	19.176	-157.100
p_3i_1	100	18.75				25	18.75	1.05	0.8	0.571	4.166	1.166		9.165	25.4	179.418	47.27	0.372	17.586	-161.832
p_3i_2	100	18.75				25	18.75	1.05	0.8	0.571	4.166	1.166		9.165	8.46	179.418	48.99	0.372	18.224	-161.193
p_3i_3	100	18.75				25	18.75	1.05	0.8	0.380	2.777	1.166		9.086	25.04	177.759	40.31	0.372	14.994	-162.766
p_3i_4	100	18.75				25	18.75	1.05	0.8	0.380	2.777	1.166		9.165	8.34	177.838	49.02	0.372	18.235	-159.604
p_3i_5	100	18.75				25	18.75	1.05	0.8	0.190	1.388	0.583	0.60	9.165	6.69	176.276	52.77	0.372	19.632	-156.645
Control	100	17.5	70					1.05	0.8	0.091	0.333	0.28		7.84	4.23	197.894	35.75	0.372	13.300	-184.595

Second year

Treatments	Planting material (₹)	FYM (₹)	Sand (₹)	Neem cake (₹)	Vermicompost (₹)	Leaf compost (₹)	Coirpith compost (₹)	Trichoderma (₹)	Lime (₹)	Urea (₹)	Mussoriephos (₹)	MOP (₹)	Foliar fertilizer (13:0:45) (₹)	Labour charge (planting+weeding+irrigation+harvest) (₹)	Labour charge fertilizer application (₹)	Total cost of cultivation (₹)	Dry yield (g)	Price of 1 g black pepper (₹)	Gross income (₹)	Net income (₹)
p_1i_1		1						1.05	0.8	0.571	4.166	1.166		9.086	25.4	17.839	117.32	0.372	43.644	25.805
p_1i_2		1						1.05	0.8	0.571	4.166	1.166		9.086	8.46	17.839	118.77	0.372	44.182	26.344
p_1i_3		1						1.05	0.8	0.380	2.777	1.166		9.086	25.04	16.259	120.62	0.372	44.869	28.610
p_1i_4		1						1.05	0.8	0.380	2.777	1.166		9.086	8.34	16.259	132.39	0.372	49.249	32.990
p_1i_5		1						1.05	0.8	0.190	1.388	0.583	0.96	9.165	6.69	15.136	121.42	0.372	45.169	30.033
p_2i_1		1						1.05	0.8	0.571	4.166	1.166		9.165	25.4	17.918	158.00	0.372	58.776	40.859
p_2i_2		1						1.05	0.8	0.571	4.166	1.166		9.165	8.46	17.918	159.63	0.372	59.384	41.466
p_2i_3		1						1.05	0.8	0.380	2.777	1.166		9.086	25.04	16.259	130.95	0.372	48.713	32.453
p_2i_4		1						1.05	0.8	0.380	2.777	1.166		9.165	8.34	16.338	212.78	0.372	79.153	62.815
p_2i_5		1						1.05	0.8	0.190	1.388	0.583	0.96	9.165	6.69	15.136	154.64	0.372	57.527	42.391
p_3i_1		1						1.05	0.8	0.571	4.166	1.166		9.165	25.4	17.918	141.82	0.372	52.757	34.840
p_3i_2		1						1.05	0.8	0.571	4.166	1.166		9.165	8.46	17.918	146.97	0.372	54.672	36.755
p_3i_3		1						1.05	0.8	0.380	2.777	1.166		9.086	25.04	16.259	120.92	0.372	44.981	28.722
p_3i_4		1						1.05	0.8	0.380	2.777	1.166		9.165	8.34	16.338	147.05	0.372	54.704	38.366
p_3i_5		1						1.05	0.8	0.190	1.388	0.583	0.96	9.165	6.69	15.136	158.32	0.372	58.895	43.759
Control		1						1.05	0.8	0.091	0.333	0.28		7.84	4.23	11.394	107.25	0.372	39.899	28.504

Third year

Treatments	Planting material (₹)	FYM (₹)	Sand (₹)	Neem cake (₹)	Vermicompost (₹)	Leaf compost (₹)	Coirpith compost (₹)	Trichoderma (₹)	Lime (₹)	Urea (₹)	Mussoorie phos (₹)	MOP (₹)	Foliar fertilizer (13:0:45) (₹)	Labour charge (planting+weeding+irrigation+harvest) (₹)	Labour charge fertilizer application (₹)	Total cost of cultivation (₹)	Dry yield (g)	Price of 1 g black pepper (₹)	Gross income (₹)	Net income (₹)
p_1i_1		18.75		43.75			18.75	1.05	0.8	0.571	4.166	1.166		9.086	25.4	98.089	234.64	0.372	87.288	-10.801
p_1i_2		18.75		43.75			18.75	1.05	0.8	0.571	4.166	1.166		9.086	8.46	98.089	237.54	0.372	88.365	-9.724
p_1i_3		18.75		43.75			18.75	1.05	0.8	0.380	2.777	1.166		9.086	25.04	96.509	241.23	0.372	89.739	-6.771
p_1i_4		18.75		43.75			18.75	1.05	0.8	0.380	2.777	1.166		9.086	8.34	96.509	264.78	0.372	98.498	1.988
p_1i_5		18.75		43.75			18.75	1.05	0.8	0.190	1.388	0.583	0.96	9.165	6.69	95.386	242.84	0.372	90.338	-5.048
p_2i_1		18.75			25		18.75	1.05	0.8	0.571	4.166	1.166		9.165	25.4	79.418	316.00	0.372	117.552	38.135
p_2i_2		18.75			25		18.75	1.05	0.8	0.571	4.166	1.166		9.165	8.46	79.418	319.27	0.372	118.767	39.350
p_2i_3		18.75			25		18.75	1.05	0.8	0.380	2.777	1.166		9.086	25.04	77.759	261.90	0.372	97.426	19.666
p_2i_4		18.75			25		18.75	1.05	0.8	0.380	2.777	1.166		9.165	8.34	77.838	425.56	0.372	158.307	80.468
p_2i_5		18.75			25		18.75	1.05	0.8	0.190	1.388	0.583	0.96	9.165	6.69	76.636	309.29	0.372	115.054	38.418
p_3i_1		18.75				25	18.75	1.05	0.8	0.571	4.166	1.166		9.165	25.4	79.418	283.64	0.372	105.515	26.097
p_3i_2		18.75				25	18.75	1.05	0.8	0.571	4.166	1.166		9.165	8.46	79.418	293.94	0.372	109.345	29.927
p_3i_3		18.75				25	18.75	1.05	0.8	0.380	2.777	1.166		9.086	25.04	77.759	241.84	0.372	89.963	12.203
p_3i_4		18.75				25	18.75	1.05	0.8	0.380	2.777	1.166		9.165	8.34	77.838	294.11	0.372	109.408	31.570
p_3i_5		18.75				25	18.75	1.05	0.8	0.190	1.388	0.583	0.96	9.165	6.69	76.636	316.64	0.372	117.790	41.154
Control		17.5	90					1.05	0.8	0.091	0.333	0.28		7.84	4.23	97.894	214.51	0.372	79.797	-18.097

