

Effect of growing media and variety on serpentine layering of black pepper

Thesis

Submitted to the

Uttar Banga Krishi Viswavidyalaya

In partial fulfilment of the requirements for the Degree of

DOCTOR OF PHILOSOPHY

In

Vegetable and Spice Crops

By

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2021

“Behind every young child who believes in himself is a parent who believed first

Dedicated

To

***MY BELOVED PARENTS, DIDI AND FAMILY
AND TO ALL BY BURJA SANTAAN
AND TO ALL THE UBKV FAMILY.***

“Who are and shall remain a part of my heart and soul”

DEPARTMENT OF VEGETABLE AND SPICES CROPS
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CERTIFICATE

This is to certify that the work recorded in the thesis entitled “**Effect of growing media and variety on serpentine layering of black pepper**” submitted by Mr. Adarsh Thapa (H-2015-1-D) in partial fulfilment of the requirements for the degree of *Doctor of Philosophy in Vegetable and Spice Crops* of Uttar Banga Krishi Viswavidyalaya, Pundibari has been checked against plagiarism through **URKUND** software on **06/07/2021** and that the similarity index has been achieved as **07%** (seven per cent) which is below the maximum tolerable range as per stipulation of this Viswavidyalaya. The thesis of **Mr. Adarsh Thapa (Registration Number: H-2015-1-D)** may be accepted for the award of the Doctoral Degree in Department of Vegetable and Spice Crops of Uttar Banga Krishi Viswavidyalaya.

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The assistance and help received during the course of investigation has been duly acknowledged.

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We, the undersigned, have been satisfied with the performance of **Mr. Adarsh Thapa (H-2015-1-D)** in the Viva-Voce Examination on the final evaluation of thesis for award of the degree of **Ph. D. in Vegetable and Spice Crops** conducted today, the 15th September, 2021, recommend that the thesis entitled "**Effect of growing media and variety on serpentine layering of black pepper**" be accepted for the award of the **Doctor of Philosophy** in Vegetable and Spice Crops.

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Acknowledgement

It is my proud privilege to express my deepest sense of gratitude and genuine obligation to my venerable and beloved Chairman of the Advisory Committee, Dr. Suchand Datta, Professor, Department of Vegetable and Spice Crops, Uttar Banga Krishi Viswavidyalaya, for his judicious and affectionate guidance, constructive criticism and unending benevolence during the entire course of the present investigation and finalization of this manuscript.

I express my extreme sense of gratitude and indebtedness to Prof. J.C Jana, respected Head, Department of Vegetable and Spice Crops, Uttar Banga Krishi Viswavidyalaya, along with Dr. Ranjit Chatterjee, Ex. Head, Department of Vegetable and Spice Crops, Uttar Banga Krishi Viswavidyalaya, for providing his precious suggestions, benevolent co-operations and needful help in different stages of my study and for their constant inspiration, valuable suggestions and needful help in carrying out my research programme.

I emphatically express my indebtedness to the respected members of my Advisory Committee Prof. J.C Jana, Department of Vegetable and Spice Crops, Dr. Ranjit Chatterjee, Department of Vegetable and Spice Crops, Prof. Amarendra Nath Dey, Department of Frostery, Prof. Prodyut Kumar Paul, Department of Pomology and Post Harvest Technology and Prof. Suvendu Kumar Roy, Department of Genetics and Plant Breeding for their keen interest, precious suggestions and needful help in different stages of my study.

I am in dearth of words to express my sense of gratitude to my beloved parents Sri Bijay Thapa and Smt. Indira Thapa, my sister Muskan gurung and Brother-in-law Avinash Gurung for their blessings, love, affection and valuable moral support throughout my life always encouraging with their kind words and priceless advice.

I would like to record my special thanks to Assist. Prof. Amrit Tamang and Assit. Prof Rakesh Yonzon and my beloved brothers Avishek Thapa, Sachin Sharma, Binoy Chettri, Sourav Pradhan, Amit Lohar, It. Mohit Subba, Bikash Subba, Anwesh Rai, Albin Lepcha, Norden Lepcha, Manish Roy, Yubu Lepcha, Sandeep Chettri, Remon Saha Choudhury, Biman Maity, Samarash Sahoo, Purn Pokhrel, Kausik Nandi, Suman Golay, Sujit Rai, Ujyol Rai, Biwash Gurung, Punnya Chandra Subba, Sangay Golay, Nim Tshering Sherpa, Tshering Ongchu Lepcha, Choyang Sherpa, Novin Chamling, Safal Rai, Sumiran Chettri, Avinash Giri, Anmol Giri, Tashi Bhutia, Kamal Tamang, Kiran Yonzon, Dev Pradhan, Swadesh Gurung, Zigmi Bhutia, Biswash Poudyal, Bupendra Koya, Mendup Tamang, Ricky Pradhan, Monish Roy, Dawa Bhutia, Diwash Darnal, Sandesh Rai and Birat Raifor their cooperation and encouragement during the course of my study.

I am especially grateful to Mr. Bhola Das and Mrs. Sapna Rava for assisting me in Laboratory works as well as the field workers and staffs of the farm section for their help in carrying out the field experiments.

On a personal note, I wish to express my gratitude and indebtedness to my Burja Santan specially my father, mother sister and Upashna Thapa for their affectionate love, constant encouragement and moral support acting as a premium to my achievement.

Needless to say errors and omissions are mine.

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Title of the Thesis : Effect of growing media and variety on the serpentine layering of Black pepper.
Name of the student : Adarsh Thapa.
Registration number : H-2015-1-D
Name of the Chairman : Dr. Suchand Datta, Professor, Dept. Veg. and Spice Crops.
Degree to be awarded : Doctor of Philosophy in Vegetable and Spice Crops.
Year of Award of Degree : 2021
Total pages in thesis : 97 + 9 pages Bibliography + 39 pages ANOVA tables.

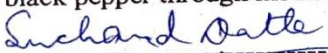
Abstract


Black pepper (*Piper nigrum* L.) is one of the most popular spices in the World. Among the different black pepper growing countries, India is the major producer, exporter and consumer in the World. The present investigations on "Effect of different growing media and varieties on serpentine layering of Black Pepper" was carried out in the polyhouse situated at Instructional Farm, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal during the year 2016-17 and 2017-18. To fulfill the objectives of the research study, total three experiments were undertaken. Experiment - I entitled "Effect of growing media on propagation of black pepper by serpentine" was carried out in Complete Randomized Design with three replications and 10 different growing media. Experiment II (Response of variety for propagation of black pepper by serpentine cutting of layers) and Experiment III (Response of variety for propagation of black pepper by modified serpentine cutting of layers) was carried out in Complete Randomized Design with eight black pepper varieties (viz. Panniyur-1, Panniyur-2, Panniyur-3, Panniyur-6, Panniyur-7, Pournami, Panchami and Subhakara) and each variety replicated thrice.

On the basis of first experiment, it was revealed that different media showed a significant response on black pepper layers with respect to different growth attributes, survivability, number of layers per year and N P K content of different media. Among different treatment, maximum number of planting material was produced (53.67) by the plants under treatment T₁₀ media comprising of top soil + coir pith + vermicompost @ 1:1:1 along with higher number of roots and leaves number and shoot length.

On the basis of second experiment, it was observed that different varieties of black pepper showed significant variations with respect to growth attributing parameters, survivability, number of layers per year and N, P and K content of different media at different time interval. Maximum survivability (93.00 %, 89.83 % and 88.33 %) at 30, 60 and 90 days after cutting of layers was found in Panniyur-1. Maximum planting material per year was produced by Panniyur-1 (51.17) which was higher than the rest of the varieties but was statically *at par* with Panniyur-2 (50.50) and Pournami (50.17). So, these two varieties may be considered for serpentine layer for production of more number of planting materials with higher root and shoot growth.

On the basis of third experiment, it was found that different parameters at different time interval showed positive response and varied significantly among different varieties. Highest growth attributes, survivability, cuttings per year at different time interval was recorded in Panniyur-1 followed by Panniyur-2. Among different varieties Panniyur-1 produce highest number of planting material per year (52.17) followed by Panniyur-2 (50.83) and these varieties may be utilized production planting material of black pepper through modified serpentine layering.


Signature of the Chairman
(Dr. Suchand Datta)
07/10/2021


Signature of the Student
(Adarsh Thapa)
27/7/2021

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INTRODUCTION



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INTRODUCTION

Black pepper (*Piper nigrum* L.) is one of the most popular spices in the World. It has a vast history back to the times of King Solomon (BC 1015-BC 66). This spice has influenced the destiny of nations and their people both economically and culturally. Today, it holds the leading position in trade among different spices in the World. Black pepper is one of the oldest and World most important spices and hence it is called “King of spices”. It belongs to the family Piperaceae.

It is a climbing herbaceous plant and grows to a height of 10 m or more. It has a spreading vine which originates from a stem cutting. Plants form short adventitious roots which connect to surrounding supports and can root easily when trailing stems touch the ground. The leaves are broadly lanceolate but wide variations can be seen in shape and are arranged alternately. It is a native to humid tropical evergreen forests of Western Ghats of India. Black pepper is either grown as pure crop and largely as a mixed crop with arecanut, coffee and tea. Other tree species like Silver oak and *Erythrina indica* are also used as live standards in hill zone of Karnataka.

It is grown in 26 countries including India, Indonesia, Srilanka, Thailand, China, Vietnam, Cambodia, Brazil, Mexico and Guatemala and occupied 4,67,708 hectares with productivity of 790.20 Kg/ha (Kumar and Swarupa, 2017). Among the different black pepper growing countries, India is the major producer, exporter and consumer in the World. In India, Black pepper is widely cultivated as a mixed crop in the coconut and coffee based multilayer cropping system and also in the farmstead gardens to a large extent in Kerala, Karnataka and Tamil Nadu (Muthumanikam, 2003 and Kumar and Swarupa, 2017). Indian spices exports have been able to record stentorian gains in volume and value. During 2017-18, a total of 10.28 lakh tonnes of spices and spice products valued Rs.17,929.55 crores (US\$ 2781.46 Million) has been exported from our country. Out of which, black pepper contributes about 16,840 tons valued Rs. 820.78 crores (Mani and Kabiraj, 2019). USA is the highest importer of black pepper from India. Beside USA, other countries like U.K, Germany, Sweden, Canada, Japan, Netherland, Australia, Franch, Spain, UAE and Turkey used to export from our country.

In India, Black pepper is cultivated in an area of 1,35,920 ha with a production of 64,000 tonnes and productivity of about 471 Kg/ha in India (Directorate of Economic and Statistics Spice Board, 2017-18). More than 90% area of black pepper is mainly concentrated in Kerala, Karanataka and Tamil Nadu. Limited extent it is cultivated in Maharashtra, West Bengal, Andaman and Nicobar Islands and North eastern states. In West Bengal pepper is mainly cultivated in Nadia, Alipurduar, Coochbehar, Jalpaiguri, Dinajpur, Murshidabad, Mednipur, Birbhum districts. In West Bengal it is cultivated in an area of 230 ha with a production of 55 MT and productivity of 239 Kg/ha (Anonymous 2017). In West Bengal, it is grown as mixed or intercrop with coconut or arecanut garden (Sit *et al* 2002 and Pariari *et al* 2002).

Black pepper is a universal spice used to flavour all types of cuisines Worldwide (Srinivasan, 2007). Black pepper is widely used spice in the World and it is an indispensable item in the preparation of processed meat, sauces, soups, curry powders and pickles. The major economic products from pepper are black pepper and white pepper. Other value added products like pepper oil and oleoresin find increasing use in food industries of developed countries. Besides some new forms of pepper like preserve green pepper in brine, vinegar, dehydrated green pepper etc. are becoming more popular. Hence the black pepper is also called as 'Black gold' on account of its economic importance. (Devasahayam *et al* 2010). Piperine is a pungent alkaloid (Tripathi *et al* 1996) that enhances the bioavailability of various structurally and therapeutically diverse drugs. (Khajuria *et al* 2002). Black pepper is also an important traditional medicine and used to treat asthma, chronic indigestion, colon toxins, obesity, sinus, congestion, fever (Ravindran, 2000), intermittent fever, cold extremities, colic, gastric ailments and diarrhoea (Ao *et al* 1998). It has been shown to have antimicrobial activity (Dorman and Deans, 2000). Indian pepper fetches a premium price in major international markets because of its intrinsic quality (Thomos *et al* 2010).

Black pepper can be propagated through seeds and vegetative methods. Owing to its heterozygous nature, seedlings do not breed true to type and known to have long pre-bearing period. Hence, vegetative propagation is commercially adopted. Cuttings taken from runners shoots (Creeping shoots on the ground) and orthotropic shoots (erect growing shoots) from high yielding and healthy plants are used commercially for vegetative propagation.

Establishing a good black pepper garden requires good quality planting materials, But the continuous use of low yielding cultivars, non availability of quality planting materials and losses of plants due to severe incidence of biotic and abiotic stress and also non adoption of appropriate agronomic practices are some of the prominent factors contributing to low productivity of black pepper in India. However, in India the productivity of black pepper is low owing to several constraints associated with its production. Among them non-availability of quality planting material of the improved varieties is of prime importance. The successful establishment and better production of black pepper depends much on the quality of planting material used.

Quality planting material is one of the most important factor and the key to success in agriculture/horticulture crop production. Vegetative propagation through cuttings is commercially practiced, as the seedlings won't breed true to type. The conventional methods adopted for establishment of black pepper have the disadvantage of false sprouting and poor root development, coupled with high disease incidence which eventually leads to poor establishment. Many factors like type of cuttings, season of propagation, rooting media, type of containers etc. have known to influence the rooting of cuttings in plants (Thankamani *et al* 1996 and Sharangi *et al* 2010). Good rooting media along with a suitable container play vital role in rooting and success of nursery plants (Agbo and Omaliko, 2006). Hence, the present investigation was carried out at to study the influence of different media and containers on nursery rising of black pepper cuttings.

Availability of adequate quantity of quality planting material for large scale multiplication is one of the major constraints faced by the pepper industry in increasing the productivity of pepper in India. Use of quality planting material is always an important aspect of black pepper production. The recent developments like, use of growth regulators, media, rapid multiplication techniques are found helpful in solving this problem to an extent. There are various methods for productions of rooted cutting of black pepper but serpentine method have some advantages over other method in rooted cutting production. Serpentine layering technique can be used for production of rooted cuttings of black pepper in a cheap and effective manner. In India, a number of improved varieties of black pepper have been developed from the different research station especially, KAU, Panniyur and IISR, Kozhikode. But very few information is available for multiplication rate of the different improved varieties. In India, among the different

improved varieties Panniyur-1 is cultivated in more than 80% of total area. This is due to non availability of the sufficient planting material of the other varieties.

Various types of materials and mixture of materials are used as media for rooting of cutting. However, there is no ideal potting media for planting cuttings of all the plant species (Hartman *et al* 2007). Appropriate media plays a vital role in plant propagation. Selection of ideal media combination provides good aeration, nutrition and provides sufficient porosity to the propagating material. Beside that an idea potting media also has good water holding capacity and free from pathogens (Gordon, 1992). Very few information is available regarding the serpentine layering, selection of suitable growing media and multiplication rate of the different black pepper varieties in West Bengal. With keeping this view, the present investigation has been outlined with the following objectives with a view to popularize black pepper cultivation in West Bengal.

Objectives

- I. Effect of growing media of serpentine layering on production of quality planting material.
- II. Response of variety on the production of planting material through serpentine layering and modified serpentine layering.



REVIEW OF LITERATURE



REVIEW OF LITERATURE

The information regarding the effect of growing media of serpentine layering on production of quality planting material of black pepper and response of variety on the production of planting material through serpentine layering and modified serpentine layering particularly in Northern parts of West Bengal was lacking. Literature on the work done so far on, different propagation methods and rooting media of black pepper and related crops had been reviewed hereunder.

2.1 Reviews on propagation of black pepper and related crops

Comparison between conventional and advance multiplication method showed that the highest success rate of black pepper cuttings was achieved by use of split bamboo method for rapid multiplication in black pepper for commercial production (IISR, 2002)

Khandekar *et al* (2004) conducted a field experiment to study rapid multiplication of black pepper (*Piper nigrum*) on soil mound at Dapoli (Maharashtra). They found that the vines in soil mound method exhibited superior performance with respect to length and root production node. The availability of cuttings from soil mound method was also the highest. The rooting percentage of cuttings obtained from soil mound and bamboo methods were significantly superior over traditional method of propagation. Planting base material at 15 cm spacing on soil mound was also the best and produced more runners' shoots per unit area as compared to other spacing treatments and traditional method. They also found that Panniyur-1 propagated through serpentine method comprising of media soil + sand + FYM 1:1:1 produced 54.16 number of planting material.

Thankamani *et al* (2004) conducted an experiment to study the production techniques for healthy rooted cutting of black pepper. They reported that number of healthy rooted cuttings can be produced by cheaper techniques (viz. rapid multiplication method, trench method and serpentine method) and in shorter period of time than a conventional method.

Basak *et al* (2014) laid out a trial to study the new techniques for adventitious rooting and clonal propagation of *Piper longum* through leaf cutting at the institutional nursery of Regional Plant Resource Centre, Bhubaneswar, Odisha India and they concluded that *Piper longum* can be regenerate through leaf cutting without use of hormone treatment and production of planting

material through leaf cutting can be substitute traditional propagules such as sucker, vine cutting, etc. They also reported that apical portion of leaf produced 8.57 numbers of roots whereas petiolar portion recorded 8.73 numbers of roots at 60 days after cutting.

Bhuyan *et al* (2015) carried out an experiment to study proper multiplication method for black pepper propagation at Spices Research Bangladesh Agricultural Research Institute (BARI), Jaintiapur Bangladesh. They reported that longest vine, maximum nodes per vine were found from soil mound method, similarly the roots produced per node, root production and number of branches per vine were superior over other methods in both the years respectively. Similarly the number of cuttings available per harvest, number of cuttings per year and maximum success percentage of cutting was showed in soil mound method. They found that total plant material production per year 54.00 through bamboo split method under Bangladesh condition.

Prajapati (2015) conducted an experiment on effect of plant growth regulators on rooting of cutting in Black pepper (*Piper nigrum* L.) cv. Panniyur-1 under protected cultivation under Navsari, Gujarat condition and he observed that number of leaves in Panniyur-1 black pepper variety was 8.87 at 90 days after planting of cutting.

Hanumanthappa *et al* (2016) carried out a field experiment to study rapid multiplication techniques of black pepper (*Piper nigrum* L.) on bamboo split method, soil mound method and serpentine method at costal district of Karnataka. Evaluation of different rapid multiplication techniques were carried out during that experiment and they concluded that the soil mound method was best for rapid multiplication of black pepper over other methods tested in year of study. This method might be recommended to produce more quality planting material of black pepper to meet the planting material requirement of farmer under Udupi district of Karnataka. They also reported survival percentage of 89.75 % in Panniyur-4 through soil mound method.

Nybe *et al* (2016) reported that serpentine layering is a plant vegetative propagation method which is basically a modification of ordinary plant layering method which is practice in plants possessing a long stem. This technique is used for production of rooted cutting of black pepper in effective and in a cheap manner. Serpentine layering is basically practices in long and flexible plants. Serpentine method can be followed throughout the year. It is simple, cheap, quick

and suited to small and marginal farmers. Recovery percentage is higher compared to rapid multiplication techniques.

Modified serpentine method is a modified form of serpentine method of plant propagation. Modified serpentine method is an advance propagation method which is basically used in long and flexible plants. Method used for modified serpentine layering is similar to serpentine layering but here in this modified form of serpentine layering mother plants are planted in a well prepared seed bed and with the vines of the mother plants begins to grow than the stem are pegged in a bed within an each node and pegged with the help bamboo peg. In about 10-14 days the stem will have grown roots and the individual's plants are separated (Nybe *et al* 2016).

Serpentine method is a rapid multiplication technique which is generally used for quick and easy multiplication of black pepper vines. Serpentine layering is usually practice for production of black pepper cuttings in an effective and cheap manner (Prasath *et al* 2016).

Sundhariya *et al* (2016) conducted an experiment to study standardization of propagation techniques in thippili (*Piper longum*) at Tamil Nadu Agriculture University, Coimbatore. The experiment consisted of three types of cuttings viz., basal middle and terminal and three types of growth regulators viz., IBA and NAA @ 500 and 1000 ppm alone and in combination and control (distilled water). During that experiment they found that highest number of roots, root length, shoot length and survival percent were recorded by basal cuttings treated with IBA @1000 ppm.

Waman *et al* (2019) carried out a field experiment at central Island Agriculture Research Institute Port Blair, Andaman and Nicobar Island to study the standardization of vegetative propagation techniques in *Piper sarmentosum* for further utilization. Effect of single, double and triple node stem cuttings along with pre-treatments of indole-3 butyric acid (0, 500 and 1,000 mg/litre) was studied. Further, effect of retention or removal of leaves from stem cutting was also studied. During that experiment they recorded 7.80 numbers of roots and root length of 19.40 cm at 60 days after cutting and concluded that stem cutting with two nodes was optimum for propagation of this medicinally important species.

2.2 Reviews on rooting media used for black pepper and related crops

Villapando (1984) carried out an experiment to study different types of black pepper cutting and growing media on yield of black pepper. They found that cutting rooted on coir dust medium gave the highest yield of 25.56 g followed by garden soil and river sand with mean yield of 77.86 and 0.73 g, respectively. The difference in yield was highly significant among the rooting media used.

Cabangbang (1988) conducted an experiment to study the percentage rooting of black pepper cutting as affected by different media, length of cutting and leaf defoliation. They found that higher percentage rooting was obtained in a media of pure sand (85 to 87 %) followed by sand mixed with chicken dung at a ratio of 2:1 (79%). Low rooting success of 72 % was obtained in soil medium of sand + Fertilizer. Single node cutting with or without leaf gave higher rooting success (83 to 87%) than two nodal cutting (75%). Defoliation caused higher rooting success (87%) than non-removal of leaf (73%).

Uddin and Hossain (1989) carried out a field trial to evaluate the different methods of raising vine cuttings of black pepper. Cutting was taken from the central leader of 15 year old mother plants of the *Piper nigrum* cv. Jaintipur were rooted in a soil bed, clay pots and polythene bags. Clay pots and polythene bags contained a 50:50 mixture of soil and FYM. Cuttings in clay pots were established in 39 days compared with 57.7 and 59.0 days in soil bed and equal in clay pots and polythene bags. For local use of rooted cuttings, soil bed method was recommended but for further distribution to growers the pot and bag methods were preferred.

Shridhar *et al* (1990) studied rooting of 4-node cuttings taken from one year old vines of cv. Panniyur-1 and planted in polyethylene bags (20 cm x 12 cm) filled with soil, sand, FYM or a mixture of two of these in equal proportions. Twenty cuttings were used for each treatment. The bags were kept in the shade and irrigated regularly. 2, 3 and 4 node cutting gave similar results with 1-node cutting being inferior. The highest rooting percentage (30.90 %), vine length (12.70 cm) and number of leaves/cuttings (4.0) were obtained with the sand + FYM rooting medium followed by sand alone. Singh and Shivadhar (1989) also reported that planting of 2-node cutting in sand + FYM (50:50) produced maximum rooting and subsequent development. Bogantes (1989) tested six substrates as rooting media for black pepper cuttings, wherein lowest

mortality with better root growth was observed in soil + Bio-rigi + sawdust (1:1:1) and soil + sand (1:1) combinations.

Rooting media recorded a vital role in rooting of cuttings. In general soil, sand and FYM/Compost in 2:1:1 ratio was recommended. The best performance was obtained from FYM, sand, soil (1:1:1) and soil + leaf mould (7:3) rooting media (Yufdi and Hayani, 1991).

Thankamani *et al* (1996) laid out an experiment to investigate the response of clove seedlings and black pepper cuttings to propagating media under nursery conditions at Indian Institute of Spice Research, Calicut. They found that vermicompost had a positive effect on parameters like plant height and number of leaves after three and six months of growth. The height of the cutting planted in vermicompost and in potting mixture containing soil, sand and farm yard manure (3:3:1) was recorded 137.63 and 10.4cm after six months of growth. The number of leaves produced after 3 to 6 months of growth was also recorded higher 6.20 and 20.07 in cuttings raised in vermicompost compared to these raised in potting mixture (3.26 and 8.10), respectively.

Srinivasan and Hamza (2000) reported that decomposed coir compost (Terra Care) could be successfully substituted for soil or sand in conventional nursery mixture (soil + sand + FYM @ 1:1:1). They also found that soil + decomposed coir compost in 80:20 ratio with small quantity of diammonium phosphate could also replace sand or FYM in nursery mixture in spice nursery.

Boateng and Asare (2001) found that the rooting media did not significantly affect the production of sprouts but survival rate of developed seedlings was higher in top soil and the mixture of top soil and river sand than cuttings set in river sand alone. Environment and rooting media each had significant interaction with nodal positions.

Norman and Edward (2005) reported that among the different growing media, media containing vermicompost is a rich source of minerals and plant nutrients and its addition to media boost quality of media by escalating microbial activity and microbial biomass which were vital factor in nutrition chain.

Sit *et al* (2005) carried out a field experiment to evaluate the suitable soil mixture for rotting of black pepper vines in bamboo method of rapid multiplication and during that

experiment they observed that the mixture containing top soil, sand and vermicompost at a ratio of 1:1:1 was found to be the best for rooting of black pepper followed by the mixture containing equal ratio of top soil and coir pith and the mixture containing equal ratio of top soil and FYM. Similarly, the percentage of recovery was maximum in the mixture containing top soil, sand and vermicompost (1:1:1). Using this rooting mixture about 60 numbers of black pepper rooted cuttings can be obtained annually from a single vine in three harvests.

In an experiment concluded by Bedasso (2006) and reported that rooting percentage of black pepper cutting was highly significantly affected by the types of growth media used in this study. The highest rooting percentage was recorded from fine sand (63.3%), followed by 1:1 mixture of Fine sand + Forest soil (51.9%) and 1:1:1 mixture of Fine sand + Forest soil + PDCH (Partially decompose coffee husk) (51.4%). However, the highest percentage of sprouted cutting was recorded from 1:1 mixture of Fine sand + Forest soil while the least was obtained from Sole PDCFI (Partially decompose coffee husk) under Ethiopia condition.

Satapathy *et al* (2006) carried out an experiment to study the performance of different rooting media for production of quality rooted cuttings of black pepper under Assam condition. Among the eight treatments tried, the mixture of sand, soil, FYM in 1:1:1 proportion amended with one gram of *Trichoderma viridae* per kg of rooting media was significantly superior in terms of morphological growth, suppression of disease incidence, survival percentage and growth parameters, followed by sand + soil + vermicompost in 1:1:1 proportion amended 10 grams of neem cake per kg of rooting media and sand + soil + vermicompost in 1:1:1 proportion drenched with 0.2 percent Blitox (copper oxychloride) in comparison to the other treatments.

Kumar *et al* (2006) conducted a field experiment to evaluate the effect of coffee pulp compost and vermicompost as potting media on growth and vigor of the seedlings of three cash crops (Cardamom, bush pepper and vanilla) under Karnataka condition. The treatment comprised the mixing of FYM, coffee pulp compost and vermicompost differently with sand and forest soil in 1:1:1 proportion (33% each). During that experiment, they found that germination percentage of bush pepper varied from 50.67 % to 60.0 % in different media. After six month period, buds produce approximately 17 cm length with four leaves. It was revealed that coffee pulp compost was the most suitable potting medium as it performed good growth and vigour on cardamom, vanilla and bush pepper seedlings. It also envisaged better recycling of waste available.

Thankamani *et al* (2007) conducted a trial to investigate the possibility of using soil-less medium containing coir pith compost and granite powder for raising black pepper cutting in the nursery at Peruvannamuzhi (Kerala). During that experiment they found that plant height, leaf production, leaf area and total dry matter production were significantly higher in the media consisting of coir pith compost and granite powder in 1:1 proportion along with *Azospirillum sp.* and *Phosphor bacteria* as nutrient source whereas the cost of production of rooted cuttings was cheaper in the media consisting of coir pith compost, granite powder and FYM in 2:1:1 proportion compared to conventional potting mixture (soil + Sand + FYM 2:1:1).

Thankamani *et al* (2008) evaluation of solarized potting mixture (soil + sand + FYM @ 2:1:1) in combination with nutrient and bio-control agents on growth of rooted cuttings of black pepper in nursery was carried out at Indian Institute of Spice Research, Calicut. The result indicated that solarized potting mixture recorded more number of leaves, increased root length compared to plant raised in non solarized potting media. Leaf area and dry matter were also superior in solarized media compared non solarized media.

Sharangi *et al* (2010) conducted an experiment at Nadia KVK Farm, Gayeshpur, Bidhan Chandra Krishi Viswavidyalaya, West Bengal and during that experiment they found that the growing media had significant influence on the survivability of vine cutting of black pepper though the preliminary observation on survivability after 15 days of cutting showed higher value, the same reduced with time and the lowest values were observed at 60 days after cutting irrespective of growing media. However, the treatments sand + soil + FYM + coir pith (1:1:1:2) and sand + soil + FYM + coir pith (1:1:1:1) at 15, 30, 45 and 60 days after cutting, respectively were found to produce the maximum survived seedlings.

Smitha (2010) studies on the organic cultivation and propagation of long pepper and stevia were carried out at Department of Horticulture, UAS, GKVK, Bengaluru. During that experiment they found that cutting treated with *Trichoderma viridae* raised on soil, sand and vermicompost media (1:1:1) in green house condition were superior in terms of growth attributing characters and exhibited good field establishment.

In an experiment, Saranraj and Stella (2012) reported that application of vermicompost and coir pith in the soil contributes to increase in available phosphorous.

In an experiment, Prasath *et al* (2014) studied the effect of different combinations of soil-less coir pith based nursery mixtures on rooting and growth of black pepper cuttings in the nursery Indian Institute of Spices Research, Kozhikode. Among the different nursery media combination, coir pith with *Trichoderma* and vermicompost recorded significantly higher growth parameters. The study confirmed that composted coir pith with vermicompost and *Trichoderma* was an ideal potting medium for black pepper nursery. They also reported that also reported that maximum numbers of leaves were recorded in potting mixture comprising of coir pith and vermicompost.

Akshay *et al* (2014) conducted an experiment to study the effect of different rooting media under greenhouse conditions at University of Agriculture and Horticulture Sciences, Shimoga, Karnataka. They found that the cuttings raised in the media comprising soil + sand + FYM + vermicompost (1:1:1:1) significantly increased the different shoot parameters of cuttings such as, days to sprout, number of leaves per cutting, length of shoot, percentage of sprouting, fresh and dry weight. Root parameters such as, minimum days to rooting (33.07 days), higher percentage of rooting (80%), higher number of primary roots (11.07), maximum 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 soil + sand + FYM + coir dust (1:1:1:1).

Akshay *et al* (2016) an experiment was laid out to study the effect of growth regulators and media on rooting of black pepper (*Piper nigrum* L.) cuttings at ZAHRS, Mudigere, Karnataka. They reported that black pepper can be multiplied easily by growing cuttings in the media comprising soil + sand + FYM + vermicompost (1:1:1:1) in poly house condition and as an alternative, media comprising of coir pith can also be used in the places where vermicompost was costly and not easily available.

Ramya *et al* (2017) carried out an experiment to study suitable rooting conditions for the production of bush pepper and during that experiment they observed that the largest number of laterals established where coir pith compost in 8 cm x 5 cm black nursery bags and kept under humid chamber (63.3 %) followed by coir pith compost in 19 inch x 8 inch transparent LDPE bags, planted the cuttings and tied the mouth for retaining humidity (60.8%). In both the cases the planting medium used was coir pith compost. They reported that coir pith compost could be

used as medium for rooting and establishment of laterals for large scale production of bush pepper.

Leormando *et al* (2018) carried out an experiment to study the propagation of *Piper hispidum* through leaf cutting under Brazil condition. During that experiment they found that *Piper hispidum* can be propagated through leaf cutting in a potting mixture comprising soil + sand (1:1) without additions of growth promoting substances.

Sharath and Bhoomika (2018) laid an experiment to study the influence of root trainer and rooting media on root and shoot growth of black pepper (*Piper nigrum* L.) at Mudigere, Karnataka. During that experiment they observed that the root parameters were superior in the cuttings raised in root trainers compared to that of poly bags. The treatment (soil + perlite + vermicompost @ 2:1:2) recorded highest rooting percentage (80.50 %) in root trainer compared to poly bag (78.00%). Root volume was found maximum in the root trainer (6.25 cm³) compared to the poly bag (5.5 cm³) in the treatment (Soil + perlite + FYM @ 2:1:2). The treatment (Soil + perlite + vermicompost @ 2:1:2) recorded early sprouting of cuttings (20.90 days) and maximum sprouting percent (84.00) in root trainers.

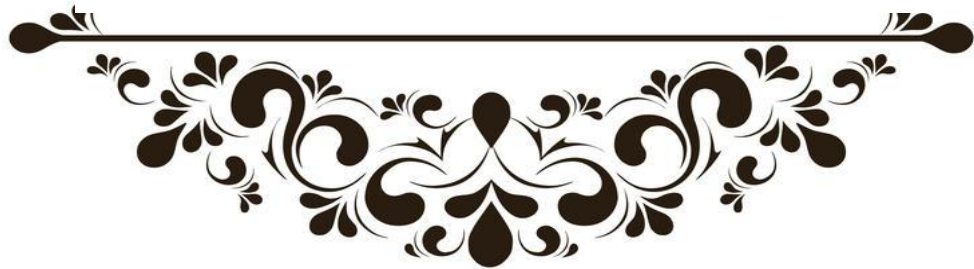
Akshay *et al* (2018) conducted an experiment at ZAHRS, Mudigere, Karnataka to study the optimum concentration of growth regulators and different types of media to induce rooting in black pepper cuttings under greenhouse conditions. Result revealed that the cuttings treated with proven growth regulator concentration (IBA 1000 ppm) was raised in the media comprising soil + sand + FYM + vermicompost (1:1:1:1 v/v) significantly increased the different shoot parameters of cuttings such as, days to sprout, number of leaves per cutting, length of shoot, percentage of sprouting, fresh and dry weight and root parameters such as, minimum days to rooting, higher percentage of rooting, higher number of primary roots, maximum fresh and dry weight of roots. Hence the study proved that, the cuttings treated with growth regulator IBA 1000 ppm concentrations and raised in rooting media of soil + sand + FYM + vermicompost (1:1:1:1 v/v) were proven best for propagating Black pepper cuttings.

Shantha *et al* (2018) carried out a field trial at Betel Research Station, Dampalassa Srilanka to investigate a fast growing method of betel vine for producing stem cutting with different planting media and during that trial they found that incorporation of coconut husk chips

enhance plant growth and the highest number of stem cuttings per pot can be produced. Beside that coir dust incorporation also appeared to be beneficial as the second best alternative.



MATERIALS AND METHODS



MATERIALS AND METHODS

The present investigations on “Effect of different growing media and varieties on serpentine layering of Black Pepper” was carried out in the polyhouse situated at the Instructional Farm, Uttar Banga Krishi Vishwavidyalaya, Pundibari, Cooch Behar, West Bengal during the year 2016-17 and 2017-18. Different materials and methods followed and the statistical techniques adopted during the course of investigation have been described in this chapter. Field site and soil characteristics, experimental designs, treatments and their combinations and all other information relevant to supplement the accomplishments have been elaborated categorically in a systematic manner.

3.1 Experimental Site

3.1.1 Location

Experiments were conducted in the polyhouse situated at the Instructional Farm of the Faculty of Horticulture, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India. Geographically the farm is situated at 26^o19'86" N latitude and 89^o23'53" E longitude, at an elevation of 43 meter above mean sea level. The area lies under the *Terai* agro climatic zone of West Bengal.

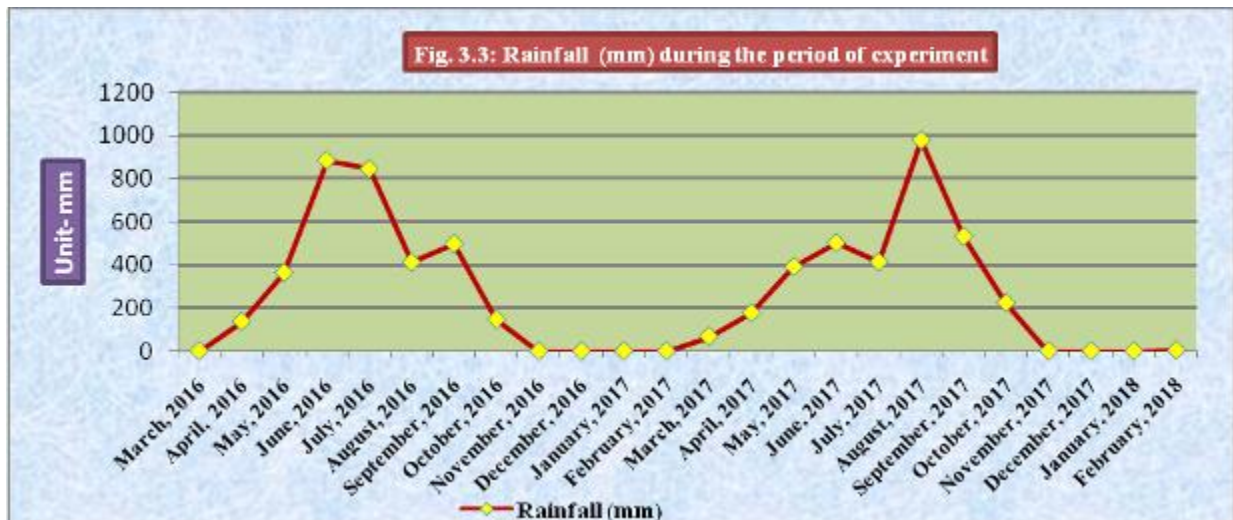
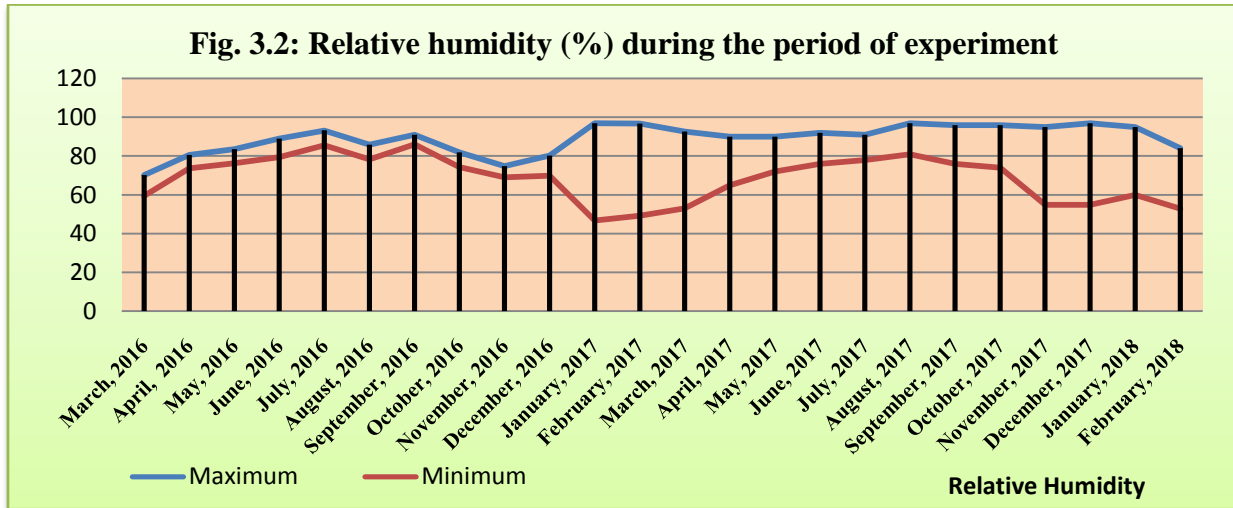
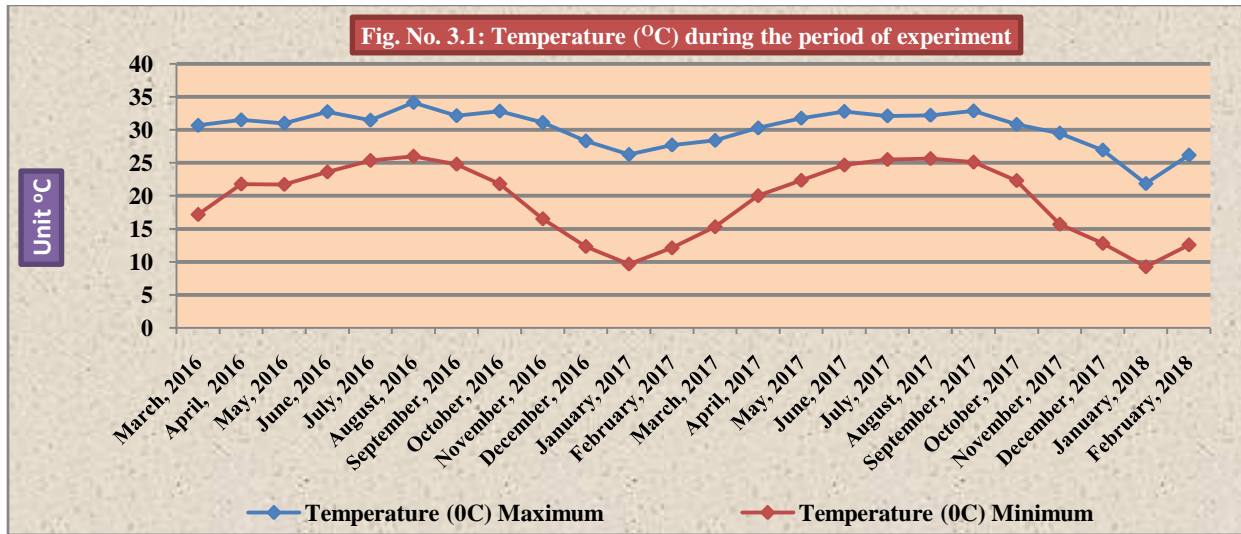
3.1.2 Agro-climatic conditions

Agro-climatically, experimental site falls under the terai zone of West Bengal. The climatic condition of terai zone is characterized by high rainfall (above 3000 mm annually), high relative humidity, moderate temperature, prolonged winter with high residual soil moisture. The crop growing season of this zone are broadly classified as dry and warm summer starting from March to May (*Pre-Kharif*), (wet and warm) monsoon starting from May to October (*Kharif*) and (dry and cool) winter starting from November to February (*Rabi*). A heavy rainfall occurs during the monsoons and winter rainfall from October to mid November is very low. The temperature range of this area varies from minimum of 7 - 8° C to maximum of 24 - 33.2° C with high relative humidity of 50 % to 70 % expect from February to May. The meteorological data for maximum and minimum temperature (°C), relative humidity (%) and rainfall (mm) recorded during the crop growing season (2016-17 and 2017-18) are presented in Table 3.1 and Fig 3.1 to 3.3.

Table 3.1 Metrological parameters during the period of experiment

Month	Temperature (⁰ C)		Relative Humidity (%)		Rainfall (mm)
	Maximum	Minimum	Maximum	Minimum	
March, 2016	30.69	17.17	70.16	59.52	0.03
April, 2016	31.52	21.78	80.57	73.80	137.60
May, 2016	31.02	21.72	83.61	76.42	364.80
June, 2016	32.77	23.61	88.97	79.43	886.20
July, 2016	31.48	25.35	93.26	85.65	846.20
August, 2016	34.16	25.99	85.90	78.42	412.85
September, 2016	32.16	24.79	91.07	86.10	498.20
October, 2016	32.85	21.81	82.00	74.32	147.70
November, 2016	31.13	16.52	74.83	69.10	0.00
December, 2016	28.32	12.32	80.32	69.97	0.00
January, 2017	26.28	9.66	97.00	46.84	0.00
February, 2017	27.71	12.11	96.86	49.25	0.00
March, 2017	28.41	15.30	92.74	53.06	67.70
April, 2017	30.30	20.01	90.00	65.00	177.70
May, 2017	31.78	22.34	90.00	72.00	391.60
June, 2017	32.80	24.66	92.00	76.00	502.50
July, 2017	32.12	25.49	91.00	78.00	413.10
August, 2017	32.22	25.64	97.00	81.00	979.50
September, 2017	32.88	25.10	96.00	76.00	532.40
October, 2017	30.84	22.31	96.00	74.00	224.50
November, 2017	29.51	15.69	95.00	55.00	0.00
December, 2017	26.94	12.78	97.00	55.00	0.00
January, 2018	21.86	9.25	95.00	60.00	0.00
February, 2018	26.18	12.57	84.00	53.00	3.80

Source: GKMS Project, AMFU-Pundibari, UBKV.



3.1.3 Soil Character

The topography of the land of the experimental site was medium to high in situation. The soil was sandy loam in nature, coarse in texture, poor in water holding capacity with low pH. The composite soil samples from the entire experimental field were collected and analyzed before layering, In order to know the physical and chemical properties of the soil of experimental site. Physio-chemical properties of the experimental soil (Table No. 3.2) and chemical properties (Table No. 3.3) of different rooting media were presented in the tabular form.

Table3.2: Physio-chemical properties of the experimental soil.

Parameters	2016-17	2017-18	Methods employed
Physical properties			
Sand (%)	65.11	64.87	International pipette method (Piper, 1966)
Silt (%)	18.67	18.72	
Clay (%)	16.22	16.41	
pH	6.12	5.95	pH meter (Jackson, 1967)
Chemical properties			
Organic carbon (%)	0.93	0.93	Rapid titration method (Walkley and Black, 1934)
Available nitrogen (Kg/ha)	192.56	199.25	Modified Macro Kjeldahi method (Jackson, 1967)
Available phosphorus (Kg/ha)	46.61	49.25	Bray's No. 1 Method (Jackson, 1967)
Available potassium (Kg/ha)	94.52	96.37	Flame photometer method (Jackson, 1973)

Table 3.3: Chemical properties of different rooting media:

Nutrient composition	Vermicompost		Coir pith		FYM		Methods employed
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	
Organic carbon	11.88%	11.95%	29.00%	29.43%	10.71%	10.73%	Rapid titration method (Walkley and Black, 1934)
Nitrogen	1.22%	1.25 %	0.26%	0.26%	0.54%	0.57%	Modified Macro Kjeldahi method (Jackson, 1967)
Phosphorous	1.13 %	1.11 %	0.01%	0.02%	0.29%	0.30%	Vanadomolybdophosphoric yellow coloured method (Jackson, 1967)
Potassium	1.16 %	1.18 %	0.78%	0.80%	0.40%	0.43%	Flame photometer method (Jackson, 1973)

3.2 EXPERIMENTAL DETAILS

Three experiments were carried out in the polyhouse situated at the experimental Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar. The experimental work was categorized under three experiments i.e. Experiment I, Experiment II and Experiment III to fulfil the objectives of the research study. Details of the experiments are given below.

3.2.1 Experiment I: Effect of growing media on propagation of black pepper by serpentine layering

Design of the experiment: Complete Randomized Design

Replications: 3

Treatments: 10 growing media

T₁: Top soil

T₂: Top soil + sand (1:1)

T₃: Top soil + Coir pith (1: 1)

T₄: Top soil + FYM (1: 2)

T₅: Top soil + FYM (1: 1)

T₆: Top soil + coir Pith + FYM (1: 1: 1)

T₇: Top soil + Vermicompost (1:2)

T₈: Top soil + Sand + FYM (1:1:1)

T₉: Top soil + Sand + Vermicompost (1: 1:1)

T₁₀: Top soil + Coir pith + vermicompost (1:1:1)

Year of study: 2016-17 and 2017-18

Time of planting: 3rd week of March for both the year

Variety: Panniyur-1

Number of layering per treatment per replication: 100

3.2.2 Experiment II: Response of variety for propagation of black pepper by serpentine layering

Design of the experiment: Complete Randomized Design

Replications: 3

Treatments: 8 varieties of black pepper

Varieties: Panniyur-1

Panniyur -2
Panniyur-3
Panniyur-6
Panniyur-7
Pournami
Panchami
Subhakara

Year of study: 2016-17 and 2017-18

Time of planting: 3rd week of March for both the year

Media: Soil + Sand + FYM (1:1:1)

Number of layering per treatment per replication: 100

3.2.3 Experiment III: Response of variety for propagation of black pepper by modified serpentine layering

Design of the experiment: Complete Randomized Design

Replications: 3

Treatments: 8 varieties of black pepper

Varieties: Panniyur-1

Panniyur -2

Panniyur-3

Panniyur-6

Panniyur-7

Pournami

Panchami

Subhakara

Year of study: 2016-17 and 2017-18

Time of planting: 3rd week of March for both the year.

Media: Soil + Sand + FYM (1:1:1).

Number of layering per treatment per replication: 100

3.3 Source of the varieties

The source of the different varieties used for the present experiment are enlisted in the Table-3.4

Table 3.4: Source of the black pepper varieties

Name	Source
Panniyur-1	ICAR-IIISR, Calicut, Kerala
Panniyur-2	ICAR-IIISR, Calicut, Kerala
Panniyur-3	ICAR-IIISR, Calicut, Kerala
Panniyur-6	ICAR-IIISR, Calicut, Kerala
Panniyur-7	ICAR-IIISR, Calicut, Kerala
Pournami	ICAR-IIISR, Calicut, Kerala
Panchami	ICAR-IIISR, Calicut, Kerala
Subhakara	ICAR-IIISR, Calicut, Kerala

3.4 SERPENTINE LAYERING AND MODIFIED SERPENTINE LAYERING

3.4.1 Serpentine Layering

Serpentine layering is a plant vegetative propagation method which is basically a modification of ordinary plant layering method which is practice in plants possessing a long stem (Thankamani *et al* 2004). This technique is used for production of rooted cutting of black pepper in effective and in cheap manner. Serpentine layering is basically practices in long and flexible plants. Firstly untangled the plant from its climbing frame and tease out the stems and choose a healthy long shoot for propagation wound the long stem. Place plastic packets filled with potting mix near the mother plant and push the each node into the potting mix and peg them with the help of bamboo sticks and firm down potting mix to secure and bend the stem to the next plastic packet. In about 10-14 days the stem will have grown roots and the individual's plants are separated.