Fourth year

Treatments	Planting material (₹)	FYM (₹)	Sand (₹)	Neem cake (₹)	Vermicompost (₹)	Leaf compost (₹)	Coirpith compost (₹)	Trichoderma (₹)	Lime (₹)	Urea (₹)	Mussoorie phos (₹)	MOP (₹)	Foliar fertilizer (13:0:45) (₹)	Labour charge (planting+weeding+irrigation+harvest) (₹)	Labour charge fertilizer application (₹)	Total cost of cultivation (₹)	Dry yield (g)	Price of 1 g black pepper (₹)	Gross income (₹)	Net income (₹)
p_1i_1		1.1						1.15	0.88	0.628	5.041	1.411		9.995	27.94	20.204	273.75	0.409	111.965	91.761
p_1i_2		1.1						1.15	0.88	0.628	5.041	1.411		9.995	9.306	20.204	277.13	0.409	113.346	93.142
p_1i_3		1.1						1.15	0.88	0.418	3.360	1.411		9.995	27.544	18.314	281.44	0.409	115.109	96.795
p_1i_4		1.1						1.15	0.88	0.418	3.360	1.411		9.995	9.174	18.314	308.91	0.409	126.344	108.030
p_1i_5		1.1						1.15	0.88	0.209	1.679	0.705	1.05	10.082	7.359	16.856	283.32	0.409	115.877	99.021
p_2i_1		1.1						1.15	0.88	0.628	5.041	1.411		10.082	27.94	20.291	368.67	0.409	150.785	130.494
p_2i_2		1.1						1.15	0.88	0.628	5.041	1.411		10.082	9.306	20.291	372.48	0.409	152.343	132.053
p_2i_3		1.1						1.15	0.88	0.418	3.360	1.411		9.995	27.544	18.314	305.55	0.409	124.969	106.654
p_2i_4		1.1						1.15	0.88	0.418	3.360	1.411		10.082	9.174	18.401	496.48	0.409	203.061	184.660
p_2i_5		1.1						1.15	0.88	0.209	1.679	0.705	1.05	10.082	7.359	16.856	360.83	0.409	147.581	130.725
p_3i_1		1.1						1.15	0.88	0.628	5.041	1.411		10.082	27.94	20.291	330.91	0.409	135.344	115.054
p_3i_2		1.1						1.15	0.88	0.628	5.041	1.411		10.082	9.306	20.291	342.93	0.409	140.257	119.966
p_3i_3		1.1						1.15	0.88	0.418	3.360	1.411		9.995	27.544	18.314	282.14	0.409	115.396	97.082
p_3i_4		1.1						1.15	0.88	0.418	3.360	1.411		10.082	9.174	18.401	343.13	0.409	140.338	121.937
p_3i_5		1.1						1.15	0.88	0.209	1.679	0.705	1.05	10.082	7.359	16.856	369.41	0.409	151.090	134.234
Control		1.1						1.15	0.88	0.100	0.403	0.339		8.624	4.653	12.596	250.26	0.409	102.357	89.761

Fifth year

Treatments	Planting material (₹)	FYM (₹)	Sand (₹)	Neemcake (₹)	Vermicompost (₹)	Leaf compost (₹)	Coirpith compost (₹)	Trichoderma (₹)	Lime (₹)	Urea (₹)	Mussoorie phos (₹)	MOP (₹)	Foliar fertilizer (13:0:45) (₹)	Labour charge (planting+weeding+irrigation+harvest) (₹)	Labour charge fertilizer application (₹)	Total cost of cultivation (₹)	Dry yield (g)	Price of 1 g black pepper (₹)	Gross income (₹)	Net income (₹)
p_1i_1	20.625		48.13			20.625	1.15	0.88	0.628	5.041	5.041	1.411		9.995	27.94	108.479	273.75	0.409	111.965	3.486
p_1i_2	20.625		48.13			20.625	1.15	0.88	0.628	5.041	5.041	1.411		9.995	9.306	108.479	277.13	0.409	113.346	4.867
p_1i_3	20.625		48.13			20.625	1.15	0.88	0.418	3.360	3.360	1.411		9.995	27.544	106.589	281.44	0.409	115.109	8.520
p_1i_4	20.625		48.13			20.625	1.15	0.88	0.418	3.360	3.360	1.411		9.995	9.174	106.589	308.91	0.409	126.344	19.755
p_1i_5	20.625		48.13			20.625	1.15	0.88	0.209	1.679	1.679	0.705	1.05	10.082	7.359	105.131	283.32	0.409	115.877	10.746
p_2i_1	20.625			27.5		20.625	1.15	0.88	0.628	5.041	5.041	1.411		10.082	27.94	87.941	368.67	0.409	150.785	62.844
p_2i_2	20.625			27.5		20.625	1.15	0.88	0.628	5.041	5.041	1.411		10.082	9.306	87.941	372.48	0.409	152.343	64.403
p_2i_3	20.625			27.5		20.625	1.15	0.88	0.418	3.360	3.360	1.411		9.995	27.544	85.964	305.55	0.409	124.969	39.004
p_2i_4	20.625			27.5		20.625	1.15	0.88	0.418	3.360	3.360	1.411		10.082	9.174	86.051	496.48	0.409	203.061	117.010
p_2i_5	20.625			27.5		20.625	1.15	0.88	0.209	1.679	1.679	0.705	1.05	10.082	7.359	84.506	360.83	0.409	147.581	63.075
p_3i_1	20.625				27.5	20.625	1.15	0.88	0.628	5.041	5.041	1.411		10.082	27.94	87.941	330.91	0.409	135.344	47.404
p_3i_2	20.625				27.5	20.625	1.15	0.88	0.628	5.041	5.041	1.411		10.082	9.306	87.941	342.93	0.409	140.257	52.316
p_3i_3	20.625				27.5	20.625	1.15	0.88	0.418	3.360	3.360	1.411		9.995	27.544	85.964	282.14	0.409	115.396	29.432
p_3i_4	20.625				27.5	20.625	1.15	0.88	0.418	3.360	3.360	1.411		10.082	9.174	86.051	343.13	0.409	140.338	54.287
p_3i_5	20.625				27.5	20.625	1.15	0.88	0.209	1.679	1.679	0.705	1.05	10.082	7.359	84.506	369.41	0.409	151.090	66.584
Control	19.25	99			0	0	1.15	0.88	0.100	0.403	0.403	0.339		8.624	4.653	107.746	250.26	0.409	102.357	-5.389

Sixth year

Treatments	Pot (₹)	FYM (₹)	Sand (₹)	Neemcake (₹)	Vermicompost (₹)	Leaf compost (₹)	Coir pith compost (₹)	Trichoderma (₹)	Lime (₹)	Urea (₹)	Mussoorie phos (₹)	MOP (₹)	Foliar fertilizer (13:0:45) (₹)	Labour charge (planting+weeding+irrigation+harvest) (₹)	Labour charge fertilizer application (₹)	Total cost of cultivation (₹)	Dry yield (g)	Price of 1g black pepper (₹)	Gross income (₹)	Net income (₹)
p_1i_1	1.1	1.1						1.15	0.88	0.628	5.041	1.411		9.995	27.94	21.304	273.75	0.409	111.965	90.661
p_1i_2	1.1	1.1						1.15	0.88	0.628	5.041	1.411		9.995	9.306	21.304	277.13	0.409	113.346	92.042
p_1i_3	1.1	1.1						1.15	0.88	0.418	3.360	1.411		9.995	27.544	19.414	281.44	0.409	115.109	95.695
p_1i_4	1.1	1.1						1.15	0.88	0.418	3.360	1.411		9.995	9.174	19.414	308.91	0.409	126.344	106.930
p_1i_5	1.1	1.1						1.15	0.88	0.209	1.679	0.705	1.05	10.082	7.359	17.956	283.32	0.409	115.877	97.921
p_2i_1	1.1	1.1						1.15	0.88	0.628	5.041	1.411		10.082	27.94	21.391	368.67	0.409	150.785	129.394
p_2i_2	1.1	1.1						1.15	0.88	0.628	5.041	1.411		10.082	9.306	21.391	372.48	0.409	152.343	130.953
p_2i_3	1.1	1.1						1.15	0.88	0.418	3.360	1.411		9.995	27.544	19.414	305.55	0.409	124.969	105.554
p_2i_4	1.1	1.1						1.15	0.88	0.418	3.360	1.411		10.082	9.174	19.501	496.48	0.409	203.061	183.560
p_2i_5	1.1	1.1						1.15	0.88	0.209	1.679	0.705	1.05	10.082	7.359	17.956	360.83	0.409	147.581	129.625
p_3i_1	1.1	1.1						1.15	0.88	0.628	5.041	1.411		10.082	27.94	21.391	330.91	0.409	135.344	113.954
p_3i_2	1.1	1.1						1.15	0.88	0.628	5.041	1.411		10.082	9.306	21.391	342.93	0.409	140.257	118.866
p_3i_3	1.1	1.1						1.15	0.88	0.418	3.360	1.411		9.995	27.544	19.414	282.14	0.409	115.396	95.982
p_3i_4	1.1	1.1						1.15	0.88	0.418	3.360	1.411		10.082	9.174	19.501	343.13	0.409	140.338	120.837
p_3i_5	1.1	1.1						1.15	0.88	0.209	1.679	0.705	1.05	10.082	7.359	17.956	369.41	0.409	151.090	133.134
Control	1.1	1.1						1.15	0.88	0.100	0.403	0.339		8.624	4.653	13.696	250.26	0.409	102.357	88.661