3.4.2 Modified Serpentine Layering

This method is a modified form of serpentine method of plant propagation. In this method long vines are allowed to creep on the bed made up of suitable potting media. In this method vines are allowed to strike root on the bed and when it reaches the end of the bed, entire strips is harvested and each rooted nodes are separated individually in poly bags filled with potting media for further establishment. The separation of nodes can also be done when the

entire vines is trailing on the bed. After activation of buds it can be separated and planted in poly bags for further establishment (Nybe *et al* 2016 and Anandraj *et al* 2014).

3.5 Preparation of mother plant

Semi-hardwood cutting of 3 years old black pepper var. Panniyur-1 for Experiment-I and eight different varieties of black pepper (viz. Panniyur-1, Panniyur-2, Panniyur-3, Panniyur-6, Panniyur-7, Pournami, Panchami and Subhakara) for experiment II and III have been prepared and kept in a poly bag filled with potting mixture of top soil + sand + FYM (@ 1:1:1) for rooting to served as base material.

100 mother plants were prepared and replicated thrice for all the experiments. Among rooting media, there were ten treatments used singly or in combination. In case of Experiment I and II as the layer produces nodes, poly bags of size 15 cm × 10 cm filled with 10 different potting mixture (Experiment-I) as mentioned above and a poly bags filled with top soil + sand + FYM (Experiment-II) were kept under each node for producing roots and this process was repeated continuously as the vine elongates.

In case of experiment-III mother plants were kept at the bottom of well prepared seed bed sized 10 m x 1.5 m as the vine elongated each node are clipped in a bed with the help of bamboo pegs. When the plant consists of 10-15 rooted nodes then single node cuttings are taken and planted in a poly bad comprising mixture of top soil + sand + FYM (1:1:1). This process was repeated continuously as the vine elongates.

Different sizes of poly packets were used for the process of serpentine layering and modified serpentine layering. For maintaining mother plant the packet size was 20 cm X 15 cm and for the layers the packet size was 15 cm × 10 cm. The packets were filled with different growing media with the help of spade or by hand.

3.6 Intercultural operations

3.6.1 Irrigation

Irrigation was done as per the visual observations, before the drying of growing media used for different treatment combination. Generally this operation was done with the help of rose can or by misting as per the requirement of water for different growing media.

3.6.2 Weeding

Weeding was done in every week with the help of hand by uprooting the weeds from the poly packets.

3.6.3 Plant Protection Measures

Different plant protection measures were taken for healthy seedling production through different layering methods. Blitox @ 3 g/litre and mancozeb @ 2.5g/litre were applied in rotation basis in every 30 days interval and in case of rainy season it was done in every 15 days interval.

3.7 Collection of planting materials

In case of serpentine method as the plant start to elongate, poly bags of size 15 cm × 10 cm filled with potting mixture were kept under each node for producing roots and this process was repeated continuously. When the plant reaches up to 15 poly bags than the terminal buds are nipped off and cutting of rooted nodes were taken and separated individually.

In case of modified serpentine method when the plant reaches the length of 1.5 m, the terminal bud is nipped off and then rooted node cuttings were taken and separated individually in poly bags.

3.8 OBSERVATION RECORDED

Three experiments were carried out in the Polyhouse situated at the experimental Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar. Observations on various root and shoot characters were recorded up to 90 days after cutting. Ten random samples were taken to observe various roots and shoot characters after 0, 30, 60 and 90 days after cuttings of layers. Among the four batches of planting material each year only first batches of planting material data was recorded.

3.8.1 Number of Planting Material Production

Number of planting material production was recorded by counting number of layers obtained throughout the year. In case of serpentine method when the vine of mother plant covers 15 poly bags than rooted poly bags were separated individually.

In case of modified serpentine method, when the vines of mother plant reaches the length of 1.5 m than each rooted cuttings were separated individually in a poly bags filled with potting

media. These processes were done four times for serpentine and modified serpentine method in a year to recorded total number of planting material produce.

3.8.2 Length of layers (cm)

The length of the layers was measured from the ground level to the tip of the main shoot at 30, 60 and 90 days after layering. Average height was measured with the help of measuring scale and recorded in centimetres.

3.8.3 Number of leaves

Leaves were counted at 30, 60 and 90 days after layering from ten randomly selected plants and recorded as number of leaves per plant.

3.8.4 Root length (cm)

Root length at different intervals was taken at initial, 30, 60 and 90 days after cuttings of ten randomly selected plants and average root length was calculated and recorded in centimetres.

3.8.5 Number of roots

Number of roots at different interval was counted at initial, 30, 60, 90 days after cuttings of ten randomly selected plants.

3.8.6 Survival percentage (%)

Survival percentage of cuttings was taken at different interval 30, 60 and 90 days after cutting.

Survival percentage = Number of plants at initial time – Number of plant died after the stipulated time / Number of plant at initial time X 100.

3.8.7 Plant fresh weight and dry weight (g)

Fresh weights of randomly taken ten plant samples were measured through electronic weighing balance and after proper drying the dry weight of the same were measured at initial, 30, 60 and 90 days after layering.

3.8.8 Crop Growth Rate (g/day)

Crop growth rate is a measure of the increase in size, mass or number of crop over a period of time (Fisher 1921). It was calculated using the following formula:

$$\text{CGR} = \frac{w_2 - w_1}{t_2 - t_1}$$

Where, w_2 and w_1 are dry weight of whole plant at time t_1 and t_2 respectively.

3.9.9 Procedure of estimation of residual nutrient content in soil after 90 days after planting:

3.9.9.1 Available N content in soil (Kg/ha)

Available N content in soil (kg per ha) was determined by Modified Kjeldahl method, as described by Jackson (1967).

3.9.9.2 Available P content in soil (Kg/ha)

Available P content in soil (kg per ha) was determined by Olsen method, as described by Jackson (1967).

3.9.9.3 Available K content in soil (Kg/ha)

Available K content in soil (kg per ha) was determined by Flame photometer method, as described by Jackson (1973).

3.9.9.4 Total number of planting material Production:

Total number of layers obtained per year was recorded.

3.10 Procedure of estimation of available nutrient content in different rooting media (other than soil)

3.10.1 Nitrogen content (Kg/ha)

1 g of samples was transferred in Kjeldahl flask after weighing. After that, added 20 ml of sulphuric acid-salicylic acid mixture and swirled gently and kept for overnight (Jackson, 1967). Next day, 5 g of sodium thiosulphate was added into the flask. 10 g of sulphate mixture is added into the flask and digested on the Kjeldahl apparatus until the solution is cleared. after that digested sample were cooled and distilled water was added to make a volume to 100 ml. after that 10 ml of digested samples were transferred to a vacuum jacket of micro-Kjeldahl distillation. After that 10 ml of boric acid containing bromocresol green and methyl red indicator were poured gently in a conical flask and then aliquot and 10 ml of NaOH solution was added. After that 5 ml aliquot was distilled into a flask containing 10 ml of boric acid. After completion of distillation, the boric acid was triturated until purple colour starts appearing.

3.10.2 Phosphorous content (Kg/ha)

Estimation of phosphorous was determined by Vanado molybdo phosphoric yellow coloured method using spectrometer (Jackson, 1967).

3.10.3 Potassium content (Kg/ha)

Samples for estimation of potassium are digested by diacid (it is carried out by using a 9:4 mixture of HNO₃:HClO₄) through wet ashing (Jackson, 1973). Firstly digested samples were diluted in a suitable concentration range lies between 0 to 5 ppm. After that reading of sample was carried out in flame photometer at 548 nm wave length.

3.11 Statistical Analysis

3.11.1 Analysis of variance

The analysis of variance (ANOVA) table was set as explained by Gomez and Gomez (1984).

Source of variation	Degree of freedom	Sum of square	Mean square	F value
Replication (r)	r-1	S _r	S _r /r-1=Mr	Mr/Me
Genotypes (g)	g-1	S _g	S _g /g-1=Mg	Mg/Me
Error	(r-1) (g-1)	S _e	S _e /(r-1) (g-1)=Me	

Where, Mr = mean square due to replications Mg = mean square due to genotypes Me= mean square due to error

The calculated F values were compared with table F value for testing of the significance. Standard error and critical difference were calculated to find out the superiority of one genotype over the other, with the help of following formula:

$$SE(m)_{\pm} = \sqrt{(Me/r)}$$

$$SE(d)_{\pm} = 2\sqrt{(Me/r)}$$

$$CD = SE(d) \times 't' \text{ value at error degrees of freedom}$$

Where,		
't'	=	table value at 5% level of probability for error degree of freedom
SE(m) _±	=	standard error of mean
SE(d) _±	=	standard error of difference

Further analysis of characters for other genetic parameters was done when there were significant differences among genotypes.



SERPENTINE METHOD (Experiment-I)



SERPENTINE METHOD (Experiment-II)



MODIFIED SERPENTINE METHOD (Experiment-III)

Plate 1-Different methods of layering on black pepper



RESULTS AND DISCUSSION



RESULTS AND DISCUSSION

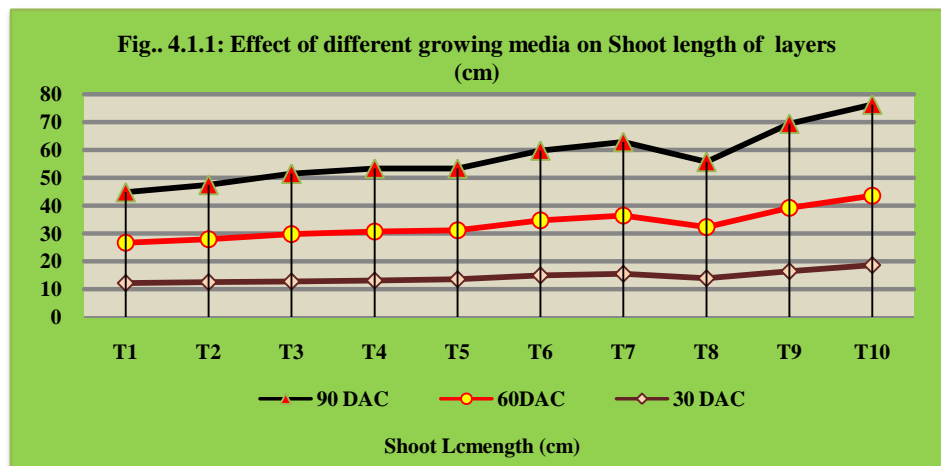
The field experiment entitled “Effect of growing media and variety on serpentine cutting of layers of Black pepper” was carried out in the polyhouse situated at the Instructional Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal during the year 2016-17 and 2017-18. To fulfil the objectives of the research study, total three experiments were undertaken i.e. Experiment I (Effect of growing media on propagation of black pepper by serpentine cutting of layers), Experiment II (Response of variety for propagation of black pepper by serpentine cutting of layers) and Experiment III (Response of variety for propagation of black pepper by modified serpentine cutting of layers). Results obtained in the different experiments with respect to the different parameters are presented and discussed in this chapter.

4.1 Experiment I

Experiment was carried out to study the effect of different growing media on serpentine cutting of layers of black pepper during the consecutive year 2016-17 and 2017-18 under Pundibari, Cooch Behar, West Bengal condition. The result recorded during this experiment has been presented and discussed in this chapter under appropriate headings.

4.1.1 Shoot length of layer (cm)

The data arranged in a tabular form (Table 4.1.1 and Fig. 4.1.1) indicated that the various growth media had a significant influence on the shoot length of black pepper at the various time intervals (30, 60 and 90 days after cutting of layers). Maximum shoot length of layer



was observed in treatment T₁₀ (Top soil + coir pith + vermicompost @ 1:1:1) with 18.65 cm, 24.90 cm and 32.72 cm at 30, 60 and 90 days after cutting of layers, respectively. Treatment T₉ (Top soil + sand + vermicompost @ 1:1:1) proceeded with a value of 16.48 cm, 22.72 cm and 28.62 cm at 30, 60 and 90 days after cutting of layers, respectively. As a whole, it showed a

Table 4.1.1 Effect of different growing media on shoot length of layers

Shoot length of layers (cm)									
Treatment	30 days after cutting			60 days after cutting			90 days after cutting		
	2016-17	2017-18	Pooled	2016-18	2017-18	Pooled	2016-17	2017-18	Pooled
T ₁	12.13	12.88	12.51	14.27	16.63	15.45	17.97	20.63	19.30
T ₂	11.87	12.47	12.17	13.47	15.53	14.50	17.43	19.00	18.22
T ₃	11.65	13.90	12.78	14.90	19.20	17.05	19.62	23.62	21.62
T ₄	11.70	14.47	13.08	15.25	19.88	17.57	20.93	24.48	22.71
T ₅	12.83	14.33	13.58	16.08	19.07	17.58	20.83	23.62	22.23
T ₆	14.43	15.47	14.95	18.25	21.30	19.78	23.83	26.27	25.05
T ₇	15.11	16.02	15.56	19.40	22.35	20.88	25.17	27.70	26.43
T ₈	13.02	15.00	14.01	16.13	20.73	18.43	22.92	25.52	24.22
T ₉	15.93	17.02	16.48	21.45	23.98	22.72	26.70	30.53	28.62
T ₁₀	17.70	19.60	18.65	23.82	25.98	24.90	32.64	32.80	32.72
SE(m) ±	0.62	0.77	0.70	0.83	0.83	0.77	1.27	0.90	1.08
C.D. (P=0.05)	1.83	2.27	2.01	2.44	2.47	2.20	3.76	2.67	3.09

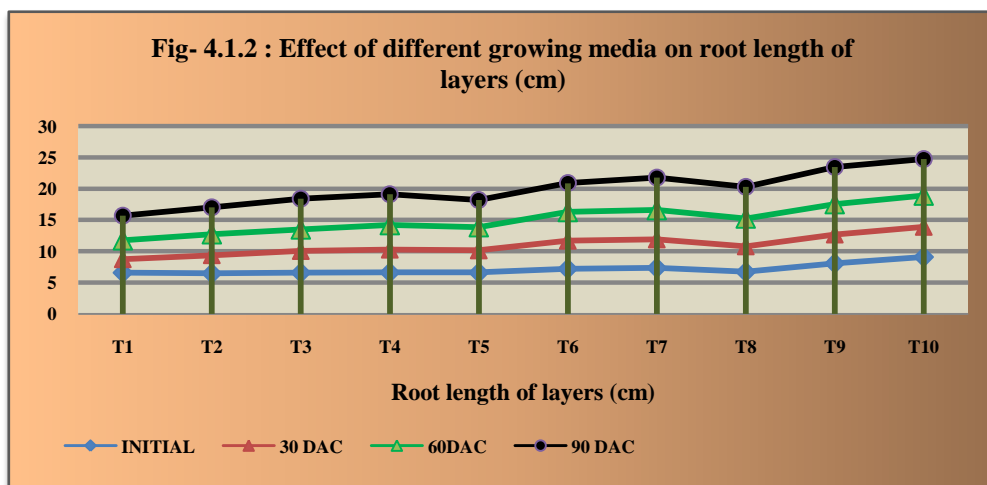
T₁: Top soil, T₂: Top soil + sand(1:1), T₃: Top soil+ Coir pith(1:1), T₄: Top soil + FYM(1:2), T₅: Top Soil + FYM(1:1), T₆: Topsoil + coir pith + FYM(1:1:1), T₇:Top soil + Vermicompost(1:2), T₈: Top soil + sand + FYM(1:1:1), T₉: Top soil + sand + vermicompost(1:1:1), T₁₀: Top soil + coir pith + vermicompost(1:1:1).

difference of 29.85 % with T₁₀ and 16.65 % with T₉ when compared to control media T₈ (Top soil + sand + FYM @ 1:1:1) at 90 days after cutting of layers. On the other hand, treatment T₂ (Top soil + sand @ 1:1) showed less influence on the shoot length with a minimum value of 12.17 cm, 14.50 cm and 18.22 cm followed by treatment T₁ (Top soil) with 12.51 cm, 15.45 cm, 19.30 cm at 30, 60 and 90 days after cutting of layers, respectively.

Among different growing media, the highest result concerning shoot length of a layer was recorded in treatment T₁₀ (Top soil + coir pith + vermicompost @ 1:1:1) which was followed by T₉ (Top soil + sand + vermicompost @ 1:1:1) might be due to the presence of a perceivable quantity of nutrients and growth-promoting substances in vermicompost as well as good aeration and good water holding ability provided by incorporation of well decomposed coir pith in a potting mixture which also helped in better utilization of stored carbohydrate, nitrogen and other factors. A more or less similar result was also reported by Akshay *et al* (2014).

4.1.2 Root length of layers (cm)

Data pertaining to root length of black pepper layers at different time intervals (initial, 30, 60 and 90 days after cutting of layers) as influenced by different growth media have been presented in (Table 4.1.2 and Fig. 4.1.2). The



observations revealed that treatment T₁₀ (Topsoil + coir pith + vermicompost @ 1:1:1) recorded the highest root length at different time intervals i.e. at initial stage (9.08 cm), 30 days (13.89 cm), 60 days (18.89 cm), and 90 days (24.73 cm) after cutting of layers. Treatment T₉ (Top soil + sand + vermicompost @ 1:1:1) also recorded maximum root length of 8.07 cm, 12.66 cm, 17.53 cm and 23.47 cm at initial, 30 days, 60 days and 90 days after cutting of layers, respectively. A difference of 19.77 % was recorded in T₁₀ treatment comprising of growing media topsoil + coir pith + vermicompost @ 1:1:1 compared with control media i.e. T₈ treatment containing

Table 4.1.2 Effect of different growing media on root length of layers

Root length of layers (cm)												
Treatment	Initial			30 days after cutting			60 days after cutting			90 days after cutting		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T ₁	6.23	6.93	6.58	8.47	10.23	9.35	11.53	13.88	12.71	15.60	18.42	17.01
T ₂	6.02	6.90	6.46	8.20	9.22	8.71	10.67	12.82	11.74	14.13	17.20	15.67
T ₃	6.15	7.01	6.58	9.23	10.81	10.02	12.38	14.58	13.48	17.17	19.63	18.40
T ₄	6.14	7.08	6.61	9.57	10.91	10.24	13.07	15.28	14.18	17.73	20.45	19.09
T ₅	6.12	7.07	6.59	10.33	11.20	10.77	12.87	14.82	13.84	16.70	19.70	18.20
T ₆	6.77	7.63	7.20	9.40	10.84	10.12	16.00	16.53	16.27	19.90	21.85	20.88
T ₇	6.83	7.85	7.34	11.35	12.40	11.88	16.17	16.98	16.58	21.27	22.30	21.78
T ₈	6.25	7.15	6.70	11.20	12.13	11.67	14.87	15.58	15.23	19.75	20.80	20.28
T ₉	7.78	8.35	8.07	12.43	12.89	12.66	17.19	17.87	17.53	22.93	24.00	23.47
T ₁₀	8.42	9.75	9.08	13.27	14.51	13.89	18.27	19.52	18.89	23.77	25.70	24.73
SE(m) ±	0.43	0.45	0.44	0.56	0.75	0.59	1.02	0.70	0.87	0.81	0.80	0.80
C.D. (P=0.05)	1.28	1.32	1.26	1.65	2.22	1.70	3.03	2.07	2.51	2.41	2.37	2.30

T₁: Top soil, T₂: Top soil + sand(1:1), T₃: Top soil+ Coir pith(1:1), T₄: Top soil + FYM(1:2), T₅: Top Soil + FYM(1:1), T₆: Topsoil + coir pith + FYM(1:1:1), T₇:Top soil + Vermicompost(1:2), T₈: Top soil + sand + FYM(1:1:1), T₉: Top soil + sand + vermicompost(1:1:1), T₁₀: Top soil + coir pith + vermicompost(1:1:1).

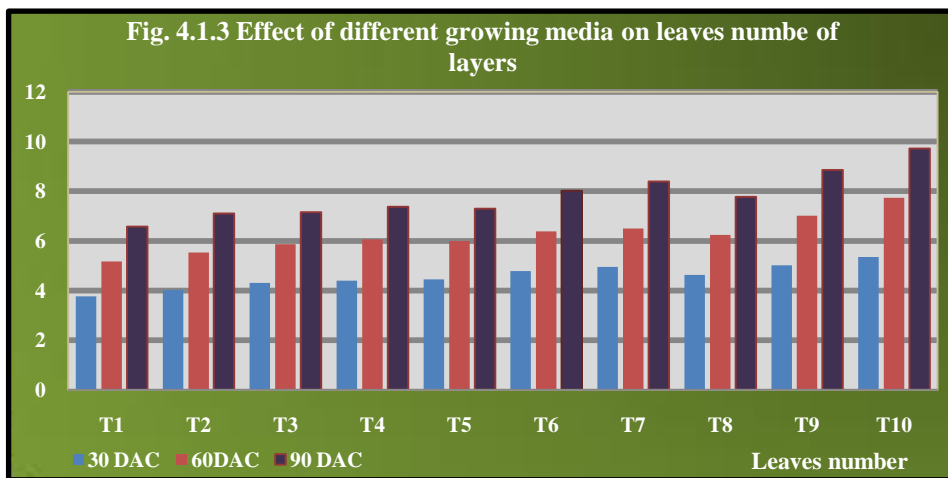
top soil + sand + FYM @ 1:1:1 at 90 days after cutting of layers. On the other hand, treatments comprising of top soil + sand @ 1:1 (T₂) recorded the lowest root length of 6.46 cm, 8.71 cm, 11.74 cm and 15.67 cm at initial, 30 days, 60 days and 90 days after cutting of layers respectively, followed by T₁ (Top soil 1:1) with a value of 6.58 cm, 9.35 cm, 12.71 cm and 17.01 cm at initial, 30 days, 60 days and 90 days after cutting of layers, respectively.

From the above mentioned result, it was apparent that the highest root length was observed in layers under the treatment T₁₀ comprising of top soil + coir pith + vermicompost @ 1:1:1 which might be due to the incorporation of coir pith which provides better texture and porosity to the media that later facilitated easy dispersion of roots. Adding coir pith in mixture also contributes high specific surface due to its low particle density and high water holding capacity (Akshay *et al* 2014). Vermicompost is a rich source of minerals and plants nutrients and its addition to media boosts the quality of media by escalating microbial activity and microbial biomass which is a vital factor in the nutrition chain (Norman and Edward 2005).

4.1.3 Number of leaves

The number of leaves of black pepper layers was recorded at 30 days, 60 days and 90 days after cutting of layers which have been depicted in table 4.1.3 and fig. 4.1.3. It was found

that during 30 days, 60 days and 90 days after cutting of layers treatment T₁₀ (Top soil + coir pith + vermicompost @ 1:1:1) recorded the maximum number of leaves 5.35, 7.73 and



9.73 respectively, followed by T₉ (Top soil + sand + vermicompost @ 1:1:1) with 5.02 (30 days after cutting of layers), 7.01 (60 days after cutting of layers) and 8.85 (90 days after cutting of layers). Whereas, treatment T₂ (Top soil + sand @ 1:1) recorded the lowest number of leaves with a value of 3.77 (30 days after cutting of layers), 5.18 (60 days after cutting of layers) and 6.58 (90 days after cutting of layers) followed by layers grown under treatment T₁ (Top soil) with

Table 4.1.3 Effect of different growing media on number of leaves of layers

Numbers of leaves									
Treatment	30 days after cutting			60 days after cutting			90 days after cutting		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T ₁	3.73	4.32	4.03	4.73	6.32	5.53	6.52	7.68	7.10
T ₂	3.27	4.27	3.77	4.13	6.22	5.18	6.00	7.15	6.58
T ₃	3.62	4.98	4.30	4.73	7.00	5.87	6.83	7.48	7.16
T ₄	3.80	5.00	4.40	5.07	7.05	6.06	6.82	7.92	7.37
T ₅	3.87	5.03	4.45	4.93	7.05	5.99	6.98	7.60	7.29
T ₆	4.00	5.57	4.78	5.27	7.48	6.38	7.60	8.45	8.03
T ₇	4.57	5.33	4.95	5.52	7.48	6.50	7.87	8.92	8.39
T ₈	4.07	5.20	4.63	5.13	7.35	6.24	7.08	8.45	7.77
T ₉	4.22	5.82	5.02	6.03	7.98	7.01	8.30	9.40	8.85
T ₁₀	4.78	5.92	5.35	6.63	8.83	7.73	9.17	10.28	9.73
SE(m) ±	0.28	0.38	0.37	0.35	0.41	0.38	0.32	0.45	0.39
C.D. (P=0.05)	0.82	1.11	1.05	1.05	1.23	1.09	0.95	1.35	1.11

T₁: Top soil, **T₂**: Top soil + sand(1:1), **T₃**: Top soil+ Coir pith(1:1), **T₄**: Top soil + FYM(1:2), **T₅**: Top Soil + FYM(1:1), **T₆**: Topsoil + coir pith + FYM(1:1:1), **T₇**:Top soil + Vermicompost(1:2), **T₈**: Top soil + sand + FYM(1:1:1), **T₉**: Top soil + sand + vermicompost(1:1:1), **T₁₀**: Top soil + coir pith + vermicompost(1:1:1).

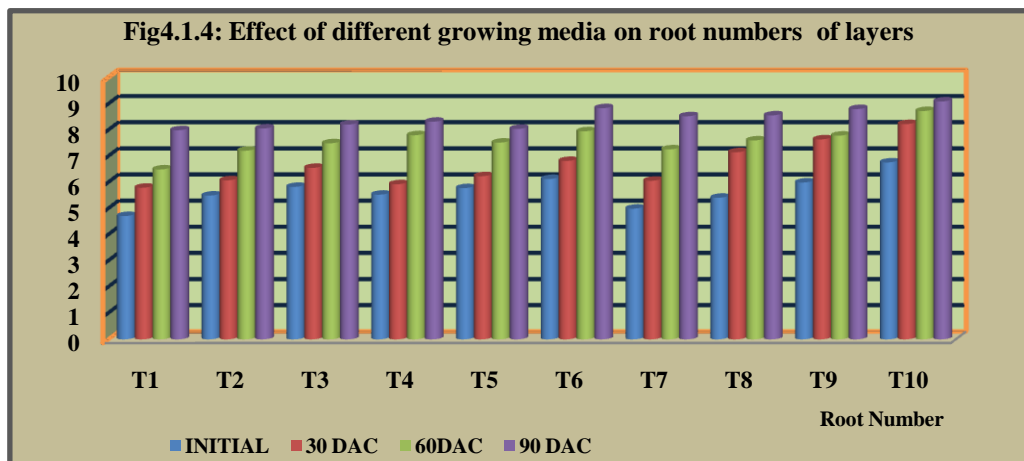
4.03, 5.53 and 7.10 at 30, 60 and 90 days after cutting of layers, respectively.

It is clear that among different media, a higher number of leaves have been recorded with treatment T₁₀ comprising of top soil + coir pith + vermicompost @ 1:1:1 which might be due to the better physiochemical properties of vermicompost and coir pith. In addition to that vermicompost is also said to be a source of plant growth regulators and contains nutrients in the readily available form which might have contributed towards the vegetative growth of leaves. Prasath *et al* (2014) also reported that maximum numbers of leaves were recorded in a potting mixture comprising of coir pith and vermicompost. Thankamani *et al* (1996) also reported that black pepper cuttings raised in a mixture of well decompose coir pith and vermicompost were significantly taller and had more number of leaves than cutting raised in the conventional mixture.

4.1.4 Number of roots

Data illustrated in table 4.1.4 and fig. 4.1.4 with regards to the number of roots clearly indicated that, at an initial stage, 30 days, 60 days and 90 days after cutting of layers, the maximum

number of roots per plant (6.77, 7.03, 7.90, and 8.93, respectively) was observed in treatment T₁₀ with growing



media comprising of top soil + coir pith + vermicompost @ 1:1:1 followed by treatment T₉ growing media comprising with top soil + sand+ vermicompost (1:1:1) with a value of 6.00 cm, 6.65 cm, 7.41 cm and 8.21 cm at initial, 30 days, 60 days and 90 days after cutting of layers, respectively.

The maximum number of the roots was observed in a media, soil mixed with vermicompost and coir pith it might be due to the better texture and porosity of coir pith (Singh *et al* 2002), presence of growth promoting substances in vermicompost and sufficient amount of

organic matter supply from the soil for better growth and development of layered plants. Subsequently, treatment T₂ (top soil + sand @ 1:1) showed the minimum number of roots i.e., 4.72 (initial stage), 4.80 (30 days after cutting of layers), 5.38 (days after cutting of layers) and 5.78 (90 days after cutting of layers). Minimum number of roots was also observed in treatment T₁ with the numerical values of 5.33 (initial stage), 5.46 (30 days after cutting of layers), 5.68 (60 days after cutting of layers) and 6.13 (90 days after cutting of layers).

4.1.5 Fresh weight of layers (g)

Data on fresh weight of black pepper layer at different time intervals have been presented in table 4.1.5. Results indicated that the different growing media had a prominent effect on fresh weight of black pepper layers at a different time interval (At initial, 30 days, 60 days and 90 days after cutting of layers). A perusal of the data revealed that the fresh weight of layers varied significantly among the different growing media for both the year as well as pooled analysis. Treatment T₁₀ comprising of top soil + coir pith + vermicompost @ 1:1:1 recorded maximum fresh weight of layer at the different time intervals (9.55 g at initial stage, 15.88 g at 30 days after cutting of layers, 23.23 g at 60 days after cutting of layers and 29.08 g at 90 days after cutting of layers, respectively). T₉ treatment recorded the second highest fresh weight of layers at initial stage (9.28 g), 30 days after cutting of layers (14.54 g), 60 days after cutting of layers (21.34 g) and 90 days after cutting of layers (27.03 g) which was statistically *at par* with T₁₀. The lowest fresh weight of layer was recorded under T₂ treatment (Top soil + sand) with a value of 7.04 g, 10.20 g, 14.65 g and 19.80 g at initial stage, 30 days, 60 days and 90 days after cutting of layers respectively which was statistically *at par* with T₁ treatment (Top soil) with a value of 7.12 g, 10.78 g, 15.66 g and 20.18 g at the initial stage, 30 days, 60 days and 90 days after cutting of layers, respectively.

The fresh weight of the plant reflects the root and shoots parameters of the layers recorded (Akshay *et al* 2018). Therefore, treatment T₁₀ showed better results concerning root and shoot parameters and recorded higher fresh weight of layers, whereas treatment T₁ showed the lowest result for roots and shoot parameters and recorded minimum fresh weight of the layer at different time intervals.

Table 4.1.4 Effect of different growing media on number of roots of layers

Treatment	Number of roots											
	Initial			30 days after cutting			60 days after cutting			90 days after cutting		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T ₁	4.93	5.72	5.33	4.50	6.42	5.46	4.57	6.78	5.68	5.58	6.67	6.13
T ₂	4.00	5.43	4.72	4.23	5.37	4.80	4.20	6.55	5.38	5.32	6.25	5.78
T ₃	5.20	5.32	5.26	4.90	6.97	5.93	4.63	7.75	6.19	5.90	7.63	6.77
T ₄	5.00	5.68	5.34	4.30	6.32	5.31	4.33	6.70	5.52	5.65	6.67	6.16
T ₅	5.13	5.92	5.53	4.63	6.60	5.62	5.20	6.93	6.07	5.38	8.05	6.72
T ₆	5.60	4.92	5.26	5.23	7.17	6.20	5.78	7.55	6.67	6.45	7.70	7.08
T ₇	4.33	5.22	4.78	4.50	6.38	5.44	6.08	7.13	6.61	6.65	7.58	7.12
T ₈	4.87	5.97	5.42	5.57	6.75	6.16	5.13	8.33	6.73	6.12	7.47	6.79
T ₉	5.33	6.67	6.00	6.00	7.30	6.65	6.47	8.35	7.41	7.20	9.22	8.21
T ₁₀	6.00	7.53	6.77	6.63	7.43	7.03	7.00	8.80	7.90	8.27	9.60	8.93
SE(m) ±	0.26	0.28	0.27	0.27	0.34	0.31	0.44	0.35	0.40	0.29	0.42	0.36
C.D. (P=0.05)	0.77	0.84	0.81	0.82	1.01	0.92	1.31	1.05	1.18	0.87	1.24	1.06

T₁: Top soil, T₂: Top soil + sand(1:1), T₃: Top soil+ Coir pith(1:1), T₄: Top soil + FYM(1:2), T₅: Top Soil + FYM(1:1), T₆: Topsoil + coir pith + FYM(1:1:1), T₇:Top soil + Vermicompost(1:2), T₈: Top soil + sand + FYM(1:1:1), T₉: Top soil + sand + vermicompost(1:1:1), T₁₀: Top soil + coir pith + vermicompost(1:1:1).

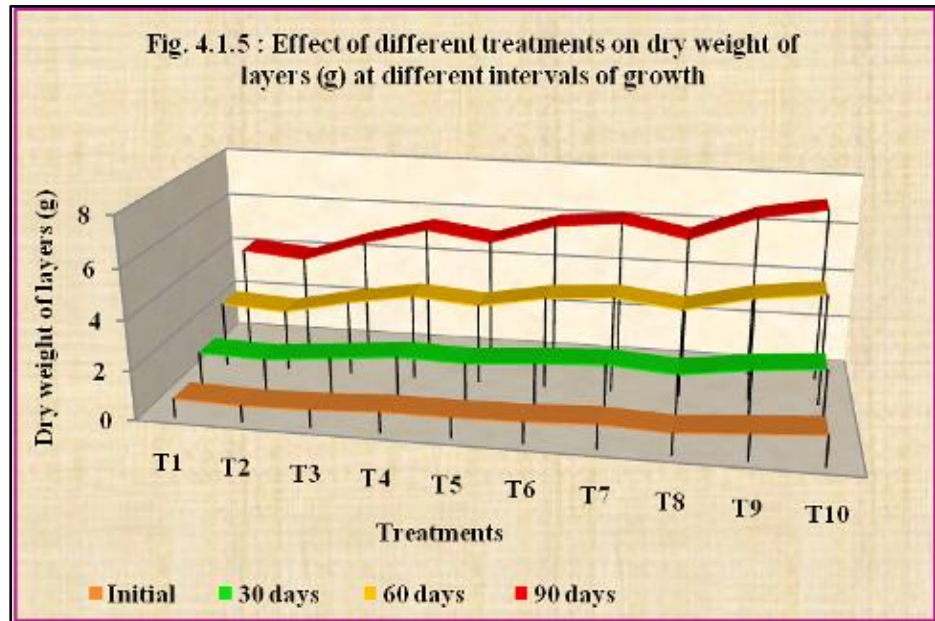
Table 4.1.5 Effect of different growing media on fresh weight of layers

Treatment	Fresh weight of layers (g)											
	Initial			30 days after cutting			60 days after cutting			90 days after cutting		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T ₁	6.92	7.32	7.12	10.08	11.48	10.78	14.70	16.61	15.66	20.88	19.49	20.18
T ₂	6.78	7.29	7.04	9.45	10.94	10.20	13.90	15.40	14.65	18.95	20.65	19.80
T ₃	7.00	8.02	7.51	10.67	11.74	11.21	15.62	17.49	16.56	21.80	22.33	21.07
T ₄	7.94	8.38	8.16	11.50	13.39	12.45	17.02	18.93	17.97	21.62	24.66	23.14
T ₅	7.62	8.57	8.10	11.31	12.73	12.02	16.33	18.18	17.26	22.59	21.73	22.16
T ₆	7.85	8.82	8.34	13.08	13.57	13.33	19.12	21.27	20.19	23.18	24.94	24.06
T ₇	8.53	9.05	8.79	13.97	14.37	14.17	20.25	21.02	20.63	24.73	26.86	25.79
T ₈	7.95	8.88	8.42	12.04	13.4	12.72	17.61	19.60	18.61	24.37	25.17	24.77
T ₉	8.78	9.77	9.28	14.33	14.75	14.54	21.77	22.64	21.34	27.59	26.53	27.03
T ₁₀	9.27	9.82	9.55	15.67	16.08	15.88	22.99	24.14	23.23	29.48	28.67	29.08
SE(m) ±	0.62	0.60	0.55	0.52	0.82	0.64	0.87	0.90	0.86	1.07	0.90	0.97
C.D. (P=0.05)	1.82	1.78	1.57	1.54	2.43	1.84	2.6	2.66	2.47	2.99	2.67	2.79

T₁: Top soil, T₂: Top soil + sand(1:1), T₃: Top soil+ Coir pith(1:1), T₄: Top soil + FYM(1:2), T₅: Top Soil + FYM(1:1), T₆: Topsoil + coir pith + FYM(1:1:1), T₇:Top soil + Vermicompost(1:2), T₈: Top soil + sand + FYM(1:1:1), T₉: Top soil + sand + vermicompost(1:1:1), T₁₀: Top soil + coir pith + vermicompost(1:1:1).

4.1.6 Dry weight of layers (g)

Data regarding the dry weight of layers have been presented in table 4.1.6 and fig. 4.1.5. indicated that T₁₀ treatment comprising growing media with top soil + coir pith + vermicompost @ 1:1:1 was found superior (1.48 g, 2.53 g, 4.09 g and 6.05 g of dry weight of layers at initial stage, 30 days, 60 days and 90 days after cutting of layers,



respectively) than the rest of the growing media which was statistically *at par* with T₉. Black pepper layers grown under treatment T₉ (top soil + sand + vermicompost @ 1:1:1) also recorded higher dry weight of layer at the different time intervals (1.31 g at initial stage, 2.46 g at 30 days after cutting of layers, 3.82 g at 60 days after cutting of layers and 5.64 g at 90 days after cutting of layers). The lowest dry weight of layers (0.93 g, 1.48 g, 2.25 g and 3.37 g at initial stage, 30 days, 60 days and 90 days after cutting of layers, respectively) was recorded in the plant grown under the growing media of top soil and sand @ 1: 1 (T₂) which was statistically *at par* with T₁. Layers grown under top soil (T₁) also recorded lowest dry weight of 1.02 g at initial stage, 1.56 g at 30 days after cutting of layers, 2.40 g at 60 days after cutting of layers and 3.66 g at 90 days after cutting of layers, respectively.

Treatment T₁₀ (top soil + coir pith + vermicompost @ 1:1:1) showed the best outcome for root and shoot parameters and the plant under treatment T₁ (Top soil + sand @ 1:1) reflected the lowest result for both the root and shoot parameters. Certainly, the plants under treatment with better root and shoot parameters have shown higher dry weight of the plant, whereas the plant under treatment with the least roots and shoot parameters had shown the least dry weight of the plant

Table 4.1.6 Effect of different growing media on dry weight of layers

Dry weight of layers (g)												
Treatment	Initial			30 days after cutting			60 days after cutting			90 days after cutting		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T ₁	0.99	1.04	1.02	1.55	1.56	1.56	2.47	2.33	2.40	3.85	3.46	3.66
T ₂	0.85	1.00	0.93	1.44	1.51	1.48	2.27	2.22	2.25	3.42	3.31	3.37
T ₃	0.89	1.05	0.97	1.71	1.71	1.71	2.9	3.5	3.20	4.76	4.52	4.64
T ₄	0.99	1.22	1.11	1.91	2.41	2.16	3.32	3.36	3.34	4.92	5.08	5.00
T ₅	1.02	1.17	1.10	1.87	1.83	1.85	3.04	3.48	3.26	4.72	4.87	4.80
T ₆	1.05	1.21	1.13	2.11	2.11	2.11	3.72	3.61	3.67	5.51	5.35	5.43
T ₇	1.16	1.33	1.25	2.25	2.11	2.18	3.92	3.61	3.77	5.61	5.48	5.55
T ₈	1.12	1.22	1.17	2.02	1.94	1.98	3.51	3.44	3.48	5.14	5.28	5.21
T ₉	1.23	1.39	1.31	2.48	2.43	2.46	3.96	3.68	3.82	5.64	5.63	5.64
T ₁₀	1.40	1.56	1.48	2.36	2.69	2.53	4.01	4.17	4.09	6.09	6.01	6.05
SE(m) ±	0.06	0.09	0.08	0.12	0.14	0.12	0.15	0.23	0.19	0.26	0.24	0.24
C.D. (P=0.05)	0.19	0.23	0.23	0.35	0.41	0.35	0.44	0.67	0.54	0.76	0.70	0.68

T₁: Top soil, T₂: Top soil + sand(1:1), T₃: Top soil+ Coir pith(1:1), T₄: Top soil + FYM(1:2), T₅: Top Soil + FYM(1:1), T₆: Topsoil + coir pith + FYM(1:1:1), T₇:Top soil + Vermicompost(1:2), T₈: Top soil + sand + FYM(1:1:1), T₉: Top soil + sand + vermicompost(1:1:1), T₁₀: Top soil + coir pith + vermicompost(1:1:1).

4.1.7 Numbers of planting material production

Referring the table 4.1.7 it is evident that the number of planting material production was maximum (53.67) in treatment T₁₀ growing media comprising of top soil + coir pith + vermicompost @ 1:1:1 which was statistically *at par* with T₉ treatment (51.17) comprising growing media of top soil + sand + vermicompost @ 1:1:1 and T₇ treatment (50.50) comprising growing media of top soil + vermicompost @ 1:2. Treatment T₆ (Top soil + coir pith + FYM @ 1:1:1) and T₅ (Top soil + FYM @ 1:2) also produced higher number of planting material (50.00 in each treatment). Meanwhile, among the various treatments, T₂ treatment (Top soil + sand) produced a minimum number of planting material (43.50).

In this experiment, T₁₀ (Top soil + coir pith + vermicompost @1:1:1) followed by treatment T₉ (top soil + coir pith + FYM @ 1:1:1) and T₇ (Top soil + vermicompost @ 1:2) recorded the highest number of planting material produced which might be due to the combined effect of the media mechanism that gives better porosity and allows good root penetration apart from having good water absorption capacity. Presence of growth promoting substances in vermicompost and sufficient amount of organic matter supply from the soil for better growth and development of layered that together was responsible for maximum planting material production of black pepper. More or less similar results were also reported by Bhuyan *et al* (2015) who found that total plant material production per year 54.00 through bamboo split method under Bangladesh condition.

Table 4.1.7 Effect of growing media on numbers of planting material production of black pepper.

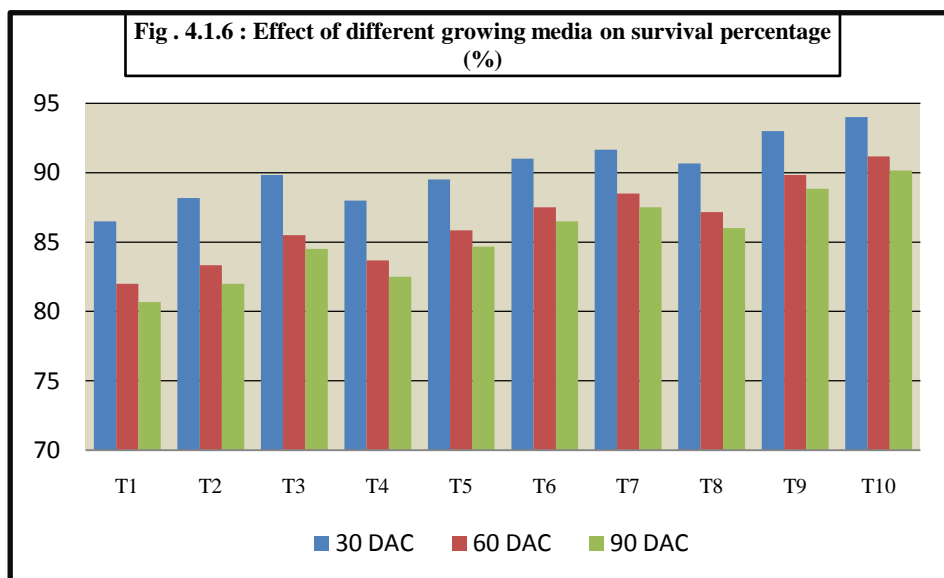
Numbers of planting material production			
Treatment	2016-17	2017-18	Pooled
T ₁	45.33	45.67	45.50
T ₂	43.00	44.00	43.50
T ₃	51.00	45.00	48.00
T ₄	52.33	47.67	50.00
T ₅	50.33	47.00	48.67
T ₆	53.67	46.33	50.00
T ₇	50.00	51.00	50.50
T ₈	47.67	50.00	48.83
T ₉	51.67	50.67	51.17
T ₁₀	53.33	54.00	53.67
SE(m) ±	1.83	1.48	1.74
C.D. (P=0.05)	5.43	4.38	4.98

T₁: Top soil, T₂: Top soil + sand(1:1), T₃: Top soil+ Coir pith(1:1), T₄: Top soil + FYM(1:2), T₅: Top Soil + FYM(1:1), T₆: Topsoil + coir pith + FYM(1:1:1), T₇:Top soil + Vermicompost(1:2), T₈: Top soil + sand + FYM(1:1:1), T₉: Top soil + sand + vermicompost(1:1:1), T₁₀: Top soil + coir pith + vermicompost(1:1:1).

4.1.8 Survival percentage (%)

Data pertaining to the survivability percentage of black pepper layers have been presented in table 4.1.8 and fig. 4.1.6. The effect of different growing media on the serpentine cutting of layers of black pepper showed significant differences for both the years and pooled data. The experimental findings revealed that highest survivability of layers at different time intervals (30, 60 and 90 days after cutting of layers) i.e. 94.00 %, 91.17 %, 90.17 %, respectively was recorded with the plant grown under treatment T₁₀ (Top soil + coir pith + vermicompost @ 1:1:1) followed by 93.00 %, 89.83 % and 88.83 % at 30, 60 and 90 days after cutting of layers, respectively in plant grown under treatment T₉ (Top soil + sand + vermicompost @ 1:1:1). On the other hand, the lowest survivability was recorded with the plant grown under treatment T₂ comprising of top soil + sand with a minimal value of 86.50 %, 82.00 % and 80.67 % at 30, 60 and 90 days after cutting of layers, respectively followed by plants grown under treatment T₁ (Top soil) with 88.17 %, 83.33 % and 82.00 % at 30 days, 60 days and 90 days after cutting of layers, respectively.

As treatment T₁₀ (Top soil + coir pith + vermicompost @ 1:1:1) recorded the highest survival percentage followed by T₇ (Top soil + vermicompost @ 1:2) at 30 days, 60 days and 90 days

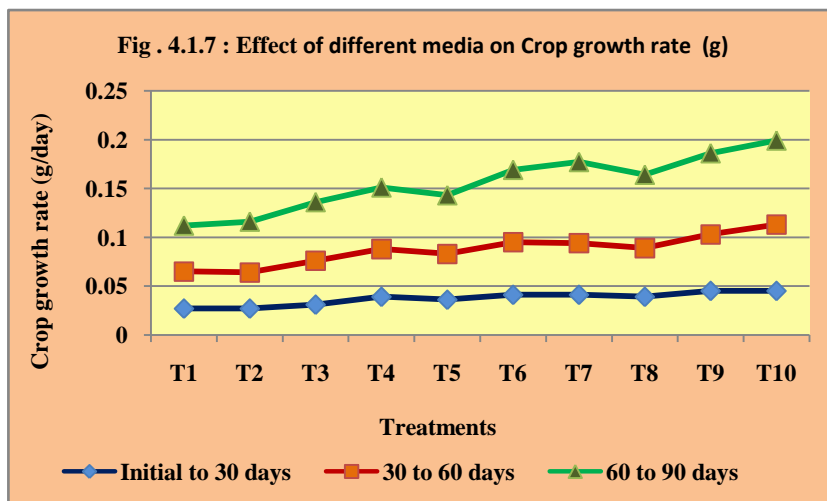


after cutting of layers which might be due to the advantage of the balanced mixture and combined effect of the media components like soil, coir pith and vermicompost that improve the porosity of potting mixture along with the best crude amendments important for root and shoot development, survival of saplings and better growth and development of layers for a considerable phase of time. A similar type of findings was also reported by Sharangi *et al* (2010)

who reported that growing media also have a significant influence on the survivability of layers. Potting media comprising of sand, soil, and FYM and coir pith were found to maximize the survivability of saplings.

4.1.9 Crop growth rate (g/day)

Data presented in the table 4.1.9 and fig. 4.1.7 revealed that the crop growth rate of layers at different time intervals was affected by different growing media. Among different treatments the highest crop growth rate of 0.032 g/day, 0.052 g/day and 0.065 g/day at initial to 30 days, 30 to 60 days and 60 to 90 days after cutting of layers was observed in plants under treatment T₁₀



(Top soil + coir pith + vermicompost @ 1:1:1) followed by layers under treatment T₉ (Top soil + sand+ vermicompost @ 1:2) with a value of 0.035 g/day, 0.046, 0.061 g/day at initial to 30 days, 30 to 60 days and 60 to 90 days after cutting of layers, respectively. Among different growing media, the lowest result with respect to the growth rate of layers (0.015 g/day 0.026 g/day and 0.037 g/day) at initial to 30 days, 30 to 60 days and 60 to 90 days after cutting of layers was found in black pepper layers grown under the treatment T₂ comprising of top soil + sand @ 1:1 followed by black pepper layers grown under T₁ (Top soil) with the values of and 0.015 g/day at initial to 30 days, 0.028 g/day at 30 to 60 days and 0.042 g/day at 60 to 90 days.