Seventh year

Treatments	Planting material (₹)	FYM(₹)	Sand (₹)	Neemcake (₹)	Vermicompost (₹)	Leaf compost (₹)	Coirpith compost (₹)	Trichoderma (₹)	Lime (₹)	Urea (₹)	Mussoorieph os (₹)	MOP (₹)	Foliar fertilizer (13:0:45) (₹)	Labour charge (planting+weeding+irrigation+harvest) (₹)	Labour charge fertilizer application (₹)	Total cost of cultivation (₹)	Dry yield (g)	Price of 1 g black pepper (₹)	Gross income (₹)	Net income (₹)
p_1i_1		20.625		48.125			20.625	1.15	0.88	0.628	5.041	1.411		9.995	27.94	108.479	273.75	0.409	111.965	3.486
p_1i_2		20.625		48.125			20.625	1.15	0.88	0.628	5.041	1.411		9.995	9.306	108.479	277.13	0.409	113.346	4.867
p_1i_3		20.625		48.125			20.625	1.15	0.88	0.418	3.360	1.411		9.995	27.544	106.589	281.44	0.409	115.109	8.520
p_1i_4		20.625		48.125			20.625	1.15	0.88	0.418	3.360	1.411		9.995	9.174	106.589	308.91	0.409	126.344	19.755
p_1i_5		20.625		48.125			20.625	1.15	0.88	0.209	1.679	0.705	1.05	10.082	7.359	105.131	283.32	0.409	115.877	10.746
p_2i_1		20.625			27.5		20.625	1.15	0.88	0.628	5.041	1.411		10.082	27.94	87.941	368.67	0.409	150.785	62.844
p_2i_2		20.625			27.5		20.625	1.15	0.88	0.628	5.041	1.411		10.082	9.306	87.941	372.48	0.409	152.343	64.403
p_2i_3		20.625			27.5		20.625	1.15	0.88	0.418	3.360	1.411		9.995	27.544	85.964	305.55	0.409	124.969	39.004
p_2i_4		20.625			27.5		20.625	1.15	0.88	0.418	3.360	1.411		10.082	9.174	86.051	496.48	0.409	203.061	117.010
p_2i_5		20.625			27.5		20.625	1.15	0.88	0.209	1.679	0.705	1.05	10.082	7.359	84.506	360.83	0.409	147.581	63.075
p_3i_1		20.625				27.5	20.625	1.15	0.88	0.628	5.041	1.411		10.082	27.94	87.941	330.91	0.409	135.344	47.404
p_3i_2		20.625				27.5	20.625	1.15	0.88	0.628	5.041	1.411		10.082	9.306	87.941	342.93	0.409	140.257	52.316
p_3i_3		20.625				27.5	20.625	1.15	0.88	0.418	3.360	1.411		9.995	27.544	85.964	282.14	0.409	115.396	29.432
p_3i_4		20.625				27.5	20.625	1.15	0.88	0.418	3.360	1.411		10.082	9.174	86.051	343.13	0.409	140.338	54.287
p_3i_5		20.625				27.5	20.625	1.15	0.88	0.209	1.679	0.705	1.05	10.082	7.359	84.506	369.41	0.409	151.090	66.584
Control		19.25	99					1.15	0.88	0.100	0.403	0.339		8.624	4.653	107.746	250.26	0.409	102.357	-5.389

Eighth year

Treatments	Planting material (₹)	FYM (₹)	Sand (₹)	Neem cake (₹)	Vermicompost (₹)	Leaf compost (₹)	Coirpith compost (₹)	Trichoderma (₹)	Lime (₹)	Urea (₹)	Mussoorie phos (₹)	MOP (₹)	Foliar fertilizer (13:0:45) (₹)	Labour charge (planting+weeding+irrigation+harvest) (₹)	Labour charge fertilizer application (₹)	Total cost of cultivation (₹)	Dry yield (g)	Price of 1 g black pepper (₹)	Gross income (₹)	Net income (₹)
p_1i_1		1.21						1.265	0.968	0.690	5.545	1.552		10.994	30.734	22.224	273.75	0.450	123.188	100.964
p_1i_2		1.21						1.265	0.968	0.690	5.545	1.552		10.994	10.237	22.224	277.13	0.450	124.708	102.484
p_1i_3		1.21						1.265	0.968	0.460	3.696	1.552		10.994	30.298	20.145	281.44	0.450	126.648	106.502
p_1i_4		1.21						1.265	0.968	0.460	3.696	1.552		10.994	10.091	20.145	308.91	0.450	139.009	118.864
p_1i_5		1.21						1.265	0.968	0.230	1.847	0.776	1.155	11.090	8.095	18.541	283.32	0.450	127.493	108.952
p_2i_1		1.21						1.265	0.968	0.690	5.545	1.552		11.090	30.734	22.320	368.67	0.450	165.900	143.580
p_2i_2		1.21						1.265	0.968	0.690	5.545	1.552		11.090	10.237	22.320	372.48	0.450	167.615	145.295
p_2i_3		1.21						1.265	0.968	0.460	3.696	1.552		10.994	30.298	20.145	305.55	0.450	137.496	117.350
p_2i_4		1.21						1.265	0.968	0.460	3.696	1.552		11.090	10.091	20.241	496.48	0.450	223.417	203.176
p_2i_5		1.21						1.265	0.968	0.230	1.847	0.776	1.155	11.090	8.095	18.541	360.83	0.450	162.375	143.834
p_3i_1		1.21						1.265	0.968	0.690	5.545	1.552		11.090	30.734	22.320	330.91	0.450	148.912	126.592
p_3i_2		1.21						1.265	0.968	0.690	5.545	1.552		11.090	10.237	22.320	342.93	0.450	154.317	131.997
p_3i_3		1.21						1.265	0.968	0.460	3.696	1.552		10.994	30.298	20.145	282.14	0.450	126.964	106.818
p_3i_4		1.21						1.265	0.968	0.460	3.696	1.552		11.090	10.091	20.241	343.13	0.450	154.406	134.165
p_3i_5		1.21						1.265	0.968	0.230	1.847	0.776	1.155	11.090	8.095	18.541	369.41	0.450	166.236	147.695
Control		1.21						1.265	0.968	0.110	0.443	0.373		9.486	5.118	13.856	250.26	0.450	112.617	98.762

Ninth year

Treatments	Planting material (₹)	FYM (₹)	Sand (₹)	Neem cake (₹)	Vermicompost (₹)	Leaf compost (₹)	Coirpith compost (₹)	Trichoderma (₹)	Lime (₹)	Urea (₹)	Mussoorieph os (₹)	MOP (₹)	Foliar fertilizer (13:0:45) (₹)	Labour charge (planting+weeding+irrigation+harvest) (₹)	Labour charge fertilizer application (₹)	Total cost of cultivation (₹)	Dry yield (g)	Price of 1 g black pepper (₹)	Gross income (₹)	Net income (₹)
p_1i_1		22.69		52.94			22.69	1.265	0.968	0.690	5.545	1.552		10.994	30.734	119.327	273.75	0.450	123.188	3.862
p_1i_2		22.69		52.94			22.69	1.265	0.968	0.690	5.545	1.552		10.994	10.237	119.327	277.13	0.450	124.708	5.382
p_1i_3		22.69		52.94			22.69	1.265	0.968	0.460	3.696	1.552		10.994	30.298	117.248	281.44	0.450	126.648	9.400
p_1i_4		22.69		52.94			22.69	1.265	0.968	0.460	3.696	1.552		10.994	10.091	117.248	308.91	0.450	139.009	21.761
p_1i_5		22.69		52.94			22.69	1.265	0.968	0.230	1.847	0.776	1.155	11.090	8.095	115.644	283.32	0.450	127.493	11.849
p_2i_1		22.69			30.25		22.69	1.265	0.968	0.690	5.545	1.552		11.090	30.734	96.735	368.67	0.450	165.900	69.165
p_2i_2		22.69			30.25		22.69	1.265	0.968	0.690	5.545	1.552		11.090	10.237	96.735	372.48	0.450	167.615	70.880
p_2i_3		22.69			30.25		22.69	1.265	0.968	0.460	3.696	1.552		10.994	30.298	94.560	305.55	0.450	137.496	42.935
p_2i_4		22.69			30.25		22.69	1.265	0.968	0.460	3.696	1.552		11.090	10.091	94.656	496.48	0.450	223.417	128.761
p_2i_5		22.69			30.25		22.69	1.265	0.968	0.230	1.847	0.776	1.155	11.090	8.095	92.956	360.83	0.450	162.375	69.419
p_3i_1		22.69				30.25	22.69	1.265	0.968	0.690	5.545	1.552		11.090	30.734	96.735	330.91	0.450	148.912	52.177
p_3i_2		22.69				30.25	22.69	1.265	0.968	0.690	5.545	1.552		11.090	10.237	96.735	342.93	0.450	154.317	57.582
p_3i_3		22.69				30.25	22.69	1.265	0.968	0.460	3.696	1.552		10.994	30.298	94.560	282.14	0.450	126.964	32.403
p_3i_4		22.69				30.25	22.69	1.265	0.968	0.460	3.696	1.552		11.090	10.091	94.656	343.13	0.450	154.406	59.750
p_3i_5		22.69				30.25	22.69	1.265	0.968	0.230	1.847	0.776	1.155	11.090	8.095	92.956	369.41	0.450	166.236	73.280
Control		21.18	108.9					1.265	0.968	0.110	0.443	0.373		9.486	5.118	118.521	250.26	0.450	112.617	-5.903