The crop growth rate is the gain of dry matter production on a unit area and time. It is affected by a series of factors including heat, levels of solar radiation, water supply, crop, cultivar and its age (Reddy 2000). Therefore, the treatment with better root and shoot parameters and treatment combination with higher dry weight has shown higher crop growth, whereas treatment with least roots and shoot parameters and low dry weight had shown the least fresh weight of the plants. In this experiment higher dry weight was recorded in the T₁₀ treatment and subsequently, T₁₀ also recorded the highest crop growth rate.

Table 4.1.8 Effect of growing media survival percentage of layers

Treatment	Survival percentage (%)								
	30 days after cutting			60 days after cutting			90 days after cutting		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T ₁	87.33 (9.42)	89.00 (9.49)	88.17 (9.40)	82.67 (9.15)	84.00 (9.22)	83.33 (9.13)	81.67 (9.09)	82.33 (9.13)	82.00 (9.06)
T ₂	85.33 (9.29)	87.67 (9.42)	86.50 (9.30)	81.00 (9.06)	83.00 (9.17)	82.00 (9.06)	80.00 (9.00)	81.33 (9.07)	80.67 (8.98)
T ₃	89.00 (9.49)	90.67 (9.57)	89.83 (9.48)	85.00 (9.27)	86.00 (9.33)	85.50 (9.25)	83.00 (9.17)	86.00 (9.33)	84.50 (9.19)
T ₄	87.67 (9.42)	88.33 (9.45)	88.00 (9.38)	83.67 (9.20)	83.67 (9.20)	83.67 (9.15)	82.00 (9.11)	83.00 (9.17)	82.50 (9.08)
T ₅	89.00 (9.49)	90.00 (9.54)	89.50 (9.46)	85.00 (9.27)	86.67 (9.36)	85.83 (9.26)	84.67 (9.26)	84.67 (9.26)	84.67 (9.20)
T ₆	90.00 (9.54)	92.00 (9.64)	91.00 (9.54)	86.00 (9.33)	89.00 (9.49)	87.50 (9.35)	86.00 (9.33)	87.00 (9.38)	86.50 (9.30)
T ₇	91.00 (9.59)	92.33 (9.66)	91.67 (9.57)	87.00 (9.38)	90.00 (9.54)	88.50 (9.41)	86.00 (9.33)	89.00 (9.49)	87.50 (9.35)
T ₈	89.00 (9.49)	92.33 (9.66)	90.67 (9.52)	88.33 (9.45)	86.00 (9.33)	87.17 (9.34)	85.00 (9.27)	87.00 (9.38)	86.00 (9.27)
T ₉	91.00 (9.59)	95.00 (9.80)	93.00 (9.64)	88.67 (9.47)	91.00 (9.59)	89.83 (9.48)	87.00 (9.38)	90.67 (9.57)	88.83 (9.43)
T ₁₀	93.00 (9.70)	95.00 (9.80)	94.00 (9.70)	89.33 (9.50)	93.00 (9.70)	91.17 (9.55)	89.00 (9.49)	91.33 (9.61)	90.17 (9.50)
SE(m) ±	0.06	0.07	0.04	0.06	0.06	0.06	0.07	0.06	0.04
C.D. (P=0.05)	0.17	0.21	0.11	0.19	0.19	0.18	0.20	0.19	0.12

T₁: Top soil, T₂: Top soil + sand(1:1), T₃: Top soil+ Coir pith(1:1), T₄: Top soil + FYM(1:2), T₅: Top Soil + FYM(1:1), T₆: Topsoil + coir pith + FYM(1:1:1), T₇:Top soil + Vermicompost(1:2), T₈: Top soil + sand + FYM(1:1:1), T₉: Top soil + sand + vermicompost(1:1:1), T₁₀: Top soil + coir pith + vermicompost(1:1:1)

*Values in parenthesis indicate the square root transformed value (Gomez and Gomez 1984)

Table 4.1.9 Effect of growing media on crop growth rate

Crop growth rate (g/day)									
Treatment	Initial 30 days after cutting			30-60 days after cutting			60-90 days after cutting		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T ₁	0.015	0.014	0.015	0.031	0.026	0.028	0.046	0.038	0.042
T ₂	0.016	0.014	0.015	0.028	0.024	0.026	0.038	0.036	0.037
T ₃	0.024	0.019	0.021	0.040	0.060	0.050	0.041	0.052	0.047
T ₄	0.027	0.036	0.032	0.047	0.032	0.039	0.053	0.057	0.055
T ₅	0.025	0.019	0.022	0.039	0.055	0.047	0.056	0.046	0.051
T ₆	0.032	0.027	0.029	0.054	0.050	0.052	0.060	0.058	0.059
T ₇	0.033	0.023	0.028	0.056	0.050	0.053	0.056	0.062	0.059
T ₈	0.027	0.021	0.024	0.050	0.050	0.050	0.054	0.061	0.058
T ₉	0.038	0.031	0.035	0.049	0.042	0.046	0.056	0.065	0.061
T ₁₀	0.040	0.023	0.032	0.055	0.049	0.052	0.069	0.061	0.065
SE(m) ±	0.005	0.004	0.004	0.007	0.005	0.006	0.006	0.007	0.007
C.D. (P=0.05)	0.015	0.011	0.013	0.019	0.016	0.018	0.019	0.022	0.021

*T₁: Top soil, T₂: Top soil + sand(1:1), T₃: Top soil+ Coir pith(1:1), T₄: Top soil + FYM(1:2), T₅: Top Soil + FYM(1:1), T₆: Topsoil + coir pith + FYM(1:1:1), T₇:Top soil + Vermicompost(1:2), T₈: Top soil + sand + FYM(1:1:1), T₉: Top soil + sand + vermicompost(1:1:1), T₁₀: Top soil + coir pith + vermicompost(1:1:1).

4.1.10 Fertility status evaluation of different media:

4.1.10.1 Available nitrogen content of media (Kg/ha)

Data pertaining to available nitrogen of different rooting media at the time of media preparation and 90 days after cutting of layers of black pepper have been tabulated in table 4.1.10.1 and Fig. 4.1.8. Different growing media showed significant variations among themselves regarding available residual nitrogen at initial and 90 days after cutting of layers. Significantly highest nitrogen content at the time of media preparation was recorded in treatment T₇ (Top soil + vermicompost @ 1:2) with a value of 253.49 Kg/ha followed by treatment T₄ (Top soil + FYM @ 1:2) with a value of 247.59 kg/ha. Maximum nitrogen content was recorded in T₇ (Top soil + vermicompost @ 1:2) which might be due to the incorporation of vermicompost in the soil which added nitrogen in the soil and shows maximum nitrogen content of media. On the contrary, the lowest nitrogen content was recorded in treatment T₂ (Top soil + sand @ 1:1) with a value of 107.22 kg/ha which might be due to the incorporation of sand in the soil mixture followed by treatment T₃ (Top soil + coir pith @ 1:1) with 131.02 Kg/ha.

Again data was recorded regarding

available residual nitrogen content of different rooting media after 90 days of cutting of layers and it was found that T₄ (Top soil + FYM @ 1:2) reordered significantly the highest residual nitrogen (168.55 Kg/ha) followed by treatment T₅ (Top soil + FYM @ 1:2) with a value of 158.55 kg/ha. On the other hand, minimum available residual nitrogen (42.93 kg/ha) was recorded in T₂ (top soil + sand @ 1:1) followed by T₃ (top soil + coir pith @ 1:1) 56.57 kg/ha. But based on the uptake (calculated on the basis of subtraction of initial values and values at 90 days after cutting of layers) the maximum uptake (114.87 kg/ha) was recorded in treatment T₁₀ (Top soil + coir pith + vermicompost @ 1:1:1) followed by T₉ (Top soil + sand + vermicompost @ 1:1:1) with a value of 100.87 Kg/ha. Similarly, minimum uptake (64.16 kg/ha) was recorded in T₂ (top soil + sand @ 1:1) followed by T₁ (top soil) with uptake of 69.87 kg/ha.

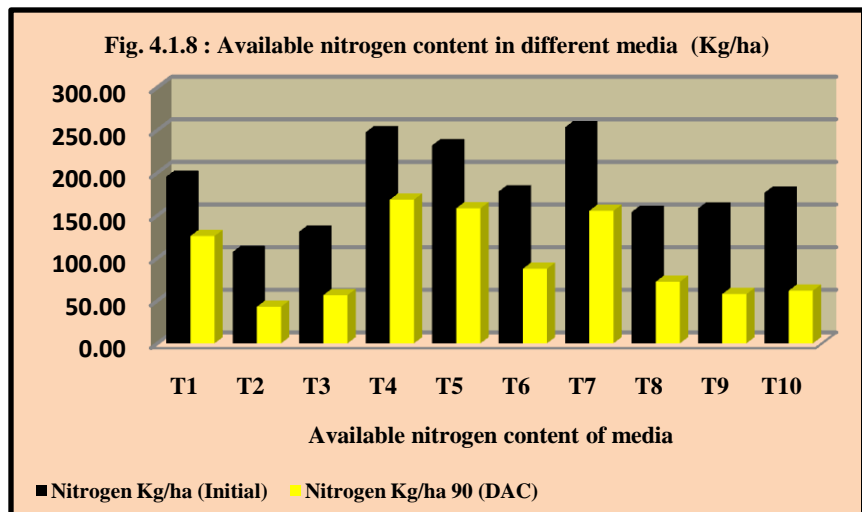


Table 4.1.10.1 Effect of different rooting media on available nitrogen content in media

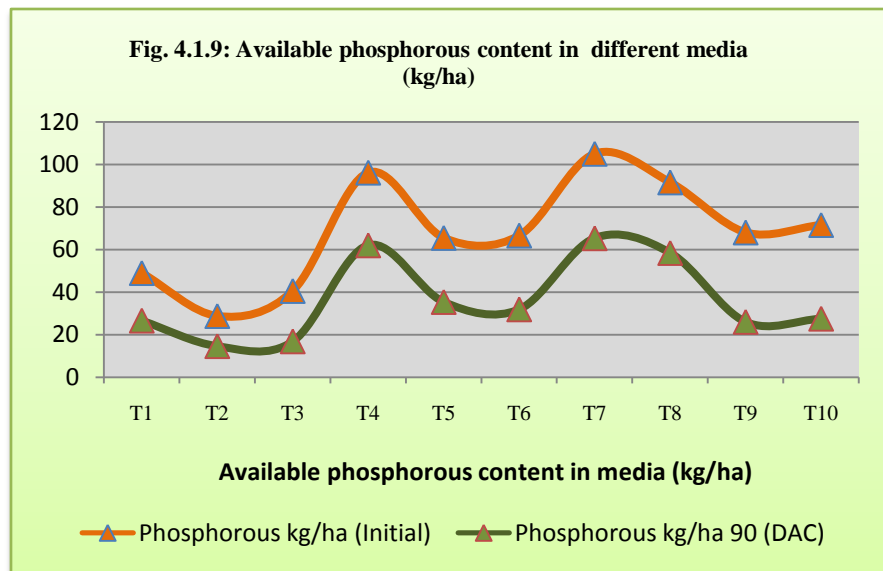
Initial nitrogen content (Kg/ha)				Nitrogen content at 90 days after cutting (Kg/ha)		
TREATMENT	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T ₁	192.25	198.71	195.48	127.85	123.82	125.83
T ₂	106.31	108.14	107.22	42.61	43.25	42.93
T ₃	133.18	128.85	131.02	54.82	58.32	56.57
T ₄	245.63	249.55	247.59	165.55	171.55	168.55
T ₅	231.12	233.42	232.27	156.55	160.35	158.45
T ₆	179.88	176.22	178.05	86.52	88.32	87.42
T ₇	250.45	256.53	253.49	157.05	153.85	155.45
T ₈	155.38	152.68	154.03	76.18	68.27	72.23
T ₉	159.78	156.58	158.18	56.75	58.76	57.76
T ₁₀	178.22	175.18	176.70	63.95	59.62	61.78
SE(m)±	2.88	2.90	2.87	2.6	2.69	2.42
C.D. (P=0.05)	8.55	8.61	8.24	7.72	7.99	6.94

T₁: Top soil, T₂: Top soil + sand(1:1), T₃: Top soil+ Coir pith(1:1), T₄: Top soil + FYM(1:2), T₅: Top Soil + FYM(1:1), T₆: Topsoil + coir pith + FYM(1:1:1), T₇:Top soil + Vermicompost(1:2), T₈: Top soil + sand + FYM(1:1:1), T₉: Top soil + sand + vermicompost(1:1:1), T₁₀: Top soil + coir pith + vermicompost(1:1:1).

The nutrient uptake of media reflects the root and shoots parameters recorded (Akshay *et al* 2018). Therefore, the plant under treatment with the better root and shoot parameters recorded the highest nitrogen uptake and showed a minimum residue in the media, whereas the plant under treatment with the least roots and shoot parameters had shown the least nitrogen uptake and showed maximum residue in the media.

4.1.10.2 Available Phosphorous content of media (Kg/ha)

Experimental results presented in table 4.1.10.2 and fig. 4.1.9 revealed that among the different treatment combinations maximum phosphorous content (104.98 kg/ha) at the time of media preparation was recorded in treatment T₇ (Top soil + vermicompost @ 1:2) followed by T₄ (Top soil + FYM @ 1:2) with a value of 96.13 kg/ha. Whereas,



minimum phosphorous content (28.77 kg/ha) was recorded in treatment T₂ comprising growing media of top soil + sand (@ 1:1 followed by (40.55 kg/ha) in T₃ treatment comprising of top soil + coir pith (1:1). Maximum phosphorous content in treatment T₇ containing mixture of top soil + vermicompost @ 1:2 might be due to the presence of vermicompost in the mixture. Prasath *et al* (2014) publicized that addition of vermicompost in media contributes to increasing the organic carbon content, phosphorous, Mg, iron and zinc availability.

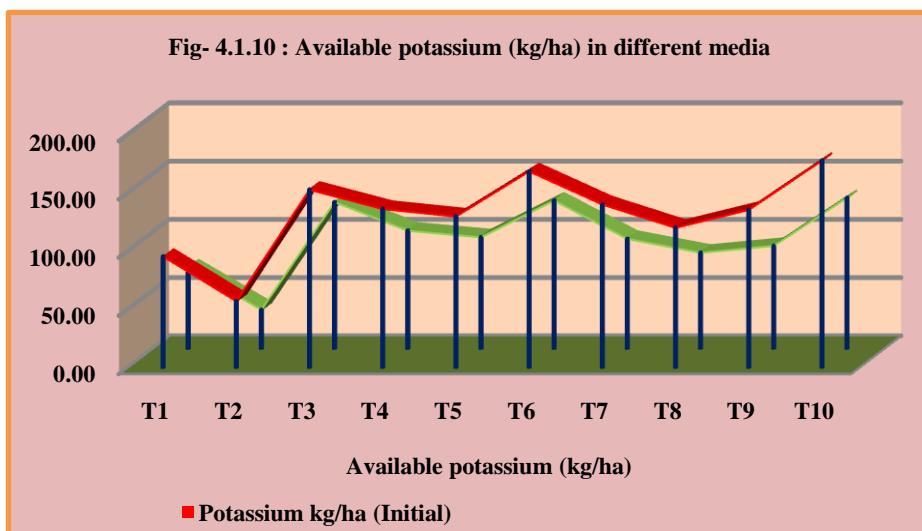
Similarly data regarding the residual phosphorous of media was observed at 90 days after cutting of layers, treatment T₇ recorded the maximum residual phosphorous (65.35 kg/ha) followed by T₃ treatment (62.02 kg/ha). On the other hand, the minimum residual phosphorous (14.62 kg/ha) was observed in treatment T₂ (Top soil + sand @ 1:1) followed by treatment T₃ (Top soil + coir pith @ 1:1) (16.86 kg/ha). But on the basis of uptake (calculated on the basis of subtraction of initial values and values at 90 days after cutting of layers), treatment T₁₀ (Top soil

+ coir pith + vermicompost @ 1:1:1) recorded maximum phosphorous uptake with a maximum value of 44.01 kg/ha which was followed by treatment T₉ (Top soil + sand + vermicompost @ 1:1:1) (41.99 kg/ha). Minimum phosphorous uptake (14.15 kg/ha) was recorded in the treatment T₂ (Top soil + sand @ 1:1) followed by treatment T₁ (Top soil) 22.35 kg/ha. The nutrient uptake by plants reflects root and shoots parameters of the layers recorded. Therefore, the treatment with better root and shoot parameters has shown higher uptake of Phosphorous, whereas treatment with least roots and shoot parameters had shown least uptake of the phosphorous. Saranraj and Stella (2012) reported that application of vermicompost and coir pith in the soil contributes to increase in available phosphorous.

4.1.10.3 Available potassium of different media (Kg/ha)

Data in relation to available potassium of different media at the time of media preparation and 90 days after cutting of layers of black pepper have been presented in table 4.1.10.3 and fig. 4.1.10.

Different growing media of black pepper layers had a profound effect and showed significant differences for both the years and as well in pooled data. The maximum potassium content (178.27 kg/ha)



was recorded in layers grown under T₁₀ treatment (Top soil + coir pith + vermicompost @ 1:1:1) followed by T₆ treatment (168.98 kg/ha) comprising growing media of top soil + coir pith + FYM @ 1:1:1 at the time of media preparation. On the other hand, the lowest available potassium content (57.53 kg/ha) was recorded in treatment T₂ (Top soil + sand @ 1:1) followed by treatment T₁ (Top soil) (95.96 kg/ha) at the time of media preparation.

Table 4.1.10.2 Effect of different rooting media on available phosphorous content in media

TREATMENT	Initial Phosphorous content (Kg/ha)			Phosphorous content at 90 days after cutting (Kg/ha)		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T ₁	51.27	46.67	48.97	24.89	28.35	26.62
T ₂	26.77	30.77	28.77	13.58	15.66	14.62
T ₃	39.45	41.65	40.55	15.37	18.35	16.86
T ₄	94.91	97.35	96.13	61.58	62.46	62.02
T ₅	63.80	67.16	65.48	33.11	37.65	35.38
T ₆	63.81	69.35	66.58	31.51	32.33	31.92
T ₇	97.61	112.35	104.98	64.42	66.28	65.35
T ₈	88.71	94.37	91.54	56.64	60.22	58.43
T ₉	66.80	69.24	68.02	24.51	27.55	26.03
T ₁₀	69.71	73.35	71.53	25.69	29.35	27.52
SE(m)±	1.93	1.53	1.91	1.53	1.6	0.92
C.D. (P=0.05)	5.73	4.55	5.49	4.55	4.77	2.64

T₁: Top soil, T₂: Top soil + sand(1:1), T₃: Top soil+ Coir pith(1:1), T₄: Top soil + FYM(1:2), T₅: Top Soil + FYM(1:1), T₆: Topsoil + coir pith + FYM(1:1:1), T₇:Top soil + Vermicompost(1:2), T₈: Top soil + sand + FYM(1:1:1), T₉: Top soil + sand + vermicompost(1:1:1), T₁₀: Top soil + coir pith + vermicompost(1:1:1).

Table 4.1.10.3 Effect of different rooting media on available potassium content in media

Initial Potassium content (Kg/ha)				Potassium content at 90 days after cutting (Kg/ha)		
TREATMENT	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T ₁	94.35	97.56	95.96	69.45	71.45	70.45
T ₂	56.85	58.22	57.53	32.85	34.65	33.75
T ₃	151.82	154.65	153.23	124.58	127.85	126.22
T ₄	133.59	139.79	136.69	98.95	104.35	101.65
T ₅	128.17	132.25	130.21	94.78	97.22	96.00
T ₆	167.58	170.38	168.98	124.55	130.45	127.50
T ₇	141.28	139.89	140.59	93.85	95.45	94.65
T ₈	118.52	122.52	120.52	81.04	84.40	82.72
T ₉	136.25	135.62	135.93	86.98	90.32	88.65
T ₁₀	177.32	179.22	178.27	128.81	130.98	129.90
SE(m)±	2.64	2.53	2.45	1.67	1.76	0.78
C.D. (P=0.05)	7.86	7.52	7.02	4.97	5.22	2.25

T₁: Top soil, T₂: Top soil + sand(1:1), T₃: Top soil+ Coir pith(1:1), T₄: Top soil + FYM(1:2), T₅: Top Soil + FYM(1:1), T₆: Topsoil + coir pith + FYM(1:1:1), T₇:Top soil + Vermicompost(1:2), T₈: Top soil + sand + FYM(1:1:1), T₉: Top soil + sand + vermicompost(1:1:1), T₁₀: Top soil + coir pith + vermicompost(1:1:1).

Maximum residual potassium content of different rooting media after 90 days of cutting of layers was recorded in T₁₀ (top soil + coir pith + vermicompost @ 1:1:1) 129.90 kg/ha followed by 127.50 kg/ha in treatment T₆ (Top soil +coir pith + FYM @ 1:1:1). Minimum residual nitrogen (33.75 kg/ha) was recorded in the T₂ treatment (Top soil + sand @ 1:1) followed by treatment T₁ (Top soil) (70.45 kg/ha). But on the basis of uptake (calculated on the basis of subtraction of initial values and values at 90 days after cutting of layers) maximum potassium uptake was recorded in treatment mixture of T₁₀ (Top soil + coir pith + vermicompost @ 1:1:1) (48.45 kg/ha) followed by T₉ (Top soil + sand + vermicompost @ 1:1:1) (47.28 kg/ha). Minimum potassium uptake (23.84 kg/ha) was recorded in treatment T₂ (Top soil + sand @ 1:1) followed by Treatment T₁ (Top soil) (25.35 kg/ha).

Maximum Potassium content at the time of media was recorded in treatment mixture of top soil + coir pith + vermicompost @ 1:1:1. Application of well decompose coir pith in the soil mixture contributes to increase in potassium availability in the soil (Saranraj and Stella, 2012) which might be the reason for maximum potassium content of different media. The uptake of nutrients by the plants from the media clearly reflects the vegetative parameters of the layers recorded. Therefore, treatment with better root and shoot parameters shows the highest uptake and treatments combination with the least root and shoot parameters recorded minimum uptake.



Plate 2: Black pepper layers at different intervals grown in different media.



Plate 3: Black pepper layers at different intervals grown in different media.

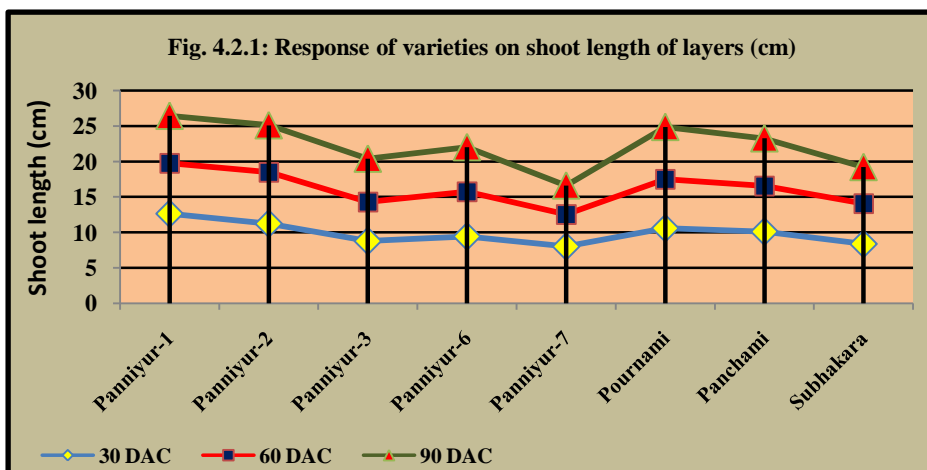
4.2 Experiment II

An experiment was carried out to study the response of black pepper varieties on the production of planting material through serpentine layering at the Instruction farm of the Faculty of Horticulture, Uttar Banga Krishi Viswavidyalaya, Cooch Behar, West Bengal during the consecutive year of 2016-17 and 2017-18. The result recorded during this experiment has been presented and discussed in this chapter under appropriate headings.

4.2.1 Shoot length of layer (cm)

The observation taken on shoot length of layers arranged in a tabular (Table No. 4.2.1 and Fig. No. 4.2.1)

form indicated that different varieties of black pepper examined during the experiment varied significantly among themselves in terms of shoot length at



different time intervals (30 days, 60 days and 90 days after cutting of the layers). At each aforesaid the longest shoot length was recorded in Panniyur-1 i.e., 12.65 cm at 30 days, 19.75 cm at 60 days and 26.44 cm at 90 days after cuttings of layers which was statistically at par with Panniyur-2 and Pournami. Longer shoot length was also recorded in Panniyur-2 with shoot length of 11.25 cm at 30 days, 18.47 cm at 60 days and 25.11 cm at 90 days whilst Pournami with 10.60 cm at 30 days, 17.50 cm at 60 days and 24.88 cm at 90 days proved a nuance in shoot length of layers with Panniyur-1. Whereas, Panniyur-7 recorded the shortest shoot length of 8.04 cm at 30 days, 12.53 cm at 60 days and 16.63 cm at 90 days after cutting of layers followed by Subhakara with 8.40 cm at 30 days, 14.08 cm at 60 days and 19.23 cm at 90 days after cutting of layers.