Tenth year

Treatments	Planting material (₹)	FYM(₹)	Sand (₹)	Neem cake (₹)	Vermicompost (₹)	Leaf compost (₹)	Coirpith compost (₹)	Trichoderma (₹)	Lime (₹)	Urea (₹)	Mussooriephos (₹)	MOP (₹)	Foliar fertilizer (13:0:45) (₹)	Labour charge (planting+weeding+irrigation+harvest) (₹)	Labour charge fertilizer application (₹)	Total cost of cultivation (₹)	Dry yield (g)	Price of 1 g black pepper (₹)	Gross income (₹)	Net income (₹)
p_1i_1		1.21						1.265	0.968	0.690	5.545	1.552		10.994	30.734	22.224	273.75	0.450	123.188	100.964
p_1i_2		1.21						1.265	0.968	0.690	5.545	1.552		10.994	10.237	22.224	277.13	0.450	124.708	102.484
p_1i_3		1.21						1.265	0.968	0.460	3.696	1.552		10.994	30.298	20.145	281.44	0.450	126.648	106.502
p_1i_4		1.21						1.265	0.968	0.460	3.696	1.552		10.994	10.091	20.145	308.91	0.450	139.009	118.864
p_1i_5		1.21						1.265	0.968	0.230	1.847	0.776	1.155	11.090	8.095	18.541	283.32	0.450	127.493	108.952
p_2i_1		1.21						1.265	0.968	0.690	5.545	1.552		11.090	30.734	22.320	368.67	0.450	165.900	143.580
p_2i_2		1.21						1.265	0.968	0.690	5.545	1.552		11.090	10.237	22.320	372.48	0.450	167.615	145.295
p_2i_3		1.21						1.265	0.968	0.460	3.696	1.552		10.994	30.298	20.145	305.55	0.450	137.496	117.350
p_2i_4		1.21						1.265	0.968	0.460	3.696	1.552		11.090	10.091	20.241	496.48	0.450	223.417	203.176
p_2i_5		1.21						1.265	0.968	0.230	1.847	0.776	1.155	11.090	8.095	18.541	360.83	0.450	162.375	143.834
p_3i_1		1.21						1.265	0.968	0.690	5.545	1.552		11.090	30.734	22.320	330.91	0.450	148.912	126.592
p_3i_2		1.21						1.265	0.968	0.690	5.545	1.552		11.090	10.237	22.320	342.93	0.450	154.317	131.997
p_3i_3		1.21						1.265	0.968	0.460	3.696	1.552		10.994	30.298	20.145	282.14	0.450	126.964	106.818
p_3i_4		1.21						1.265	0.968	0.460	3.696	1.552		11.090	10.091	20.241	343.13	0.450	154.406	134.165
p_3i_5		1.21						1.265	0.968	0.230	1.847	0.776	1.155	11.090	8.095	18.541	369.41	0.450	166.236	147.695
Control		1.21						1.265	0.968	0.110	0.443	0.373		9.486	5.118	13.856	250.26	0.450	112.617	98.762

Eleventh year

Treatments	Planting material (₹)	FYM (₹)	Sand (₹)	Neem cake (₹)	Vermicompost (₹)	Leaf compost (₹)	Coirpith compost (₹)	Trichoderma (₹)	Lime (₹)	Urea (₹)	Mussoriephos (₹)	MOP (₹)	Foliar fertilizer (13:0:45) (₹)	Labour charge (planting+weeding+irrigation+harvest) (₹)	Labour charge fertilizer application (₹)	Total cost of cultivation (₹)	Dry yield (g)	Price of 1 g black pepper (₹)	Gross income (₹)	Net income (₹)
p_1i_1		22.69		52.94			22.688	1.265	0.968	0.690	5.545	1.552		10.994	30.734	119.327	273.75	0.450	123.188	3.862
p_1i_2		22.69		52.94			22.688	1.265	0.968	0.690	5.545	1.552		10.994	10.237	119.327	277.13	0.450	124.708	5.382
p_1i_3		22.69		52.94			22.688	1.265	0.968	0.460	3.696	1.552		10.994	30.298	117.248	281.44	0.450	126.648	9.400
p_1i_4		22.69		52.94			22.688	1.265	0.968	0.460	3.696	1.552		10.994	10.091	117.248	308.91	0.450	139.009	21.761
p_1i_5		22.69		52.94			22.688	1.265	0.968	0.230	1.847	0.776	1.155	11.090	8.095	115.644	283.32	0.450	127.493	11.849
p_2i_1		22.69			30.25		22.688	1.265	0.968	0.690	5.545	1.552		11.090	30.734	96.735	368.67	0.450	165.900	69.165
p_2i_2		22.69			30.25		22.688	1.265	0.968	0.690	5.545	1.552		11.090	10.237	96.735	372.48	0.450	167.615	70.880
p_2i_3		22.69			30.25		22.688	1.265	0.968	0.460	3.696	1.552		10.994	30.298	94.560	305.55	0.450	137.496	42.935
p_2i_4		22.69			30.25		22.688	1.265	0.968	0.460	3.696	1.552		11.090	10.091	94.656	496.48	0.450	223.417	128.761
p_2i_5		22.69			30.25		22.688	1.265	0.968	0.230	1.847	0.776	1.155	11.090	8.095	92.956	360.83	0.450	162.375	69.419
p_3i_1		22.69				30.25	22.688	1.265	0.968	0.690	5.545	1.552		11.090	30.734	96.735	330.91	0.450	148.912	52.177
p_3i_2		22.69				30.25	22.688	1.265	0.968	0.690	5.545	1.552		11.090	10.237	96.735	342.93	0.450	154.317	57.582
p_3i_3		22.69				30.25	22.688	1.265	0.968	0.460	3.696	1.552		10.994	30.298	94.560	282.14	0.450	126.964	32.403
p_3i_4		22.69				30.25	22.688	1.265	0.968	0.460	3.696	1.552		11.090	10.091	94.656	343.13	0.450	154.406	59.750
p_3i_5		22.69				30.25	22.688	1.265	0.968	0.230	1.847	0.776	1.155	11.090	8.095	92.956	369.41	0.450	166.236	73.280
Control		21.18	108.90					1.265	0.968	0.110	0.443	0.373		9.486	5.118	118.521	250.26	0.450	112.617	-5.903