From the above mention result, it was cleared that the different varieties had significantly affected the shoot length of black pepper layers at different time intervals. Maximum value regarding shoot length of layers was recorded in Panniyur-1 followed by Panniyur-2 and

Table 4.2.1 Response of different varieties of black pepper on shoot length of layers

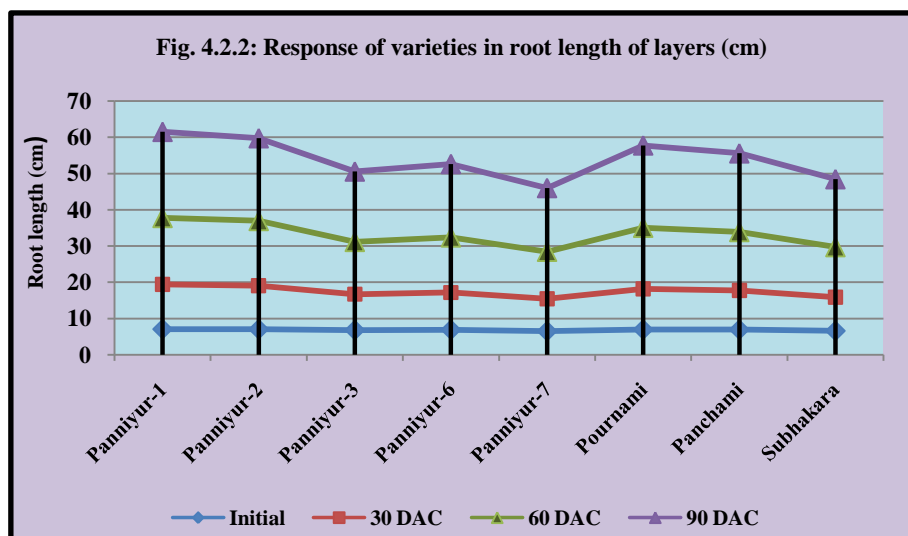
Varieties	Shoot length of layer (cm)								
	30 days after cutting			60 days after cutting			90 days after cutting		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Panniyur-1	12.20	13.11	12.65	19.05	20.46	19.75	24.08	28.80	26.44
Panniyur-2	10.51	12.00	11.25	17.37	19.57	18.47	24.30	25.93	25.11
Panniyur-3	8.43	9.17	8.80	14.03	14.57	14.30	19.28	21.53	20.41
Panniyur-6	9.04	9.87	9.45	14.77	16.7	15.74	20.55	23.50	22.03
Panniyur-7	7.50	8.58	8.04	12.17	12.90	12.53	15.75	17.50	16.63
Pournami	9.85	11.35	10.60	16.17	18.83	17.50	22.52	27.23	24.88
Panchami	9.32	10.93	10.13	15.27	17.83	16.55	21.43	25.10	23.27
Subhakara	8.08	8.72	8.40	13.50	14.67	14.08	18.08	20.37	19.23
SE(m) ±	0.61	0.66	0.64	0.72	0.95	0.84	0.81	0.97	0.91
C.D. (P=0.05)	1.84	2.59	2.15	2.17	2.88	2.43	2.46	2.94	2.65

Pournami. The variations in length of layers among different varieties might be due to the genetic characteristic among the individual variety.

4.2.2 Root length of layers (cm)

Data recorded on root length of black pepper layers at different time intervals i.e. at initial, 30, 60 and 90 days after cutting of layers have been presented in table 4.2.2 and fig 4.2.2.

Experimental findings revealed that different varieties responded significantly to the root length of black pepper layers at 30, 60 and 90 days but showed a non-significant effect at the initial stage after cutting of layers.



Maximum root length of 7.06 cm, 12.36 cm, 18.30 cm and 23.75 cm was recorded in Panniyur-1 which was statically *at par* with Panniyur-2 (7.03 cm, 12.02 cm, 17.84 cm and 22.83 cm) and Pournami (6.95 cm, 11.20 cm, 16.88 cm and 22.71 cm) at initial stage, 30 days, 60 days and 90 days after cutting of layers, respectively. Whereas, Panniyur-7 recorded the lowest root length of 6.50 cm, 8.93 cm, 12.99 cm and 17.58 cm followed by Subhakara (6.58 cm, 9.32 cm, 13.80 cm and 18.74 cm) at initial, 30, 60 and 90 days after cutting of layers, respectively they were statically *at par* with each other.

The longest root length was recorded in Panniyur-1 followed by Panniyur-2. Similar reports were recorded by Akshay *et al* (2018) in Panniyur-1 under the Karnataka condition, wherein the root length at 75 days after cutting was 26.79 cm. Similar results were also reported by Waman *et al* (2019) who conserved that 19.40 cm of root length in *Piper sarmentosum* at 60 days after cutting under Plot Blair condition. Sundhariya *et al* (2016) also reported a more or less similar result in *Piper longum*. Bedossa (2006) also reported similar findings with respect to root length of cuttings in Panniyur-1 (17.42 at 8 weeks after cutting) under Ethiopian conditions. Hence, it may be concluded that the root length of different plants was closely related to its

genotypes and the findings of the present experiment were more or less similar to the above findings of the different scientists.

4.2.3 Number of leaves

Data presented in table 4.2.3 indicated that the different varieties of black pepper in serpentine layering showed a significant variation with respect to number of leaves at a different time interval (30, 60 and 90 days after cuttings of layers). The highest number of leaves i.e. 4.63 at 30 days, 6.90 at 60 days and 8.39 at 90 days after cuttings of layers was observed in Panniyur-1 and it was statistically *at par* with Panniyur-2 (4.28, 6.14 and 7.45 at 30 days, 60 days and 90 days after cutting of layers, respectively). Higher number of leaves was also recorded in Pournami (3.96, 5.68 and 6.84 at 30 days, 60 days and 90 days after cutting of layers, respectively). Whilst, the lowest number of leaves at 30, 60 and 90 days after cutting of layers was recorded in Panniyur-7 (3.43, 4.03 and 5.48, respectively) followed by Subhakara (3.60, 4.45 and 6.21 respectively) which was statistically *at par* with Panniyur-7.

From the above mentioned result, it was apparent that number of leaves of black pepper layers at different time intervals significantly varied among themselves. Among the different varieties, highest number of leaves was recorded in Panniyur-1 followed by Panniyur-2. The possible reason might be due to genetic make up of the individual varieties. Similar result was also reported by Prajapati (2015) regarding number of leaves in Panniyur-1 black pepper variety (8.87 at 90 days after planting of cutting) grown under Navsari, Gujarat condition.

4.2.4 Number of roots

The data pertaining to the number of roots at various time intervals as influenced by different black pepper varieties have been presented in table 4.2.4. The observations lead to the undisputed result that the variety Panniyur-1 had a prominent effect on the number roots of layers at a different stage. The experimental result revealed that the highest number of roots was found in Panniyur-1 (3.78, 5.95, 7.85 and 8.73 at initial, 30, 60 and 90 days, respectively after cutting of layers) followed by Panniyur-2 (3.58, 5.33, 7.38 and 8.36 at initial, 30, 60 and 90 days, respectively after cutting of layers) which was statically *at par* with Panniyur-1. All the varieties showed significant variations regarding the root number of layers at different time intervals except the initial stage which showed non-significant differences. On other hand, the lowest

number of roots was recorded in variety Panniyur-7 (2.28, 2.50, 4.68 and 5.58 at an initial stage, 30, 60 and 90 days, respectively after cutting of layers) followed by Subhakara (2.49, 3.10, 5.35 and 6.48 at an initial stage, 30, 60 and 90 days, respectively after cutting of layers).

Variation in the number of roots among different varieties may be due to genetically inherited traits and to some extent due to environmental effects. Smitha (2010) recorded 7.79 numbers of roots at 60 days after cutting in long pepper when he conducted an experiment on propagation of long pepper through stem cutting under Bengaluru conditions. Prajapati (2015) also reported the number of roots in Panniyur-1 (9.40 at 90 days after planting of cuttings) grown under Gujarat conditions. Waman *et al* (2019) also reported more or less similar results regarding the number of roots in *Piper sarmentosum* (7.80 at 60 days after cutting) grown under Plot Blair condition. A similar result was also reported by Sundharaiya *et al* (2016) regarding the number of roots in *Piper longum* under Tamil Nadu conditions. Akshay *et al* (2018) also reported more or less similar result regarding the number of roots in Panniyur-1 (11.07 at 75 days after cutting) under the Karnataka condition. Basak *et al* (2014) also reported root numbers of 8.57 (apical) and 8.73 (petiolar) at 60 days after cutting in *Piper longum* (pippali) through leaf cutting. From the above discussion, it may be appear that the number of roots observed with the present experiment was more or less similar to findings of the above said experiments on black pepper and related species of the black pepper at different locations of the country.

4.2.5 Fresh weight of layers (g)

Data illustrated to fresh weight of layers have been presented in table 4.2.5. The result indicated that there was a significant response among the different varieties of black pepper with respect to the fresh weight of layers at different time intervals. After perusal of the data, a maximum fresh weight of 9.73 g, 13.70 g, 18.81 g and 25.07 g was observed in Panniyur-1 at the initial stage, 30, 60 and 90 days, respectively after cutting of layers which was statistically *at par* with Panniyur-2 (9.00 g, 12.83 g, 17.74 g and 23.81 g) and Pournami (8.79 g, 12.39 g, 17.05 g and 22.63 g) also recorded maximum result with respect to fresh weight of layers at initial, 30 days, 60 days and 90 days after cutting of layers. The lowest fresh weight of layers was recorded in Panniyur-7 with 6.06 g at the initial stage, 7.85 g at 30 days, 10.09 g at 30 days and 12.63 g at 90 days after cutting of layers followed by Subhakara with 6.74 g at initial, 9.16 g at 30 days, 12.34 g at 60 days and 16.08 g at 90 days respectively, after cutting of layers.

Table 4.2.2 Response of different varieties of black pepper on root length of layer

Root length of layer (cm)												
Varieties	Initial			30 days after cutting			60 days after cutting			90 days after cutting		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Panniyur-1	6.87	7.25	7.06	11.78	12.93	12.36	17.19	19.42	18.3	22.69	24.82	23.75
Panniyur-2	6.98	7.07	7.03	11.54	12.5	12.02	16.85	18.83	17.84	22.03	23.63	22.83
Panniyur-3	6.67	6.93	6.8	9.67	10.15	9.91	13.43	15.41	14.42	18.05	20.80	19.42
Panniyur-6	6.73	7.02	6.88	9.85	10.7	10.28	14.35	16.06	15.2	19.00	21.53	20.27
Panniyur-7	6.20	6.8	6.5	8.14	9.73	8.93	11.57	14.4	12.99	15.99	19.17	17.58
Pournami	6.80	7.1	6.95	10.95	11.44	11.2	16.08	17.68	16.88	21.40	24.01	22.71
Panchami	6.75	7.12	6.93	10.35	11.23	10.79	15.00	17.26	16.13	20.00	23.41	21.71
Subhakara	6.42	6.73	6.58	8.80	9.83	9.32	12.55	15.05	13.80	17.10	20.38	18.74
SE(m) ±	0.46	0.62	0.41	0.66	0.73	0.61	0.92	0.72	0.65	0.90	0.92	0.88
C.D. (P=0.05)	N.S	N.S	N.S	1.98	2.21	1.77	2.79	2.18	1.89	2.72	2.78	2.55

N.S. – Non significant

Table 4.2.3 Response of different varieties of black pepper on number of leaves of layers

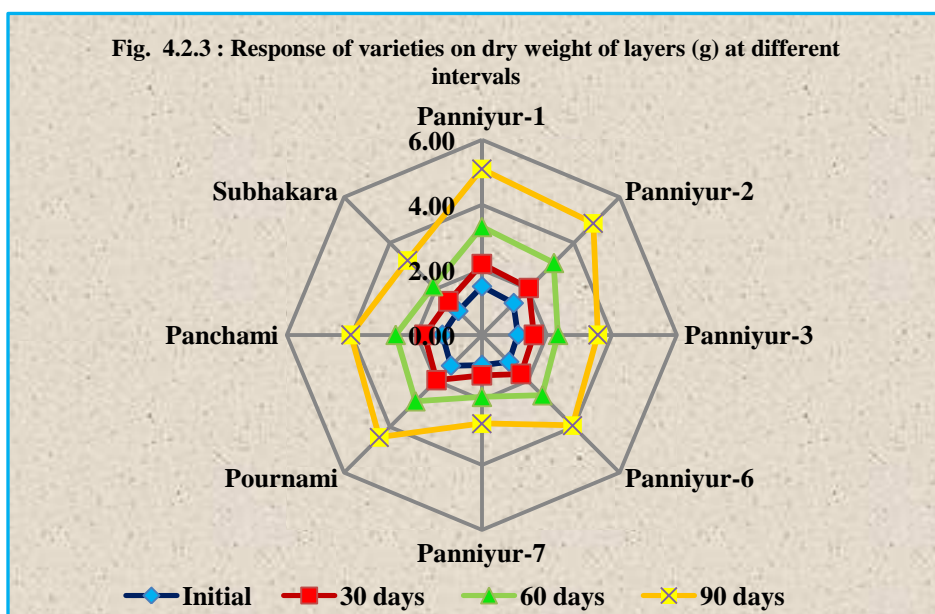
Number of leaves									
Varieties	30 days after cutting			60 days after cutting			90 days after cutting		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Panniyur-1	4.18	5.07	4.63	6.50	7.30	6.90	7.98	8.80	8.39
Panniyur-2	3.73	4.83	4.28	5.87	6.42	6.14	7.05	7.85	7.45
Panniyur-3	3.33	4.02	3.73	4.57	5.10	4.83	5.78	6.95	6.37
Panniyur-6	3.43	4.17	3.72	4.50	5.00	4.75	6.03	7.18	6.61
Panniyur-7	3.13	3.73	3.43	3.77	4.30	4.03	4.93	6.02	5.48
Pournami	3.55	4.37	3.96	5.37	6.00	5.68	6.35	7.33	6.84
Panchami	3.47	4.27	3.87	4.63	4.67	4.65	6.18	7.27	6.73
Subhakara	3.27	3.87	3.6	4.20	4.70	4.45	5.45	6.97	6.21
SE(m) ±	0.19	0.28	0.25	0.23	0.31	0.31	0.42	0.49	0.42
C.D. (P=0.05)	0.56	0.84	0.73	0.71	0.94	0.90	1.25	1.47	1.22

As per the above mentioned result, it was observed that different varieties of black pepper responded significantly to the fresh weight of layers at different time intervals i.e. at initial, 30, 60 and 90 days after cutting of layers. The highest fresh weight was recorded in Panniyur-1. According to Akshay *et al* (2018) the fresh weight of the plant reflected the root and shoots parameters of the layers recorded. The above mentioned root and shoot parameters combined might have led to the higher fresh weight of the plant in Panniyur-1. Therefore variety with the highest root and shoot parameters contribute to higher fresh weight.

4.2.6 Dry weight of layers (g)

The data pertaining to the dry weight of plants at various time intervals of black pepper as influenced by varietal differences have been represented in table 4.2.6 and fig. 4.2.3.

On the basis of pooled data, it was found that the different varieties imparted differences on the plant dry weight. As per the



table, the highest dry weight was observed in Panniyur-1 with 1.49 g at the initial stage, 2.18 g at 30 days, 3.32 g at 60 days and 5.10 g at 90 days after cutting which was significantly higher than the other varieties except for Panniyur-2 (1.38 g at initial stage, 2.04 g at 30 days, 3.13 g at 60 days and 4.85 g at 90 days after cutting of layers). The lowest dry weight was observed in variety Panniyur-7 with a dry weight of 0.93 g at the initial stage, 1.25 g at 30 days, 1.91 g at 60 days and 2.73 g at 90 days after cutting of layers followed by Subhakara with 1.03 g, 1.46 g, 2.12 g and 3.23 g at initial, 30, 60 and 90 days after cutting of layers, respectively.

Table 4.2.4 Response of different varieties of black pepper on number of roots of layers

Number of roots												
Varieties	Initial			30 days after cutting			60 days after cutting			90 days after cutting		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Panniyur-1	3.40	4.15	3.78	5.10	6.80	5.95	7.20	8.50	7.85	8.48	8.97	8.73
Panniyur-2	3.20	3.97	3.58	4.30	6.37	5.33	6.60	8.17	7.38	7.82	8.90	8.36
Panniyur-3	2.65	3.52	3.08	2.90	3.93	3.42	5.13	7.10	6.12	6.80	7.00	6.90
Panniyur-6	2.83	3.47	3.15	2.77	4.23	3.50	5.90	6.97	6.43	6.93	6.97	6.95
Panniyur-7	1.95	2.60	2.28	2.33	2.67	2.50	4.23	5.13	4.68	5.50	5.67	5.58
Pournami	3.12	3.90	3.48	3.70	4.60	4.15	6.40	7.70	7.05	7.77	7.50	7.63
Panchami	3.07	3.87	3.49	3.80	4.60	4.20	6.07	7.33	6.70	7.33	7.37	7.35
Subhakara	2.18	2.80	2.49	2.53	3.67	3.10	5.03	5.67	5.35	6.30	6.67	6.48
SE(m) ±	0.39	0.35	0.38	0.25	0.19	0.22	0.26	0.25	0.25	0.24	0.29	0.25
C.D. (P=0.05)	N.S.	N.S.	N.S.	0.75	0.56	0.64	0.77	0.75	0.72	0.72	0.86	0.72

N.S. – Non significant.

Table 4.2.5 Response of different varieties of black pepper on fresh weight of layers

Fresh weight of layers (g)												
Varieties	Initial			30 days after cutting			60 days after cutting			90 days after cutting		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Panniyur-1	8.71	10.75	9.73	12.90	14.50	13.70	18.44	19.17	18.81	24.81	25.33	25.07
Panniyur-2	7.98	10.01	9.00	12.08	13.59	12.83	17.14	18.33	17.74	23.33	24.28	23.81
Panniyur-3	5.82	8.67	7.24	8.70	11.42	10.06	12.78	15.00	13.89	17.58	19.17	18.38
Panniyur-6	7.02	8.34	7.68	10.37	11.16	10.76	14.52	14.78	14.65	17.94	20.61	19.28
Panniyur-7	5.22	6.89	6.06	6.70	9.00	7.85	9.06	11.11	10.09	12.09	13.16	12.63
Pournami	7.77	9.81	8.79	11.64	13.14	12.39	16.77	17.33	17.05	21.94	23.31	22.63
Panchami	7.33	8.67	8.00	10.56	11.67	11.11	14.59	15.83	15.21	18.48	21.61	20.05
Subhakara	5.87	7.61	6.74	8.06	10.25	9.16	11.33	13.35	12.34	15.39	16.76	16.08
SE(m) ±	0.45	0.41	0.41	0.57	0.59	0.61	0.75	0.73	0.65	0.84	0.47	0.86
C.D. (P=0.05)	1.35	1.23	1.20	1.73	1.70	1.77	2.27	2.21	1.89	2.54	1.43	2.48

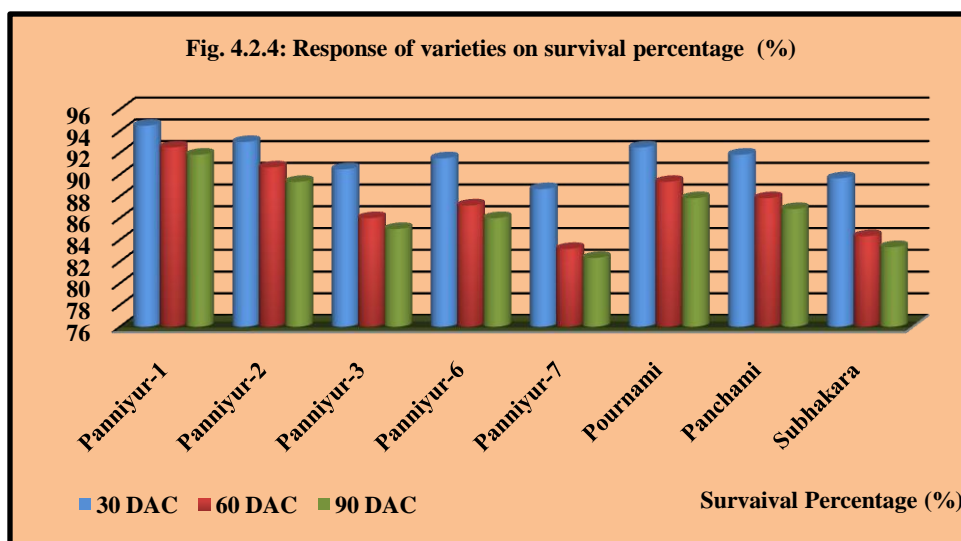
Table 4.2.6 Response of different varieties of black pepper on dry weight of layers

Dry weight of layers (g)												
Varieties	Initial			30 days after cutting			60 days after cutting			90 days after cutting		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Panniyur-1	1.31	1.67	1.49	2.00	2.36	2.18	3.17	3.46	3.32	4.85	5.35	5.10
Panniyur-2	1.20	1.55	1.38	1.87	2.21	2.04	2.99	3.27	3.13	4.60	5.10	4.85
Panniyur-3	0.88	1.35	1.11	1.35	1.86	1.60	1.95	2.73	2.34	3.09	4.06	3.57
Panniyur-6	1.06	1.30	1.18	1.59	1.82	1.70	2.53	2.73	2.63	3.79	4.12	3.95
Panniyur-7	0.79	1.07	0.93	1.04	1.47	1.25	1.63	2.20	1.91	2.39	3.07	2.73
Pournami	1.17	1.52	1.35	1.81	2.14	1.97	2.63	3.16	2.89	4.17	4.74	4.46
Panchami	1.10	1.35	1.22	1.64	1.90	1.77	2.48	2.82	2.65	3.82	4.25	4.03
Subhakara	0.88	1.18	1.03	1.25	1.67	1.46	1.74	2.51	2.12	2.71	3.75	3.23
SE(m) ±	0.07	0.06	0.06	0.09	0.10	0.09	0.19	0.12	0.14	0.21	0.23	0.20
C.D. (P=0.05)	0.20	0.19	0.17	0.27	0.29	0.25	0.59	0.36	0.41	0.63	0.70	0.58

As Panniyur-1 exhibited better shoot parameters and number of roots while Panniyur-7 offered the lowest values for both of the root and shoot parameters. Certainly, the plants with better root and shoot parameters (Panniyur-1) reflected higher dry weight (Panniyur-1) of the plant as previously suggested by Akshay *et al* (2018).

4.2.7 Survival percentage (%)

Data pertaining to the survivability percentage of black pepper layers have been presented in table 4.2.7 and fig. 4.2.4. Response of different varieties of black pepper on serpentine layering showed significant differences. The experimental findings revealed that the maximum survival percentage of layers was observed in Panniyur-1 with



93.00 %, 89.83 % and 88.33 % followed by Panniyur-2 with 92.17 %, 88.84 % and 87.67 % and Pournami with 91.17 %, 87.83 % and 86.33 % at 30 days, 60 days and 90 days respectively, after cutting of layers. On the other hand, the lowest survivability of layers was recorded in Panniyur-7 with 85.50 %, 82.50 %, and 80.67 % followed by Subhakara with 86.33 %, 83.17 % and 81.67 % at 30 days, 60 days and 90 days, respectively after cutting of layers.

Survival percentage among different varieties have been ranged from 81.67 to 88.83 at 90 days after cutting of layers, It might be due to varietal characteristic among the individual varieties and to some extent due to environmental conditions prevailed during the experiment. Khandekar *et al* (2004) reported at par result regarding survival percentage (89.77 % at 90 days after cutting of layers) in Panniyur-1 propagated through bamboo split method comprising of media Soil + sand + FYM @ 1:1:1 under Dapoli Maharashtra condition. Bhuyan *et al* (2015) also concluded the closest result regarding survival percentage 89.75 % in (2013-14), 88.21 % in at 90 days after cutting of layer in Jaintia Black Pepper I propagated through serpentine method

frown in a potting mixture of soil + sand + FYM under Bangladesh condition. Hanumanthappa *et al* (2016) also reported a survival percentage of 87.00 through the serpentine method at 90 days after cutting under the coastal district of Karnataka condition. So, the findings of the present experiment were also recorded similar types of results with respect to the survival percentage of Panniyur-1 as observed by the different scientists.

4.2.8 Numbers of planting material production

The observation recorded for the number of planting material production by different black pepper varieties has been presented in table 4.2.8. The highest number of planting materials was produced by Panniyur-1 (51.17) which was statically *at par* with Panniyur-2 (50.50) and Pournami (50.17). Similarly, on the other hand among the different varieties, Panniyur-7 recorded the lowest planting material production (45.17) which was followed by Subhakara (47.00).