Twelfth year

Treatments	Pot (₹)	FYM(₹)	Sand (₹)	Neemcake (₹)	Vermicompost (₹)	Leaf compost (₹)	Coir pith compost (₹)	Trichoderma (₹)	Lime (₹)	Urea (₹)	Mussoriephos (₹)	MOP (₹)	Foliar fertilizer (13:0:45) (₹)	Labour charge (planting+weeding+irrigation+harvest) (₹)	Labour charge fertilizer application (₹)	Total cost of cultivation (₹)	Dry yield (g)	Price of 1 g black pepper (₹)	Gross income (₹)	Net income (₹)
p_1i_1	1.21	1.33						1.392	1.065	0.759	6.099	1.707		12.093	33.807	25.657	273.75	0.495	135.507	109.851
p_1i_2	1.21	1.33						1.392	1.065	0.759	6.099	1.707		12.093	11.260	25.657	277.13	0.495	137.179	111.523
p_1i_3	1.21	1.33						1.392	1.065	0.506	4.066	1.707		12.093	33.328	23.370	281.44	0.495	139.312	115.942
p_1i_4	1.21	1.33						1.392	1.065	0.506	4.066	1.707		12.093	11.101	23.370	308.91	0.495	152.910	129.540
p_1i_5	1.21	1.33						1.392	1.065	0.253	2.032	0.854	1.270	12.199	8.904	21.605	283.32	0.495	140.242	118.637
p_2i_1	1.21	1.33						1.392	1.065	0.759	6.099	1.707		12.199	33.807	25.762	368.67	0.495	182.490	156.728
p_2i_2	1.21	1.33						1.392	1.065	0.759	6.099	1.707		12.199	11.260	25.762	372.48	0.495	184.377	158.615
p_2i_3	1.21	1.33						1.392	1.065	0.506	4.066	1.707		12.093	33.328	23.370	305.55	0.495	151.246	127.876
p_2i_4	1.21	1.33						1.392	1.065	0.506	4.066	1.707		12.199	11.101	23.475	496.48	0.495	245.759	222.283
p_2i_5	1.21	1.33						1.392	1.065	0.253	2.032	0.854	1.270	12.199	8.904	21.605	360.83	0.495	178.613	157.008
p_3i_1	1.21	1.33						1.392	1.065	0.759	6.099	1.707		12.199	33.807	25.762	330.91	0.495	163.803	138.041
p_3i_2	1.21	1.33						1.392	1.065	0.759	6.099	1.707		12.199	11.260	25.762	342.93	0.495	169.749	143.987
p_3i_3	1.21	1.33						1.392	1.065	0.506	4.066	1.707		12.093	33.328	23.370	282.14	0.495	139.660	116.290
p_3i_4	1.21	1.33						1.392	1.065	0.506	4.066	1.707		12.199	11.101	23.475	343.13	0.495	169.847	146.372
p_3i_5	1.21	1.33						1.392	1.065	0.253	2.032	0.854	1.270	12.199	8.904	21.605	369.41	0.495	182.859	161.255
Control	1.21	1.33						1.392	1.065	0.121	0.488	0.410		10.435	5.630	16.451	250.26	0.495	123.879	107.428

Thirteenth year

Treatments	Planting material (₹)	FYM (₹)	Sand (₹)	Neem cake (₹)	Vermicompost (₹)	Leaf compost (₹)	Coirpith compost (₹)	Trichoderma (₹)	Lime (₹)	Urea (₹)	Mussoriephos (₹)	MOP (₹)	Foliar fertilizer (13:0:45) (₹)	Labour charge (planting+weeding+irrigation+harvest) (₹)	Labour charge fertilizer application (₹)	Total cost of cultivation (₹)	Dry yield (g)	Price of 1 g black pepper (₹)	Gross income (₹)	Net income (₹)
p_1i_1		22.69		52.94			22.688	1.392	1.065	0.759	6.099	1.707		12.093	33.807	121.428	273.75	0.495	135.507	14.079
p_1i_2		22.69		52.94			22.688	1.392	1.065	0.759	6.099	1.707		12.093	11.260	121.428	277.13	0.495	137.179	15.751
p_1i_3		22.69		52.94			22.688	1.392	1.065	0.506	4.066	1.707		12.093	33.328	119.141	281.44	0.495	139.312	20.171
p_1i_4		22.69		52.94			22.688	1.392	1.065	0.506	4.066	1.707		12.093	11.101	119.141	308.91	0.495	152.910	33.769
p_1i_5		22.69		52.94			22.688	1.392	1.065	0.253	2.032	0.854	1.270	12.199	8.904	117.376	283.32	0.495	140.242	22.866
p_2i_1		22.69			30.25		22.688	1.392	1.065	0.759	6.099	1.707		12.199	33.807	98.846	368.67	0.495	182.490	83.644
p_2i_2		22.69			30.25		22.688	1.392	1.065	0.759	6.099	1.707		12.199	11.260	98.846	372.48	0.495	184.377	85.531
p_2i_3		22.69			30.25		22.688	1.392	1.065	0.506	4.066	1.707		12.093	33.328	96.454	305.55	0.495	151.246	54.792
p_2i_4		22.69			30.25		22.688	1.392	1.065	0.506	4.066	1.707		12.199	11.101	96.559	496.48	0.495	245.759	149.199
p_2i_5		22.69			30.25		22.688	1.392	1.065	0.253	2.032	0.854	1.270	12.199	8.904	94.689	360.83	0.495	178.613	83.924
p_3i_1		22.69				30.25	22.688	1.392	1.065	0.759	6.099	1.707		12.199	33.807	98.846	330.91	0.495	163.803	64.957
p_3i_2		22.69				30.25	22.688	1.392	1.065	0.759	6.099	1.707		12.199	11.260	98.846	342.93	0.495	169.749	70.903
p_3i_3		22.69				30.25	22.688	1.392	1.065	0.506	4.066	1.707		12.093	33.328	96.454	282.14	0.495	139.660	43.206
p_3i_4		22.69				30.25	22.688	1.392	1.065	0.506	4.066	1.707		12.199	11.101	96.559	343.13	0.495	169.847	73.288
p_3i_5		22.69				30.25	22.688	1.392	1.065	0.253	2.032	0.854	1.270	12.199	8.904	94.689	369.41	0.495	182.859	88.171
Control		21.18	108.90				0.000	1.392	1.065	0.121	0.488	0.410		10.435	5.630	119.785	250.26	0.495	123.879	4.094

Fourteenth year

Treatments	Planting material (₹)	FYM (₹)	Sand (₹)	Neem cake (₹)	Vermicompost (₹)	Leaf compost (₹)	Coirpith compost (₹)	Trichoderma (₹)	Lime (₹)	Urea (₹)	Mussoorie phos (₹)	MOP (₹)	Foliar fertilizer (13:0:45) (₹)	Labour charge (planting+weeding+irrigation+harvest) (₹)	Labour charge fertilizer application (₹)	Total cost of cultivation (₹)	Dry yield (g)	Price of 1 g black pepper (₹)	Gross income (₹)	Net income (₹)
p_1i_1		1.33						1.392	1.065	0.759	6.099	1.707		12.093	33.807	24.447	273.75	0.495	135.507	111.061
p_1i_2		1.33						1.392	1.065	0.759	6.099	1.707		12.093	11.260	24.447	277.13	0.495	137.179	112.733
p_1i_3		1.33						1.392	1.065	0.506	4.066	1.707		12.093	33.328	22.160	281.44	0.495	139.312	117.152
p_1i_4		1.33						1.392	1.065	0.506	4.066	1.707		12.093	11.101	22.160	308.91	0.495	152.910	130.750
p_1i_5		1.33						1.392	1.065	0.253	2.032	0.854	1.270	12.199	8.904	20.395	283.32	0.495	140.242	119.847
p_2i_1		1.33						1.392	1.065	0.759	6.099	1.707		12.199	33.807	24.552	368.67	0.495	182.490	157.938
p_2i_2		1.33						1.392	1.065	0.759	6.099	1.707		12.199	11.260	24.552	372.48	0.495	184.377	159.825
p_2i_3		1.33						1.392	1.065	0.506	4.066	1.707		12.093	33.328	22.160	305.55	0.495	151.246	129.086
p_2i_4		1.33						1.392	1.065	0.506	4.066	1.707		12.199	11.101	22.265	496.48	0.495	245.759	223.493
p_2i_5		1.33						1.392	1.065	0.253	2.032	0.854	1.270	12.199	8.904	20.395	360.83	0.495	178.613	158.218
p_3i_1		1.33						1.392	1.065	0.759	6.099	1.707		12.199	33.807	24.552	330.91	0.495	163.803	139.251
p_3i_2		1.33						1.392	1.065	0.759	6.099	1.707		12.199	11.260	24.552	342.93	0.495	169.749	145.197
p_3i_3		1.33						1.392	1.065	0.506	4.066	1.707		12.093	33.328	22.160	282.14	0.495	139.660	117.500
p_3i_4		1.33						1.392	1.065	0.506	4.066	1.707		12.199	11.101	22.265	343.13	0.495	169.847	147.582
p_3i_5		1.33						1.392	1.065	0.253	2.032	0.854	1.270	12.199	8.904	20.395	369.41	0.495	182.859	162.465
Control		1.33						1.392	1.065	0.121	0.488	0.410		10.435	5.630	15.241	250.26	0.495	123.879	108.638

Fifteenth year

Treatments	Planting material (₹)	FYM (₹)	Sand (₹)	Neem cake (₹)	Vermicompost (₹)	Leaf compost (₹)	Coirpith compost (₹)	Trichoderma (₹)	Lime (₹)	Urea (₹)	Mussoorieph os (₹)	MOP (₹)	Foliar fertilizer (13:0:45) (₹)	Labour charge (planting+weeding+irrigation+harvest) (₹)	Labour charge fertilizer application (₹)	Total cost of cultivation (₹)	Dry yield (g)	Price of 1 g black pepper (₹)	Gross income (₹)	Net income (₹)
p_1i_1		22.69		52.94			22.688	1.392	1.065	0.759	6.099	1.707		12.093	33.807	121.428	273.75	0.495	135.507	14.079
p_1i_2		22.69		52.94			22.688	1.392	1.065	0.759	6.099	1.707		12.093	11.260	121.428	277.13	0.495	137.179	15.751
p_1i_3		22.69		52.94			22.688	1.392	1.065	0.506	4.066	1.707		12.093	33.328	119.141	281.44	0.495	139.312	20.171
p_1i_4		22.69		52.94			22.688	1.392	1.065	0.506	4.066	1.707		12.093	11.101	119.141	308.91	0.495	152.910	33.769
p_1i_5		22.69		52.94			22.688	1.392	1.065	0.253	2.032	0.854	1.270	12.199	8.904	117.376	283.32	0.495	140.242	22.866
p_2i_1		22.69			30.25		22.688	1.392	1.065	0.759	6.099	1.707		12.199	33.807	98.846	368.67	0.495	182.490	83.644
p_2i_2		22.69			30.25		22.688	1.392	1.065	0.759	6.099	1.707		12.199	11.260	98.846	372.48	0.495	184.377	85.531
p_2i_3		22.69			30.25		22.688	1.392	1.065	0.506	4.066	1.707		12.093	33.328	96.454	305.55	0.495	151.246	54.792
p_2i_4		22.69			30.25		22.688	1.392	1.065	0.506	4.066	1.707		12.199	11.101	96.559	496.48	0.495	245.759	149.199
p_2i_5		22.69			30.25		22.688	1.392	1.065	0.253	2.032	0.854	1.270	12.199	8.904	94.689	360.83	0.495	178.613	83.924
p_3i_1		22.69				30.25	22.688	1.392	1.065	0.759	6.099	1.707		12.199	33.807	98.846	330.91	0.495	163.803	64.957
p_3i_2		22.69				30.25	22.688	1.392	1.065	0.759	6.099	1.707		12.199	11.260	98.846	342.93	0.495	169.749	70.903
p_3i_3		22.69				30.25	22.688	1.392	1.065	0.506	4.066	1.707		12.093	33.328	96.454	282.14	0.495	139.660	43.206
p_3i_4		22.69				30.25	22.688	1.392	1.065	0.506	4.066	1.707		12.199	11.101	96.559	343.13	0.495	169.847	73.288
p_3i_5		22.69				30.25	22.688	1.392	1.065	0.253	2.032	0.854	1.270	12.199	8.904	94.689	369.41	0.495	182.859	88.171
Control		21.18	108.90					1.392	1.065	0.121	0.488	0.410		10.435	5.630	119.785	250.26	0.495	123.879	4.094

APPENDIX III. DISCOUNTED BENEFIT COST RATIO, NET PRESENT WORTH AND INTERNAL RATE OF RETURNS FOR VARIOUS TREATMENTS OF BUSH PEPPER FOR 15 YEARS

Treatment combination, p_1i_1

Treatment combination, p_1i_1						
Year	Total cost of cultivation	Gross income	Net income	Discounted factor at 12 %	Discounted cost	Discounted benefit
1st	198.08	14.55	-183.53	0.8929	176.8571	12.9892
2nd	17.84	43.64	25.81	0.7972	14.2207	34.7926
3rd	98.09	87.29	-10.80	0.7118	69.8175	62.1297
4th	20.20	111.96	91.76	0.6355	12.8399	71.1555
5th	108.48	111.96	3.49	0.5674	61.5538	63.5317
6th	21.30	111.96	90.66	0.5066	10.7932	56.7247
7th	108.48	111.96	3.49	0.4523	49.0703	50.6471
8th	22.22	123.19	100.96	0.4039	8.9760	49.7537
9th	119.33	123.19	3.86	0.3606	43.0304	44.4229
10th	22.22	123.19	100.96	0.3220	7.1556	39.6633
11th	119.33	123.19	3.86	0.2875	34.3036	35.4137
12th	25.66	135.51	109.85	0.2567	6.5854	34.7813
13th	121.43	135.51	14.08	0.2292	27.8282	31.0547
14th	24.45	135.51	111.06	0.2046	5.0023	27.7275
15th	121.43	135.51	14.08	0.1827	22.1845	24.7567
					550.2184	639.5443
BCR	1.16		NPW	89.32	IRR	20%

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Treatment combination, p_1i_2

Treatment combination, p_1i_2						
Year	Total cost of cultivation	Gross income	Net income	Discounted factor at 12 %	Discounted cost	Discounted benefit
1st	198.08	14.73	-183.35	0.8929	176.8571	13.1495
2nd	17.84	44.18	26.34	0.7972	14.2207	35.2219
3rd	98.09	88.36	-9.72	0.7118	69.8175	62.8963
4th	20.20	113.35	93.14	0.6355	12.8399	72.0335
5th	108.48	113.35	4.87	0.5674	61.5538	64.3156
6th	21.30	113.35	92.04	0.5066	10.7932	57.4246
7th	108.48	113.35	4.87	0.4523	49.0703	51.2720
8th	22.22	124.71	102.48	0.4039	8.9760	50.3676
9th	119.33	124.71	5.38	0.3606	43.0304	44.9711
10th	22.22	124.71	102.48	0.3220	7.1556	40.1528
11th	119.33	124.71	5.38	0.2875	34.3036	35.8507
12th	25.66	137.18	111.52	0.2567	6.5854	35.2105
13th	121.43	137.18	15.75	0.2292	27.8282	31.4379
14th	24.45	137.18	112.73	0.2046	5.0023	28.0696
15th	121.43	137.18	15.75	0.1827	22.1845	25.0621
					550.2184	647.4358
BCR	1.18		NPW	97.21	IRR	21%

Treatment combination, p_1i_3

Treatment combination, p_1i_3						
Year	Total cost of cultivation	Gross income	Net income	Discounted factor at 12 %	Discounted cost	Discounted benefit
1st	196.50	14.96	-181.54	0.8929	175.4464	13.3540
2nd	16.26	44.87	28.61	0.7972	12.9619	35.7696
3rd	96.51	89.74	-6.77	0.7118	68.6935	63.8743
4th	18.31	115.11	96.79	0.6355	11.6389	73.1536
5th	106.59	115.11	8.52	0.5674	60.4815	65.3157
6th	19.41	115.11	95.69	0.5066	9.8358	58.3176
7th	106.59	115.11	8.52	0.4523	48.2155	52.0693
8th	20.15	126.65	106.50	0.4039	8.1364	51.1508
9th	117.25	126.65	9.40	0.3606	42.2808	45.6704
10th	20.15	126.65	106.50	0.3220	6.4863	40.7771
11th	117.25	126.65	9.40	0.2875	33.7060	36.4082
12th	23.37	139.31	115.94	0.2567	5.9985	35.7580
13th	119.14	139.31	20.17	0.2292	27.3042	31.9268
14th	22.16	139.31	117.15	0.2046	4.5344	28.5061
15th	119.14	139.31	20.17	0.1827	21.7667	25.4518
					537.4866	657.5034
BCR	1.22		NPW	120.01	IRR	23%

Treatment combination, p_1i_4

Treatment combination, p_1i_4						
Year	Total cost of cultivation	Gross income	Net income	Discounted factor at 12 %	Discounted cost	Discounted benefit
1st	196.50	16.42	-180.08	0.8929	175.4464	14.6574
2nd	16.26	49.25	32.99	0.7972	12.9619	39.2610
3rd	96.51	98.50	1.99	0.7118	68.6935	70.1089
4th	18.31	126.34	108.03	0.6355	11.6389	80.2938
5th	106.59	126.34	19.75	0.5674	60.4815	71.6909
6th	19.41	126.34	106.93	0.5066	9.8358	64.0097
7th	106.59	126.34	19.75	0.4523	48.2155	57.1515
8th	20.15	139.01	118.86	0.4039	8.1364	56.1435
9th	117.25	139.01	21.76	0.3606	42.2808	50.1281
10th	20.15	139.01	118.86	0.3220	6.4863	44.7572
11th	117.25	139.01	21.76	0.2875	33.7060	39.9618
12th	23.37	152.91	129.54	0.2567	5.9985	39.2482
13th	119.14	152.91	33.77	0.2292	27.3042	35.0430
14th	22.16	152.91	130.75	0.2046	4.5344	31.2884
15th	119.14	152.91	33.77	0.1827	21.7667	27.9361
					537.4866	721.6795
BCR	1.34		NPW	184.19	IRR	28%