It was clear from the above mentioned result that the different varieties of black pepper performed differently and showed a significant variation in terms of total numbers of planting material production. Above mentioned result showed that the total number of planting material production has ranged from 51.17 to 45.17 among the different varieties, which might be due to the genetic constituent of the varieties. The result regarding the total number of planting material production corroborates with the findings of Bhuyan *et al* (2015) who was also found that 54.00 cuttings per year in Jaintia black pepper I through bamboo split method comprising of media mixture soil + sand + FYM @ 1:1:1 under Bangladesh condition. A more or less similar result was also reported by Khandekar *et al* (2004) who concluded that the total number of planting material production 54.16 in Panniyur-1 propagated through serpentine method comprising of media soil + sand + FYM 1:1:1 under Dapoli Maharashtra condition.

Table 4.2.7 Response of different varieties of black pepper on survival percentage

Survival percentage									
Varieties	30 days after cutting			60 days after cutting			90 days after cutting		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Panniyur-1	92.00 (9.75)	94.00 (9.80)	93.00 (9.72)	89.00 (9.64)	90.67 (9.70)	89.83 (9.62)	88.00 (9.59)	89.67 (9.68)	88.83 (9.58)
Panniyur-2	91.33 (9.66)	93.00 (9.73)	92.17 (9.64)	88.67 (9.52)	89.00 (9.62)	88.84 (9.52)	87.33 (9.43)	88.00 (9.57)	87.67 (9.45)
Panniyur-3	86.33 (9.52)	88.00 (9.61)	87.17 (9.51)	83.00 (9.27)	85.00 (9.38)	84.00 (9.27)	81.67 (9.20)	83.67 (9.34)	82.67 (9.22)
Panniyur-6	87.00 (9.57)	90.33 (9.66)	88.67 (9.56)	84.33 (9.35)	85.67 (9.43)	85.00 (9.34)	82.67 (9.27)	84.00 (9.38)	83.33 (9.27)
Panniyur-7	84.00 (9.45)	87.00 (9.49)	85.50 (9.42)	82.00 (9.14)	83.00 (9.20)	82.50 (9.12)	80.00 (9.07)	81.33 (9.18)	80.67 (9.07)
Pournami	89.67 (9.64)	92.67 (9.70)	91.17 (9.62)	87.00 (9.49)	88.67 (9.52)	87.83 (9.45)	85.33 (9.38)	87.33 (9.47)	86.33 (9.37)
Panchami	88.00 (9.61)	90.67 (9.66)	89.33 (9.58)	85.00 (9.40)	86.00 (9.45)	85.50 (9.37)	83.67 (9.35)	85.00 (9.40)	84.33 (9.32)
Subhakara	85.00 (9.49)	87.67 (9.56)	86.33 (9.47)	82.33 (9.22)	84.00 (9.26)	83.17 (9.18)	80.67 (9.15)	82.67 (9.22)	81.67 (9.13)
SE(m) ±	0.07	0.06	0.02	0.10	0.08	0.03	0.08	0.07	0.02
C.D. (P=0.05)	0.16	0.17	0.05	0.44	0.24	0.07	0.25	0.21	0.07

Values in parenthesis indicate the square root transformed value (Gomez and Gomez 1984).

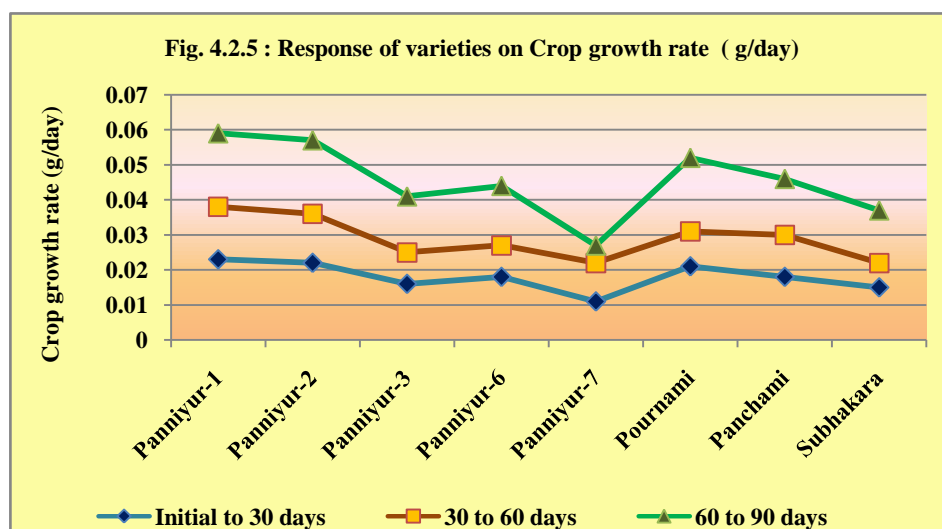
Table 4.2.8 Response of different varieties of black pepper on numbers of planting material production

Numbers of planting material production			
Varieties	2016-17	2017-18	Pooled
Panniyur-1	50.00	52.33	51.17
Panniyur-2	49.00	52.00	50.50
Panniyur-3	46.67	49.33	48.00
Panniyur-6	48.00	50.00	49.00
Panniyur-7	44.00	46.33	45.17
Pournami	49.00	51.33	50.17
Panchami	48.33	51.00	49.67
Subhakara	46.00	48.00	47.00
SE(m) ±	1.01	0.81	0.94
C.D. (P=0.05)	3.04	2.42	2.71

4.2.9 Crop Growth Rate (g/day)

The data pertaining to the crop growth rate of black pepper with response to different varieties as influenced by different black pepper varieties have been recorded in table 4.2.9 and fig. 4.2.5.

Experimental findings revealed that significantly the highest crop growth rate was observed in Panniyur-1 with the crop growth rate of 0.023 g/day (Initial to 30 days after cutting),



0.047 g/day (30 to 60 days after cutting) and 0.059 g/day (60 to 90 days after cutting) followed by Panniyur-2 with 0.022 g/day (Initial to 30 days after cutting), 0.045 g/day (30 to 60 days after cutting) and 0.057 g/day (60 to 90 days after cutting). Whereas, the minimum crop growth rate was observed in Panniyur-7 with 0.011 g/day (Initial to 30 days after cutting), 0.024 g/day (30 to 60 days after cutting) and 0.029 g/day (60 to 90 days after cutting) followed by Subhakara with 0.014 g/day, 0.029 g/day and 0.037 g/day at initial to 30 days, 30 to 60 days and 60 to 90 days, after cutting of layers, respectively.

The crop growth rate is the gain of dry matter production on a unit area and time. It is affected by a series of factors including heat, levels of solar radiation, water supply, crop, cultivar and its age (Reddy 2000). Therefore, the treatment with better root and shoot parameters and treatment combination with higher dry weight has shown higher crop growth, whereas treatment with least roots and shoot parameters and low dry weight had shown the least dry weight of the plants.

Table 4.2.9 Response of different varieties of black pepper on crop growth rate

Crop Growth Rate (g/day)									
Varieties	Initial-30 days after cutting			30-60 days after cutting			60-90 days after cutting		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Panniyur-1	0.023	0.023	0.023	0.045	0.049	0.047	0.056	0.063	0.059
Panniyur-2	0.022	0.022	0.022	0.042	0.048	0.045	0.054	0.061	0.057
Panniyur-3	0.016	0.017	0.016	0.030	0.034	0.032	0.038	0.044	0.041
Panniyur-6	0.018	0.017	0.018	0.032	0.038	0.035	0.042	0.046	0.044
Panniyur-7	0.009	0.013	0.011	0.023	0.025	0.024	0.025	0.029	0.027
Pournami	0.021	0.021	0.021	0.037	0.041	0.039	0.051	0.053	0.052
Panchami	0.018	0.018	0.018	0.034	0.040	0.037	0.044	0.048	0.046
Subhakara	0.012	0.016	0.014	0.026	0.032	0.029	0.032	0.042	0.037
SE(m) ±	0.004	0.004	0.004	0.008	0.005	0.006	0.004	0.008	0.006
C.D. (P=0.05)	0.011	0.012	0.012	0.023	0.015	0.017	0.011	0.024	0.018

4.2.10 Fertility status evaluation of media after harvest

4.2.10.1 Available nitrogen content of media (Kg/ha)

Estimation of available nitrogen after 90 days after cutting of layers in the growing media of different varieties asserted a significant difference. Outcomes were depicted in table 4.2.10 and fig. 4.2. 6. and it was evident that the maximum available nitrogen after 90 days after cutting of layers was recorded from media holding Panniyur-7 (93.89 kg/ha). It was found to be significantly higher than all the other media of the rest other varieties except media holding Subhakara succeeded with 90.84 kg/ha of available nitrogen. On the other hand, media having the lowest available nitrogen (70.53 kg/ha) after 90 days after cutting of layers was recorded with Panniyur-1. But on the basis of uptake (calculated on the basis of subtraction of initial values and

values of 90 days after cutting of layers), the maximum uptake was recorded in Panniyur-1 (83.59 kg/ha) followed by Panniyur-2 (80.24 kg/ha.) Similarly, minimum uptake was recorded in Panniyur-7 (60.23 kg/ha) followed by Subhakara (63.28 kg/ha) respectively after 90 days of cutting of layers.

The nutrient uptake of media reflects the root and shoots parameters developed (Akshay *et al* 2018). Therefore, varieties with better root and shoot parameters have shown the highest nitrogen uptake and recorded the lowest residues in media, whereas the varieties with the least root and shoot parameters had shown the least nitrogen uptake and showed the highest residue in media.

4.2.10.2 Available Phosphorous content of media (Kg/ha)

Data pertaining to available phosphorous of the media of different varieties at 90 days after cutting of layers have been presented in table 4.2.10 and fig. 4.2.6.

Experimental results revealed that among different treatments, significantly the highest phosphorous content was recorded in Panniyur-7 (64.56 kg/ha) which was statistically *at par* with Subhakara (62.79 Kg/ha). On the other hand, minimum phosphorous content was recorded in Panniyur-1 (55.53 kg/ha) followed by Panniyur-2 (57.09 kg/ha) at 90 days after cutting layers. But based on the uptake (calculated on the basis of subtraction of initial values and values of 90 days after cutting of layers) Panniyur-1 recorded maximum phosphorous uptake 35.38 kg/ha followed by Panniyur-2 (33.82 kg/ha) respectively at 90 days after layering. Similarly, minimum phosphorous uptake was recorded in Panniyur-7 with a minimum uptake of 26.35 kg/ha followed by Subhakara (28.12 kg/ha). Likewise, nitrogen, varieties with better vegetative parameters have shown the highest uptake and lowest residue and varieties with poor root and shoot growth recorded the lowest uptake and showed maximum residues in the media.

4.2.10.3 Available potassium content of media (Kg/ha)

Data on available potassium of media of different varieties at 90 days after cutting of layers have been presented in table 4.2.10 and fig. 4.2. 6. Experiment findings revealed that all the varieties showed a significant response to potassium availability. Based on the pooled analysis, Panniyur-7 recorded significantly highest available potassium with 97.89 kg/ha at 90 days after cutting of layers followed by Subhakara (96.04 kg/ha) 90 days after cutting of layers

which was statistically *at par* with Panniyur-1. Similarly, Panniyur-1 showed minimum availability of potassium (79.15 kg/ha) followed by Panniyur-2 with an availability of 88.27 kg/ha at 90 days after cutting of layers. But based on potassium uptake, (calculated on the basis of subtraction of initial values and values of 90 days after cutting of layers) Panniyur-1 recorded maximum uptake (42.25 kg/ha) followed by Panniyur-2 (33.13 kg/ha). Similarly, minimum uptake was recorded in Panniyur-7 (23.51 kg/ha) followed by Subhakara (25.36 kg/ha) respectively at 90 days after cutting of layers.

Maximum Potassium uptake was recorded in Panniyur-1 which was followed by Panniyur-2. The uptake of nutrients by the plants from the media reflects the vegetative parameters of the layers recorded. Therefore treatment with better root and shoot parameters showed the highest uptake and treatments combination with the least root and shoot parameters recorded minimum uptake.

Fig. 4.2.6: Available residual nutrients in media of different varieties of black pepper layers.

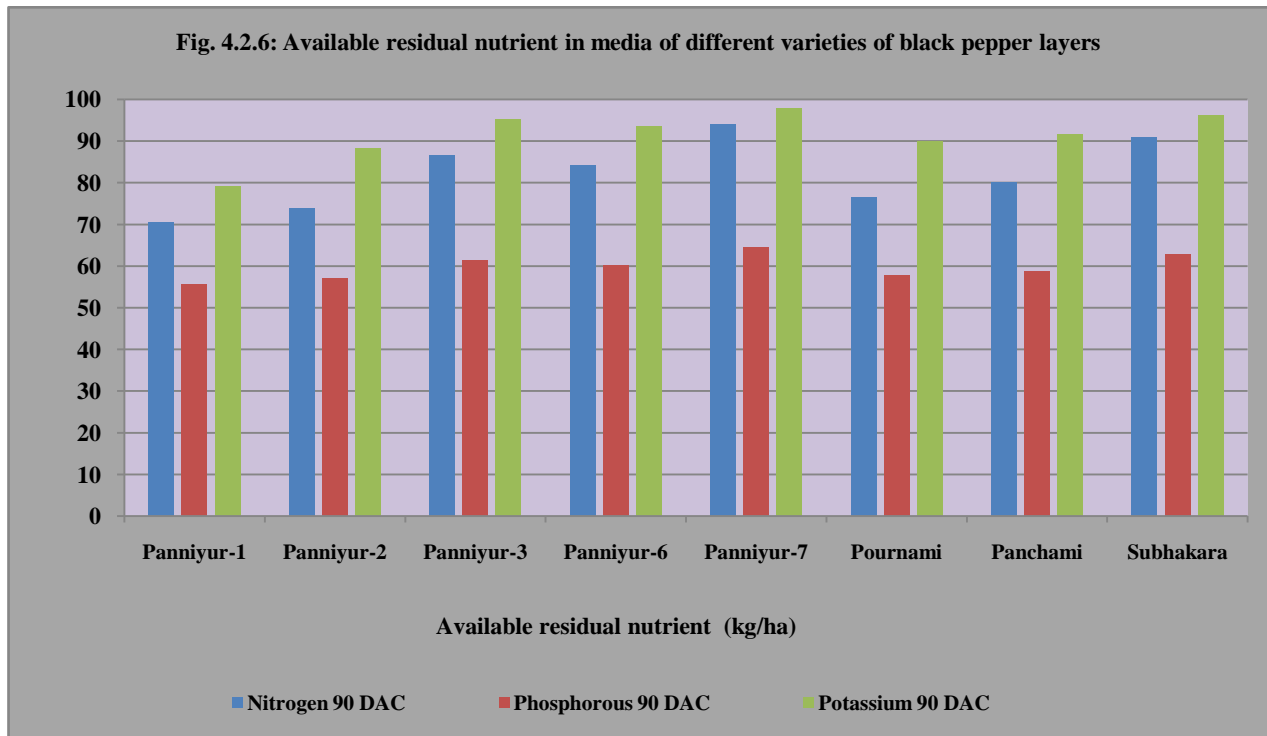


Table 4.2.10 Available residual nutrients in media of different varieties of black pepper layers

Varieties	Nitrogen 90 days (Kg/ha)			Phosphorous 90 days (Kg/ha)			Potassium 90 days (Kg/ha)		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Panniyur-1	71.55	69.51	70.53	57.73	53.33	55.53	81.15	77.15	79.15
Panniyur-2	74.25	73.51	73.88	58.90	55.28	57.09	89.16	87.38	88.27
Panniyur-3	86.97	86.13	86.55	62.51	60.05	61.28	95.57	94.87	95.22
Panniyur-6	85.35	83.15	84.25	61.93	58.33	60.13	95.85	91.25	93.55
Panniyur-7	95.65	92.13	93.89	66.87	62.25	64.56	99.33	96.45	97.89
Pournami	78.18	74.60	76.39	60.39	55.33	57.86	91.56	88.24	89.90
Panchami	81.32	78.70	80.01	60.91	56.45	58.68	92.91	90.25	91.58
Subhakara	91.22	90.46	90.84	64.04	61.54	62.79	96.23	95.85	96.04
SE(m) ±	1.43	1.53	1.42	1.01	1.15	1.10	1.20	1.48	1.25
C.D. (P=0.05)	4.28	4.59	4.12	3.03	3.43	3.18	3.60	4.45	3.62
Initial	155.13	153.10	154.12	88.04	93.77	90.91	119.14	123.65	121.40



Plate 4: Layers of different black pepper varieties at different intervals (Serpentine method)



Panniyur-3 at initial stage



Panniyur-3 at 30 days after cutting of layers.



Panniyur-3 at 60 days after cutting of layers.



Panniyur-3 at 90 days after cutting of layers.



Panniyur-6 at initial stage



Panniyur-6 at 30 days after cutting of layers.



Panniyur-6 at 60 days after cutting of layers.



Panniyur-6 at 90 days after cutting of layers.

Plate 5: Layers of different black pepper varieties at different intervals (Serpentine method)



Plate 6: Layers of different black pepper varieties at different intervals (Serpentine method)

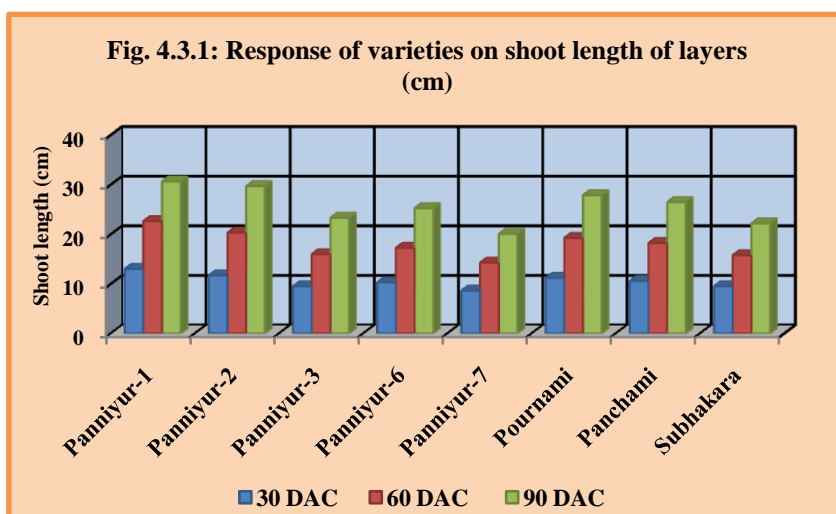
4.3 Experiment III

Experiment entitled “Response of variety for propagation of black pepper by modified serpentine layering” was carried out to study the response of black pepper variety for propagation by modified serpentine layering during the consecutive year 2016-17 and 2017-18 under Pundibari, Cooch Behar, West Bengal condition. Results recorded during this experiment have been presented and discussed in this chapter under appropriate headings.

4.3.1 Shoot length of layers (cm)

The observation taken on shoot length of layers and data arranged in a tabular form have been presented in table 4.3.1 and fig. 4.3.1.

Experimental findings revealed that different varieties showed significant variations on the shoot length of layers at different time intervals. On the basis of pooled analysis, significantly



highest shoot length was recorded in Panniyur-1 (13.00 cm at 30 days after cutting, 22.67 cm at 60 days after cutting and 30.66 cm at 90 days after cutting) and showed differences of 41.70 % when compared with Panniyur-7. Panniyur-2 (11.71 cm, 20.32 cm and 29.72 cm at 30 days, 60 days and 90 days after cutting of layers) also recorded maximum shoot length which was statistically *at par* with Panniyur-1. Panniyur-7 recorded lowest shoot length of 8.65 cm, 14.29 cm and 20.08 cm which was followed by Subhakara (9.52 cm, 15.78 cm and 22.21 cm) at 30 days, 60 days and 90 days after cutting of layers, respectively.

The result mentioned above with respect to shoot length of layers showed that highest shoot length was found in Panniyur-1 followed by Panniyur-2. The variations in shoot length of layers among different varieties might be due to the variation of genetic constituents of the different genotypes preferment differently.

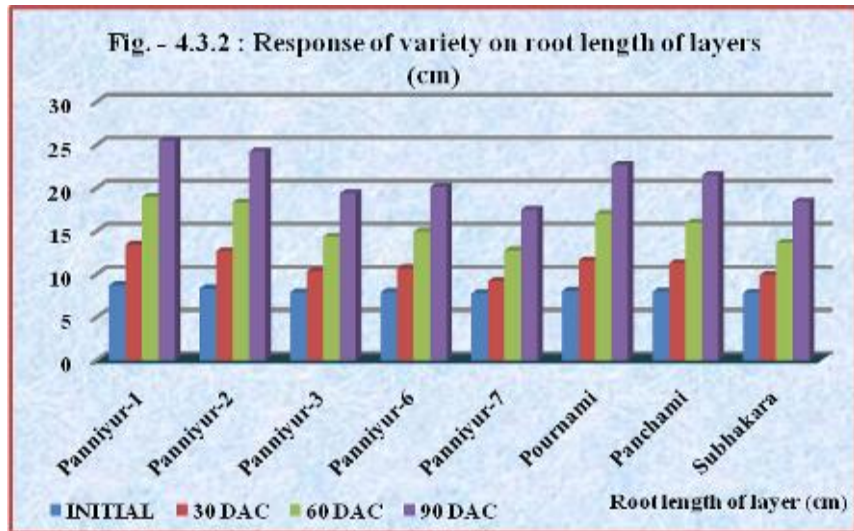
Table 4.3.1 Response of different varieties of black pepper on shoot length of layers

Shoot length of layer (cm)									
Varieties	30 days after cutting			60 days after cutting			90 days after cutting		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Panniyur-1	12.56	13.44	13.00	22.02	23.31	22.67	29.83	31.48	30.66
Panniyur-2	11.66	11.75	11.71	20.12	20.52	20.32	29.15	30.28	29.72
Panniyur-3	9.05	9.98	9.52	14.98	17.00	15.99	22.45	24.23	23.34
Panniyur-6	9.98	10.65	10.32	16.47	18.02	17.25	24.72	25.82	25.27
Panniyur-7	8.25	9.05	8.65	13.84	14.74	14.29	19.97	20.20	20.08
Pournami	10.85	11.56	11.21	18.85	19.68	19.27	27.00	28.79	27.90
Panchami	10.35	10.86	10.61	17.96	18.52	18.24	26.44	26.53	26.49
Subhakara	9.06	9.98	9.52	14.83	16.72	15.78	21.68	22.73	22.21
SE(m) ±	0.81	0.71	0.72	0.95	0.95	0.82	0.61	0.71	0.70
C.D. (P=0.05)	2.44	2.14	2.10	2.87	2.86	2.38	1.83	2.13	2.02

4.3.2 Root length of layers (cm)

Data recorded for root length of layers at different stages have been presented in table 4.3.2 and fig. 4.3.2.

Experimental data revealed that different varieties of black pepper under modified serpentine varied significantly among themselves with respect to root length of layers at 30, 60 and 90 days but showed non-significant variations at



initial stage after cutting of layers. Among different varieties, maximum root length of 8.70 cm at initial, 13.44 cm at 30 days, 18.97 cm at 60 days and 25.48 cm at 90 days after cutting of layers was recorded in Panniyur-1. Higher root length was also recorded in Panniyur-2 (8.35 cm, 12.65 cm, 18.30 cm and 24.23 cm) at initial stage, 30 days, 60 days and 90 days after cutting of layers, respectively which was statistically *at par* with Panniyur-1. Panniyur-7 recorded lowest root length (7.75 cm at initial, 9.17 cm at 30 days, 12.75 cm at 60 days and 17.47 cm at 90 days after cutting of layers). Minimum root length was also recorded in Subhakara with a minimal value of 7.82 cm, 9.90 cm, 13.62 cm and 18.41 cm at initial, 30, 60 and 90 days after cutting of layers, respectively which was statistically *at par* with Panniyur-7. As Panniyur-1 recorded highest root length and showed differences of 37.30 % when compared to Panniyur-7.

Variations among different varieties regarding root length might be due to varietal characteristic among the individual varieties. Akshay *et al* (2018) in Panniyur-1 under Karnataka condition reported similar result, wherein the root length at 75 days after cutting was 26.79 cm. Waman *et al* (2019) also reported that 19.40 cm of root length in *Piper sarmentosum* at 60 days after cutting under Plot Blair condition. Findings with respect to the root length of the Panniyur - 1 was more or less similar with the finding of the Akshay *et al* (2018) and slight variation might be due to the variation of the environmental conditions of experimental location.