Treatment combination, p_1i_5

Treatment combination, p_1i_5						
Year	Total cost of cultivation	Gross income	Net income	Discounted factor at 12 %	Discounted cost	Discounted benefit
1st	195.02	15.06	-179.96	0.8929	174.1250	13.4431
2nd	15.14	45.17	30.03	0.7972	12.0663	36.0083
3rd	95.39	90.34	-5.05	0.7118	67.8939	64.3006
4th	16.86	115.88	99.02	0.6355	10.7123	73.6418
5th	105.13	115.88	10.75	0.5674	59.6542	65.7516
6th	17.96	115.88	97.92	0.5066	9.0971	58.7068
7th	105.13	115.88	10.75	0.4523	47.5559	52.4168
8th	18.54	127.49	108.95	0.4039	7.4884	51.4922
9th	115.64	127.49	11.85	0.3606	41.7024	45.9752
10th	18.54	127.49	108.95	0.3220	5.9697	41.0493
11th	115.64	127.49	11.85	0.2875	33.2449	36.6511
12th	21.61	140.24	118.64	0.2567	5.5455	35.9966
13th	117.38	140.24	22.87	0.2292	26.8995	32.1399
14th	20.40	140.24	119.85	0.2046	4.1732	28.6963
15th	117.38	140.24	22.87	0.1827	21.4442	25.6217
					527.5724	661.8912
BCR	1.25		NPW	134.31	IRR	24%

Treatment combination, p_2i_1

Treatment combination, p_2i_1						
Year	Total cost of cultivation	Gross income	Net income	Discounted factor at 12 %	Discounted cost	Discounted benefit
1st	179.41	19.59	-159.82	0.8929	160.1875	17.4929
2nd	17.92	58.78	40.86	0.7972	14.2837	46.8559
3rd	79.42	117.55	38.13	0.7118	56.5278	83.6712
4th	20.29	150.78	130.49	0.6355	12.8951	95.8264
5th	87.94	150.78	62.84	0.5674	49.8999	85.5593
6th	21.39	150.78	129.39	0.5066	10.8372	76.3922
7th	87.94	150.78	62.84	0.4523	39.7799	68.2073
8th	22.32	165.90	143.58	0.4039	9.0146	67.0042
9th	96.73	165.90	69.17	0.3606	34.8835	59.8252
10th	22.32	165.90	143.58	0.3220	7.1864	53.4154
11th	96.73	165.90	69.17	0.2875	27.8089	47.6923
12th	25.76	182.49	156.73	0.2567	6.6124	46.8406
13th	98.85	182.49	83.64	0.2292	22.6529	41.8220
14th	24.55	182.49	157.94	0.2046	5.0238	37.3411
15th	98.85	182.49	83.64	0.1827	18.0588	33.3402
					475.6525	861.2861
BCR	1.81		NPW	385.63	IRR	44%

Treatment combination, p_2i_2

Treatment combination, p_2i_2						
Year	Total cost of cultivation	Gross income	Net income	Discounted factor at 12 %	Discounted cost	Discounted benefit
1st	179.41	19.79	-159.62	0.8929	160.1875	17.6737
2nd	17.92	59.38	41.47	0.7972	14.2837	47.3403
3rd	79.42	118.77	39.35	0.7118	56.5278	84.5362
4th	20.29	152.34	132.05	0.6355	12.8951	96.8170
5th	87.94	152.34	64.40	0.5674	49.8999	86.4438
6th	21.39	152.34	130.95	0.5066	10.8372	77.1819
7th	87.94	152.34	64.40	0.4523	39.7799	68.9125
8th	22.32	167.62	145.30	0.4039	9.0146	67.6969
9th	96.73	167.62	70.88	0.3606	34.8835	60.4437
10th	22.32	167.62	145.30	0.3220	7.1864	53.9676
11th	96.73	167.62	70.88	0.2875	27.8089	48.1853
12th	25.76	184.38	158.61	0.2567	6.6124	47.3249
13th	98.85	184.38	85.53	0.2292	22.6529	42.2544
14th	24.55	184.38	159.82	0.2046	5.0238	37.7271
15th	98.85	184.38	85.53	0.1827	18.0588	33.6849
					475.6525	870.1901
BCR	1.83		NPW	394.53	IRR	45%

Treatment combination, p_2i_3

Treatment combination, p_2i_3						
Year	Total cost of cultivation	Gross income	Net income	Discounted factor at 12 %	Discounted cost	Discounted benefit
1st	177.75	16.24	-161.51	0.8929	158.7054	14.4979
2nd	16.26	48.71	32.45	0.7972	12.9619	38.8336
3rd	77.76	97.43	19.67	0.7118	55.3476	69.3457
4th	18.31	124.97	106.65	0.6355	11.6389	79.4198
5th	85.96	124.97	39.00	0.5674	48.7783	70.9105
6th	19.41	124.97	105.55	0.5066	9.8358	63.3129
7th	85.96	124.97	39.00	0.4523	38.8858	56.5294
8th	20.15	137.50	117.35	0.4039	8.1364	55.5323
9th	94.56	137.50	42.94	0.3606	34.0994	49.5824
10th	20.15	137.50	117.35	0.3220	6.4863	44.2700
11th	94.56	137.50	42.94	0.2875	27.1839	39.5268
12th	23.37	151.25	127.88	0.2567	5.9985	38.8210
13th	96.45	151.25	54.79	0.2292	22.1048	34.6616
14th	22.16	151.25	129.09	0.2046	4.5344	30.9478
15th	96.45	151.25	54.79	0.1827	17.6218	27.6320
					462.319	713.8236
BCR	1.54		NPW	251.5	IRR	34%

Treatment combination, p_2i_4

Treatment combination, p_2i_4						
Year	Total cost of cultivation	Gross income	Net income	Discounted factor at 12 %	Discounted cost	Discounted benefit
1st	177.83	26.38	-151.45	0.8929	158.7768	23.5576
2nd	16.34	79.15	62.82	0.7972	13.0249	63.1006
3rd	77.84	158.31	80.47	0.7118	55.4038	112.6797
4th	18.40	203.06	184.66	0.6355	11.6941	129.0490
5th	86.05	203.06	117.01	0.5674	48.8276	115.2223
6th	19.50	203.06	183.56	0.5066	9.8798	102.8771
7th	86.05	203.06	117.01	0.4523	38.9251	91.8545
8th	20.24	223.42	203.18	0.4039	8.1750	90.2343
9th	94.66	223.42	128.76	0.3606	34.1339	80.5664
10th	20.24	223.42	203.18	0.3220	6.5171	71.9343
11th	94.66	223.42	128.76	0.2875	27.2113	64.2270
12th	23.48	245.76	222.28	0.2567	6.0255	63.0801
13th	96.56	245.76	149.20	0.2292	22.1289	56.3215
14th	22.27	245.76	223.49	0.2046	4.5559	50.2871
15th	96.56	245.76	149.20	0.1827	17.6410	44.8992
					462.9206	1159.891
BCR	2.51		NPW	696.97	IRR	67%

Treatment combination, p_2i_5

Treatment combination, p_2i_5						
Year	Total cost of cultivation	Gross income	Net income	Discounted factor at 12 %	Discounted cost	Discounted benefit
1st	176.27	19.18	-157.09	0.8929	157.3839	17.1212
2nd	15.14	57.53	42.39	0.7972	12.0663	45.8603
3rd	76.64	115.05	38.42	0.7118	54.5480	81.8934
4th	16.86	147.58	130.72	0.6355	10.7123	93.7904
5th	84.51	147.58	63.07	0.5674	47.9510	83.7414
6th	17.96	147.58	129.62	0.5066	9.0971	74.7691
7th	84.51	147.58	63.07	0.4523	38.2262	66.7581
8th	18.54	162.38	143.83	0.4039	7.4884	65.5806
9th	92.96	162.38	69.42	0.3606	33.5209	58.5541
10th	18.54	162.38	143.83	0.3220	5.9697	52.2805
11th	92.96	162.38	69.42	0.2875	26.7226	46.6790
12th	21.61	178.61	157.01	0.2567	5.5455	45.8454
13th	94.69	178.61	83.92	0.2292	21.7003	40.9334
14th	20.40	178.61	158.22	0.2046	4.1732	36.5477
15th	94.69	178.61	83.92	0.1827	17.2993	32.6319
					452.4047	842.9865
BCR	1.86		NPW	390.58	IRR	45%

Treatment combination, p_3i_1

Treatment combination, p_3i_1						
Year	Total cost of cultivation	Gross income	Net income	Discounted factor at 12 %	Discounted cost	Discounted benefit
1st	179.41	17.59	-161.82	0.8929	160.1875	15.7016
2nd	17.92	52.76	34.84	0.7972	14.2837	42.0578
3rd	79.42	105.51	26.10	0.7118	56.5278	75.1032
4th	20.29	135.34	115.05	0.6355	12.8951	86.0137
5th	87.94	135.34	47.40	0.5674	49.8999	76.7979
6th	21.39	135.34	113.95	0.5066	10.8372	68.5696
7th	87.94	135.34	47.40	0.4523	39.7799	61.2229
8th	22.32	148.91	126.59	0.4039	9.0146	60.1430
9th	96.73	148.91	52.18	0.3606	34.8835	53.6991
10th	22.32	148.91	126.59	0.3220	7.1864	47.9456
11th	96.73	148.91	52.18	0.2875	27.8089	42.8086
12th	25.76	163.80	138.04	0.2567	6.6124	42.0441
13th	98.85	163.80	64.96	0.2292	22.6529	37.5394
14th	24.55	163.80	139.25	0.2046	5.0238	33.5173
15th	98.85	163.80	64.96	0.1827	18.0588	29.9262
					475.652473	773.089876
BCR	1.63		NPW	297.43	IRR	45%

Treatment combination, p_3i_2

Treatment combination, p_3i_2						
Year	Total cost of cultivation	Gross income	Net income	Discounted factor at 12 %	Discounted cost	Discounted benefit
1st	179.41	18.22	-161.19	0.8929	160.1875	16.2715
2nd	17.92	54.67	36.75	0.7972	14.2837	43.5844
3rd	79.42	109.34	29.93	0.7118	56.5278	77.8293
4th	20.29	140.26	119.97	0.6355	12.8951	89.1358
5th	87.94	140.26	52.32	0.5674	49.8999	79.5855
6th	21.39	140.26	118.87	0.5066	10.8372	71.0585
7th	87.94	140.26	52.32	0.4523	39.7799	63.4451
8th	22.32	154.32	132.00	0.4039	9.0146	62.3260
9th	96.73	154.32	57.58	0.3606	34.8835	55.6482
10th	22.32	154.32	132.00	0.3220	7.1864	49.6859
11th	96.73	154.32	57.58	0.2875	27.8089	44.3624
12th	25.76	169.75	143.99	0.2567	6.6124	43.5702
13th	98.85	169.75	70.90	0.2292	22.6529	38.9020
14th	24.55	169.75	145.20	0.2046	5.0238	34.7339
15th	98.85	169.75	70.90	0.1827	18.0588	31.0124
					475.652473	801.151341
BCR	1.68		NPW	325.49	IRR	40%

Treatment combination, p_3i_3

Treatment combination, p_3i_3						
Year	Total cost of cultivation	Gross income	Net income	Discounted factor at 12 %	Discounted cost	Discounted benefit
1st	177.75	14.99	-162.76	0.8929	158.7054	13.3873
2nd	16.26	44.98	28.72	0.7972	12.9619	35.8589
3rd	77.76	89.96	12.20	0.7118	55.3476	64.0338
4th	18.31	115.40	97.08	0.6355	11.6389	73.3362
5th	85.96	115.40	29.43	0.5674	48.7783	65.4788
6th	19.41	115.40	95.98	0.5066	9.8358	58.4632
7th	85.96	115.40	29.43	0.4523	38.8858	52.1993
8th	20.15	126.96	106.82	0.4039	8.1364	51.2785
9th	94.56	126.96	32.40	0.3606	34.0994	45.7844
10th	20.15	126.96	106.82	0.3220	6.4863	40.8789
11th	94.56	126.96	32.40	0.2875	27.1839	36.4990
12th	23.37	139.66	116.29	0.2567	5.9985	35.8473
13th	96.45	139.66	43.21	0.2292	22.1048	32.0065
14th	22.16	139.66	117.50	0.2046	4.5344	28.5772
15th	96.45	139.66	43.21	0.1827	17.6218	25.5154
					462.319	659.1448
BCR	1.43		NPW	196.82	IRR	30%

Treatment combination, p_3i_4

Treatment combination, p_3i_4						
Year	Total cost of cultivation	Gross income	Net income	Discounted factor at 12 %	Discounted cost	Discounted benefit
1st	177.83	18.23	-159.60	0.8929	158.7768	16.2809
2nd	16.34	54.70	38.37	0.7972	13.0249	43.6097
3rd	77.84	109.41	31.57	0.7118	55.4038	77.8744
4th	18.40	140.34	121.94	0.6355	11.6941	89.1875
5th	86.05	140.34	54.29	0.5674	48.8276	79.6317
6th	19.50	140.34	120.84	0.5066	9.8798	71.0997
7th	86.05	140.34	54.29	0.4523	38.9251	63.4819
8th	20.24	154.41	134.17	0.4039	8.1750	62.3622
9th	94.66	154.41	59.75	0.3606	34.1339	55.6805
10th	20.24	154.41	134.17	0.3220	6.5171	49.7147
11th	94.66	154.41	59.75	0.2875	27.2113	44.3882
12th	23.48	169.85	146.37	0.2567	6.0255	43.5955
13th	96.56	169.85	73.29	0.2292	22.1289	38.9246
14th	22.27	169.85	147.58	0.2046	4.5559	34.7541
15th	96.56	169.85	73.29	0.1827	17.6410	31.0304
					462.9206	801.616
.						
BCR	1.73		NPW	338.69	IRR	41%

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Treatment combination, p_3i_5

Treatment combination, p_3i_5						
Year	Total cost of cultivation	Gross income	Net income	Discounted factor at 12 %	Discounted cost	Discounted benefit
1st	176.27	19.63	-156.64	0.8929	157.3839	17.5283
2nd	15.14	58.90	43.76	0.7972	12.0663	46.9507
3rd	76.64	117.79	41.15	0.7118	54.5480	83.8406
4th	16.86	151.09	134.23	0.6355	10.7123	96.0204
5th	84.51	151.09	66.58	0.5674	47.9510	85.7325
6th	17.96	151.09	133.13	0.5066	9.0971	76.5469
7th	84.51	151.09	66.58	0.4523	38.2262	68.3454
8th	18.54	166.24	147.69	0.4039	7.4884	67.1399
9th	92.96	166.24	73.28	0.3606	33.5209	59.9463
10th	18.54	166.24	147.69	0.3220	5.9697	53.5235
11th	92.96	166.24	73.28	0.2875	26.7226	47.7888
12th	21.61	182.86	161.25	0.2567	5.5455	46.9355
13th	94.68	182.86	88.18	0.2292	21.6982	41.9067
14th	20.39	182.86	162.47	0.2046	4.1722	37.4167
15th	94.68	182.86	88.18	0.1827	17.2977	33.4077
					452.4	863.03
BCR	1.91		NPW	410.63	IRR	47%

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Control

Control						
Year	Total cost of cultivation	Gross income	Net income	Discounted factor at 12 %	Discounted cost	Discounted benefit
1st	197.89	13.30	-184.59	0.8929	176.6875	11.8746
2nd	11.39	39.90	28.51	0.7972	9.0800	31.8070
3rd	97.89	79.80	-18.09	0.7118	69.6762	56.7982
4th	12.59	102.36	89.77	0.6355	8.0012	65.0495
5th	107.74	102.36	-5.38	0.5674	61.1346	58.0799
6th	13.69	102.36	88.67	0.5066	6.9358	51.8571
7th	107.74	102.36	-5.38	0.4523	48.7361	46.3009
8th	13.85	112.62	98.77	0.4039	5.5938	45.4843
9th	118.52	112.62	-5.90	0.3606	42.7395	40.6109
10th	13.86	112.62	98.76	0.3220	4.4612	36.2598
11th	118.52	112.62	-5.90	0.2875	34.0717	32.3748
12th	16.45	123.88	107.43	0.2567	4.2226	31.7967
13th	119.78	123.88	4.10	0.2292	27.4505	28.3899
14th	15.24	123.88	108.64	0.2046	3.1187	25.3481
15th	119.78	123.88	4.10	0.1827	21.8834	22.6322
					523.7926	584.6639
BCR	1.12		NPW	60.87	IRR	18%