Table 4.3.2 Response of different varieties of black pepper on root length of layers

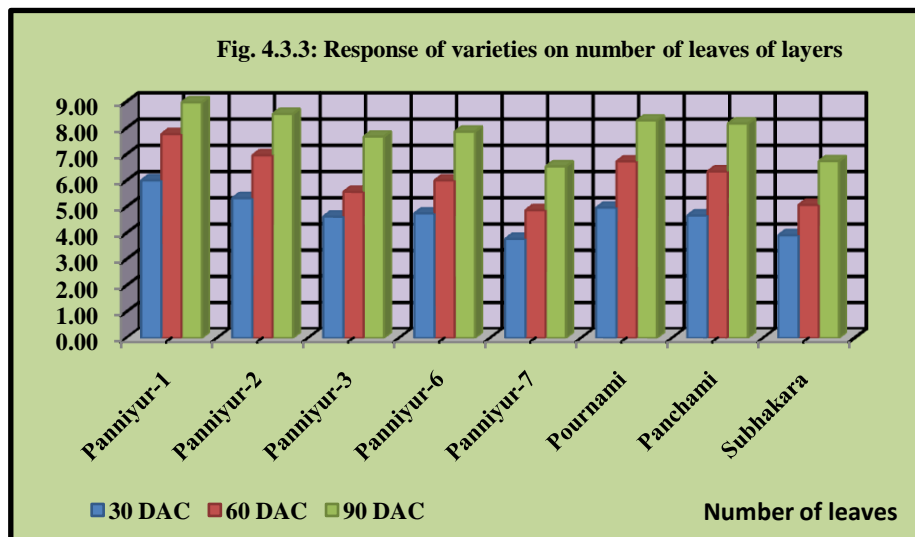
Root length of layer (cm)												
Varieties	Initial			30 days after cutting			60 days after cutting			90 days after cutting		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Panniyur-1	7.85	9.55	8.70	12.03	14.85	13.44	17.75	20.18	18.97	23.98	26.98	25.48
Panniyur-2	7.55	9.15	8.35	11.34	13.95	12.65	16.95	19.65	18.30	22.72	25.75	24.23
Panniyur-3	7.08	8.70	7.89	10.13	10.48	10.31	13.33	15.35	14.34	18.23	20.48	19.36
Panniyur-6	7.11	8.75	7.93	10.40	10.97	10.68	13.85	15.97	14.91	18.88	21.38	20.13
Panniyur-7	6.90	8.60	7.75	9.52	8.82	9.17	12.65	12.85	12.75	17.48	17.47	17.47
Pournami	6.53	9.54	8.04	10.29	12.85	11.57	15.48	18.48	16.98	21.02	24.32	22.67
Panchami	7.15	8.79	7.97	10.87	11.63	11.25	15.05	16.87	15.96	20.48	22.48	21.48
Subhakara	6.95	8.68	7.82	9.90	9.90	9.90	13.05	14.18	13.62	17.82	19.00	18.41
SE(m) ±	0.36	0.38	0.37	0.42	0.89	0.62	0.82	0.84	0.84	0.90	0.87	0.76
C.D. (P=0.05)	N.S.	N.S.	N.S.	1.27	2.68	1.79	2.48	2.54	2.43	2.71	2.62	2.19

N.S. – Non significant

4.3.3 Number of leaves

Data pertaining to number of leaves at various stages as influenced by different black pepper varieties have been presented in table 4.3.3 and fig. 4.3.3.

Result with respect to number of leaves of black pepper layers revealed that maximum number of leaves was recorded in Panniyur-1 (6.01 at 30 days, 7.78 at 60 days and 8.98 at 90 days after cutting of layers) followed by Panniyur-2 (5.33, 6.97 and 8.54) which was statistically *at par* with Panniyur-1 at 30, 60 and 90 days after cutting of layers respectively. Minimum number of leaves was recorded in variety Panniyur-7 (3.78, 4.88, 6.54) followed by Subhakara (3.92, 5.08 and 6.74) at 30, 60 and 90 days after cutting of layers, respectively in modified serpentine layering which was statistically *at par* with Panniyur-7.



From the above mentioned result, it is clear that different varieties showed significant variations with respect to number of leaves of black pepper layers at different time interval i.e. at 30 days, 60 days and 90 days after cutting of layers. Among different varieties, maximum number of leaves was recorded in Panniyur-1 followed by Panniyur-2 which might be due to the genetic characteristic of the individual's varieties.

4.3.4 Number of roots

Data arranged in a tabular form in table 4.3.4 indicated that the different variety of black pepper showed a significant effect on number of roots of black pepper through modified serpentine layering.

The experimental results revealed that the highest number of roots was recorded in Panniyur-1 (4.50 at initial, 6.85 at 30 days, 7.83 at 60 days and 8.96 at 90 days after cutting of layers) followed by Panniyur-2 (3.94, 6.10, 7.26 and 8.34 at initial, 30, 60 and 90 days after

Table 4.3.3 Response of different varieties of black pepper on number of leaves

Number of leaves									
Varieties	30 days after cutting			60 days after cutting			90 days after cutting		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Panniyur-1	5.47	6.55	6.01	7.32	8.12	7.78	7.62	10.35	8.98
Panniyur-2	4.93	5.73	5.33	7.02	6.80	6.97	7.23	9.85	8.54
Panniyur-3	4.18	5.08	4.63	5.38	5.65	5.58	7.12	8.24	7.68
Panniyur-6	4.20	5.30	4.75	5.65	6.25	6.01	7.18	8.55	7.87
Panniyur-7	3.47	4.10	3.78	4.58	5.05	4.88	5.98	7.10	6.54
Pournami	4.42	5.53	4.97	6.37	6.98	6.73	7.93	8.65	8.29
Panchami	4.33	5.00	4.67	6.00	6.58	6.35	7.70	8.65	8.18
Subhakara	3.53	4.30	3.92	4.65	5.38	5.08	6.25	7.23	6.74
SE(m) ±	0.40	0.46	0.44	0.61	0.55	0.50	0.42	0.46	0.36
C.D. (P=0.05)	1.21	1.39	1.28	1.83	1.66	1.46	1.26	1.38	1.04

cutting of layers, respectively) which was statistically *at par* with Panniyur-1. All the varieties showed the significant variation with respect to root number of cuttings at different growth stage but showed non-significant variations at initial stage. The lowest value regarding number of roots was recorded in variety Panniyur-7 (3.13 at initial, 3.63 at 30 days, 4.27 at 60 days and 5.25 at 90 days after cutting of layers) followed by Subhakara (3.32, 4.54, 4.91 and 5.95) at initial stage, 30, 60 and 90 days after layering respectively.

Maximum number of roots was recorded in Panniyur-1 followed by Panniyur-2 which might be due to variations of genetic constituents of the different genotypes. Prajapati (2015) was also reported closest results with respect to number of roots in Panniyur-1 (9.40 at 90 days after planting of cuttings) under Gujarat condition. Akshay *et al* (2018) also reported more or less similar result regarding the number of roots in Panniyur-1 (11.07 at 75 days after cutting) under Karnataka condition.

4.3.5 Fresh weight of layers (g)

The data pertaining to fresh weight of layers at various stages as influenced by different black pepper varieties have been presented in table 4.3.5. After perusal of the data, it was observed that the fresh weight of layers varied significantly with respect to the layers of the different varieties of black pepper. The highest fresh weight of 9.21 g, 14.58 g, 20.71 g and 27.62 g at initial, 30 days, 60 days and 90 days after cutting of layers, respectively was recorded in Panniyur-1. Panniyur-2 also recorded the higher fresh weight of layers at different time intervals (8.89 g, 13.58 g, 18.83 g and 24.85 g) at initial, 30, 60 and 90 days after cutting of layers, respectively. Among the different black pepper varieties, Panniyur-7 recorded the lowest fresh weight of 6.38 g at initial, 8.86 g at 30 days, 11.27 g at 60 days and 14.30 g at 90 days after cutting of layers followed by Subhakara (7.00 g, 9.80 g, 12.92 g and 16.55 g) at initial, 30, 60 and 90 days after cutting of layers, respectively.

As Panniyur-1 showed better for root and shoot parameters and Panniyur-7 showed the lowest result for both roots and shoots parameters. Therefore, the plant under treatment with better root and shoot parameters had shown higher fresh weight of plant, whereas the plant under treatment with least roots and shoot parameters had shown least dry weight of the plants. Similar trends were also reported by Akshay *et al* (2018) in their experiment with black pepper var. Panniyur-1 under Karnataka condition.

Table 4.3.4 Response of different varieties of black pepper on number of roots

Number of roots												
Varieties	Initial			30 days after cutting			60 days after cutting			90 days after cutting		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Panniyur-1	4.07	4.93	4.50	6.33	7.37	6.85	7.15	8.52	7.83	8.71	9.21	8.96
Panniyur-2	3.80	4.08	3.94	6.00	6.20	6.10	6.68	7.84	7.26	7.52	9.15	8.34
Panniyur-3	3.12	3.92	3.52	4.40	4.93	4.67	4.95	5.22	5.08	5.60	6.67	6.14
Panniyur-6	3.35	3.83	3.59	4.65	5.00	4.83	5.34	5.85	5.60	6.07	7.47	6.77
Panniyur-7	2.75	3.52	3.13	3.17	4.10	3.63	4.18	4.35	4.27	4.67	5.83	5.25
Pournami	3.67	4.12	3.89	5.07	6.02	5.55	6.16	6.68	6.42	6.83	8.63	7.73
Panchami	3.47	3.90	3.68	4.75	5.68	5.22	5.44	5.97	5.71	6.17	8.03	7.10
Subhakara	3.03	3.60	3.32	3.92	5.17	4.54	4.65	5.17	4.91	5.27	6.63	5.95
SE(m) ±	0.36	0.42	0.40	0.44	0.51	0.24	0.58	0.68	0.38	0.70	0.58	0.62
C.D. (P=0.05)	N.S.	N.S.	N.S.	1.32	1.55	0.69	1.76	2.05	1.10	2.12	1.75	1.78

N.S. – Non significant

Table 4.3.5 Response of different varieties of black pepper on fresh weight of layers

Fresh weight of layers (g)												
Varieties	Initial			30 days after cutting			60 days after cutting			90 days after cutting		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Panniyur-1	8.43	10.00	9.21	13.33	15.83	14.58	19.17	22.25	20.71	25.83	29.41	27.62
Panniyur-2	7.99	9.79	8.89	12.58	14.58	13.58	17.77	19.90	18.83	23.77	25.93	24.85
Panniyur-3	6.33	8.18	7.25	9.95	10.83	10.39	13.90	13.87	13.88	18.47	17.36	17.91
Panniyur-6	6.78	8.78	7.78	10.76	11.83	11.30	15.10	15.26	15.18	20.17	19.23	19.70
Panniyur-7	5.43	7.33	6.38	8.60	9.12	8.86	12.01	10.53	11.27	15.93	12.67	14.30
Pournami	7.50	9.33	8.41	11.68	13.37	12.52	16.30	17.90	17.10	21.68	23.07	22.37
Panchami	7.13	8.99	8.06	11.23	12.58	11.91	15.73	16.57	16.15	20.97	21.13	21.05
Subhakara	6.00	7.99	7.00	9.37	10.23	9.80	13.00	12.84	12.92	17.23	15.87	16.55
SE(m) ±	0.48	0.51	0.50	0.46	0.60	0.50	0.72	0.89	0.63	0.77	0.84	0.83
C.D. (P=0.05)	1.44	1.54	1.46	1.40	1.85	1.45	2.18	2.69	1.82	2.33	2.55	2.42

4.3.6 Dry weight of layers (g)

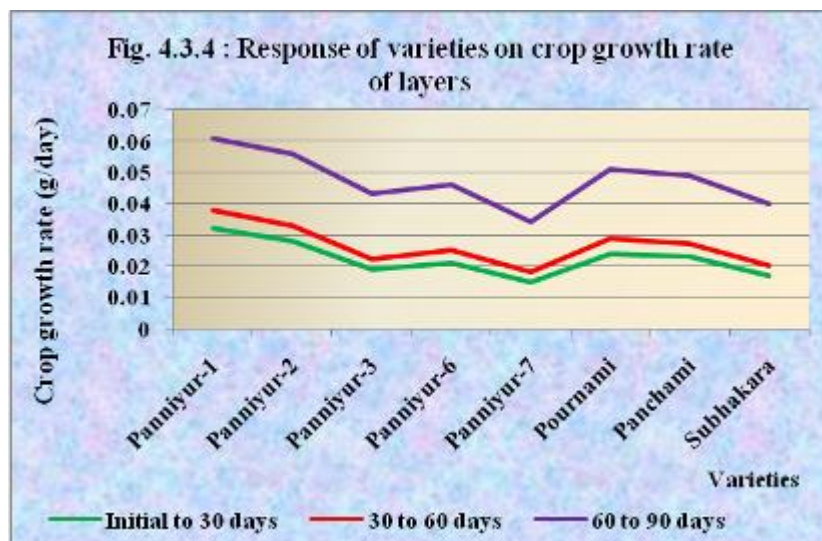
Data illustrated to layers dry weight of black pepper have been presented in the table 4.3.6. The result indicated that significant response was showed by different varieties of black pepper. Perusal of the data revealed that maximum dry weight of 1.76 g at initial, 2.52 g at 30 days, 3.73 g at 60 days and 5.94 g at 90 days after cutting of layers was recorded in Panniyur-1 followed by Panniyur-2 (1.60 g, 2.35 g, 3.38 g and 5.45 g) at initial stage, 30 days, 60 days and 90 days after layering, respectively which was statistically *at par* with Panniyur-1. Similarly with respect to dry weight of layers the lowest dry weight of layers was recorded in Panniyur-7 (1.26 g at initial, 1.56 g at 30 days, 2.18 g at 60 days and 3.76 g at 90 days after cutting of layers followed by Subhakara (1.29 g, 1.72 g, 2.37 g and 3.96 g) at initial stage, 30 days, 60 days and 90 days after cutting of layers, respectively which was statistically *at par* with Panniyur-7.

The fresh weight of plant reflects the root and shoots parameters of the layers recorded (Akshay *et al* 2018). From the above mention result it is apparent that the root and shoot parameters combined, led to higher fresh weight of the plant. Therefore variety with highest root and shoot parameters contributes to higher dry weight of layers.

4.3.7 Crop growth rate (g/day)

The data pertaining response of different black pepper varieties on crop growth rate of black pepper layers have been presented in table 4.3.7 and fig.4.3.4.

Experimental findings revealed that significantly highest result with respect to crop growth rate of layers was recorded in Panniyur-1 with growth rate of 0.025 g/day (Initial to 30 days after cutting), 0.040 g/day (30 to 60



days after cutting) and 0.074 g/day (60 to 90 days after cutting) followed by Panniyur-2 (0.025 g/day at initial to 30 days after cutting, 0.034 g/day at 30 to 60 days after cutting and 0.069 g/day

Table 4.3.6 Response of different varieties of black pepper on dry weight of layers

Dry weight of layers (g)												
Varieties	Initial			30 days after cutting			60 days after cutting			90 days after cutting		
	2016-17	2017-18	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Panniyur-1	1.57	1.94	1.76	2.15	2.89	2.52	3.15	4.30	3.73	5.78	6.10	5.94
Panniyur-2	1.38	1.82	1.60	2.02	2.68	2.35	2.67	4.10	3.38	4.91	5.98	5.45
Panniyur-3	1.23	1.55	1.39	1.59	2.04	1.82	2.12	2.95	2.54	3.96	4.44	4.20
Panniyur-6	1.26	1.55	1.41	1.73	2.21	1.97	2.28	3.25	2.77	4.29	4.75	4.52
Panniyur-7	1.13	1.39	1.26	1.37	1.75	1.56	1.85	2.51	2.18	3.52	4.00	3.76
Pournami	1.32	1.74	1.53	1.88	2.47	2.17	2.39	3.80	3.10	4.63	5.37	5.00
Panchami	1.24	1.68	1.46	1.80	2.34	2.07	2.31	3.55	2.93	4.52	5.00	4.76
Subhakara	1.06	1.52	1.29	1.50	1.94	1.72	2.14	2.60	2.37	3.67	4.24	3.96
SE(m) ±	0.09	0.08	0.09	0.10	0.10	0.08	0.22	0.30	0.19	0.36	0.46	0.21
C.D. (P=0.05)	0.28	0.23	0.26	0.30	0.31	0.24	0.67	0.91	0.54	1.10	1.38	0.61

at 60 to 90 days after cutting of layers respectively. Whereas, minimum growth rate was observed in Panniyur-7 (0.10 g/day, 0.021g/day and 0.053 g/day) followed by Subhakara (0.015 g/day, 0.022g/day and 0.053 g/day) at initial to 30 days, 30 to 60 days and 60 to 90 days, respectively after cutting of layers.

Table 4.3.7 Response of different varieties of black pepper on crop growth rate

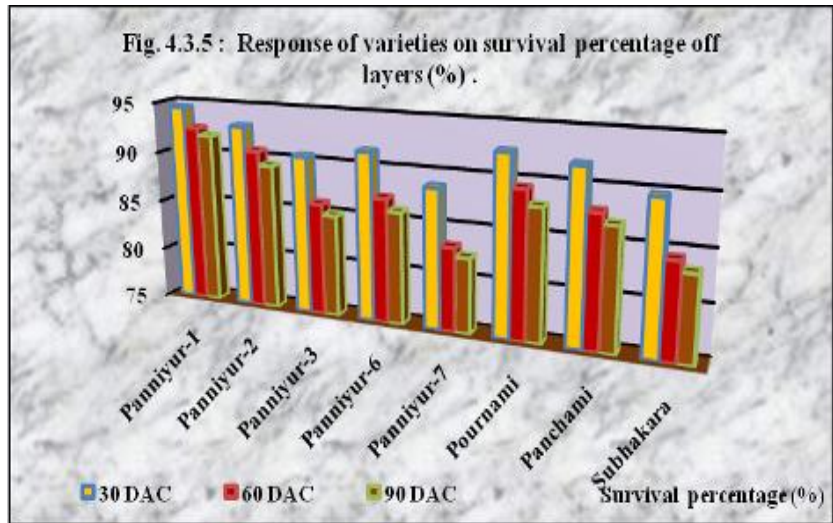
Crop growth rate (g/day)									
Varieties	Initial-30 days after cutting			30-60 days after cutting			60-90 days after cutting		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Panniyur-1	0.023	0.027	0.025	0.033	0.047	0.040	0.079	0.069	0.074
Panniyur-2	0.022	0.029	0.025	0.031	0.038	0.034	0.072	0.065	0.069
Panniyur-3	0.012	0.016	0.014	0.022	0.026	0.024	0.059	0.052	0.056
Panniyur-6	0.015	0.022	0.019	0.024	0.029	0.027	0.063	0.054	0.059
Panniyur-7	0.008	0.012	0.010	0.018	0.023	0.021	0.055	0.050	0.053
Pournami	0.018	0.025	0.021	0.024	0.037	0.031	0.068	0.059	0.064
Panchami	0.019	0.022	0.020	0.025	0.032	0.029	0.054	0.068	0.061
Subhakara	0.015	0.014	0.015	0.021	0.022	0.022	0.055	0.051	0.053
SE(m) ±	0.003	0.009	0.005	0.006	0.007	0.006	0.004	0.006	0.005
C.D. (P=0.05)	0.01	0.026	0.016	0.017	0.023	0.018	0.013	0.019	0.015

Crop growth rate is the gain of dry matter production on a unit area and time. It is affected by a series of factors including heat, levels of solar radiation, water supply, crop, cultivar and its age (Reddy 2000). Therefore, the treatment with better root and shoot parameters and treatment combination with higher dry weight has shown higher crop growth, whereas treatment with least roots and shoot parameters and low dry weight had shown least fresh weight of the plants.

4.3.8 Survival percentage (%)

Data pertaining to survivability percentage of black pepper layers have been presented in the table 4.3.8 and fig. 4.3.5. Response of different varieties of black pepper on modified serpentine layering showed significant variations among themselves.

It was revealed that the maximum survival percentage of layers was observed in Panniyur-1 (94.50 % at 30



days, 92.50 % at 60 days and 91.83 % at 90 days after cutting of layers, respectively. Panniyur-2 (93.00 %, 90.67 % and 89.33 %) and Pournami (92.50 %, 89.33 % and 87.83 %) also showed higher survival percentage at the different time intervals i.e. at 30 days, 60 days and 90 days after cutting of layers. On the other hand, the lowest survivability of layers was recorded in Panniyur-7 with a minimal value of 88.67 %, 83.17 %, and 82.33 % followed by Subhakara with a value of 89.67 %, 84.33 % and 83.33 % at 30 days, 60 days and 90 days, respectively after cutting of layers.

Panniyur-1 recorded highest survival percentage which was followed by Panniyur-2 at different time intervals. It might be due to varietal characteristic. More or less similar results were also reported by Khandekar *et al* (2004). They found that survival percentage 90.71 % at 90 days after cutting of layers in Panniyur-1 propagated through soil mound method i.e similar like modified serpentine layering. Hanumanthappa *et al* (2016) also reported survival percentage (89.75 %) in Panniyur-4 through soil mound method at 90 days after cutting under costal district of Karnataka condition. Bhuyan *et al* (2015) also reported that survival percentage (89.18 %) at 90 days after cutting of layer in Jaintia black pepper I propagated through soil mound method grown in Bangladesh condition. These findings were more or less similar with findings of the present experiment.

Table 4.3.8 Response of different varieties of black pepper on survival percentage

Survival percentage									
Varieties	30 days after cutting			60 days after cutting			90 days after cutting		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Panniyur-1	94.00 (9.75)	95.00 (9.80)	94.50 (9.72)	92.00 (9.64)	93.00 (9.70)	92.50 (9.62)	91.00 (9.59)	92.67 (9.68)	91.83 (9.58)
Panniyur-2	92.33 (9.66)	93.67 (9.73)	93.00 (9.64)	89.67 (9.52)	91.67 (9.63)	90.67 (9.52)	88.00 (9.43)	90.67 (9.57)	89.33 (9.45)
Panniyur-3	89.67 (9.52)	91.33 (9.61)	90.50 (9.51)	85.00 (9.27)	87.00 (9.38)	86.00 (9.27)	83.67 (9.20)	86.33 (9.35)	85.00 (9.22)
Panniyur-6	90.67 (9.57)	92.33 (9.66)	91.50 (9.56)	86.33 (9.35)	88.00 (9.43)	87.17 (9.34)	85.00 (9.27)	87.00 (9.38)	86.00 (9.27)
Panniyur-7	88.33 (9.45)	89.00 (9.49)	88.67 (9.42)	82.67 (9.15)	83.67 (9.20)	83.17 (9.12)	81.33 (9.07)	83.33 (9.18)	82.33 (9.07)
Pournami	92.00 (9.64)	93.00 (9.70)	92.50 (9.62)	89.00 (9.49)	89.67 (9.52)	89.33 (9.45)	87.00 (9.38)	88.67 (9.47)	87.83 (9.37)
Panchami	91.33 (9.61)	92.33 (9.66)	91.83 (9.58)	87.33 (9.40)	88.33 (9.45)	87.83 (9.37)	86.33 (9.35)	87.33 (9.40)	86.83 (9.32)
Subhakara	89.00 (9.49)	90.33 (9.56)	89.67 (9.47)	84.00 (9.22)	84.67 (9.26)	84.33 (9.18)	82.67 (9.15)	84.00 (9.22)	83.33 (9.13)
SE(m) ±	0.03	0.03	0.02	0.04	0.03	0.02	0.03	0.06	0.02
C.D. (P=0.05)	0.09	0.09	0.07	0.11	0.08	0.07	0.09	0.04	0.04

Values in parenthesis indicate the square root transformed value (Gomez and Gomez 1984)

4.3.9 Number of planting material production:

The data illustrated to planting material productions as influenced by different black pepper varieties have been presented in table 4.3.9.

On the basis of pooled analysis, number of planting material production was recorded maximum in Panniyur-1 with a maximum production of 52.17 which was also statistically *at par* with Panniyur-2 (50.83), Pournami (49.83) and Panchami (48.33). Minimum number of planting material was produced by Panniyur-7 (46.00) followed by Subhakara (47.17).

Variations in total number of planting material production showed that different black pepper varieties responded significantly and recorded 52.17 to 46.00 cuttings per year which might be due to genetically inherited traits. More or less similar result was also reported by Khandekar *et al* (2004), they found that total number of planting material production 54.16 (2014-15) in Panniyur-1 propagated through serpentine method under Dapoli Maharashtra condition.

Table 4.3.9 Response of different varieties of black pepper on numbers of planting material production

Numbers of planting material production			
Treatments	2016-17	2017-18	Pooled
Panniyur-1	51.33	53.00	52.17
Panniyur-2	50.33	51.33	50.83
Panniyur-3	47.00	48.33	47.67
Panniyur-6	48.67	49.00	48.83
Panniyur-7	45.00	47.00	46.00
Pournami	49.67	50.00	49.83
Panchami	48.00	49.67	48.33
Subhakara	46.67	47.67	47.17
SE(m) ±	1.09	1.16	1.10
C.D. (P=0.05)	3.31	3.51	3.19

4.3.10 Fertility status evaluation of media at different time interval

4.3.10.1 Available residual nitrogen in media of different varieties.

Data on available nitrogen of different treatment at 90 days after cutting of layers have been presented in the table 4.3.10. All the treatment showed the significant variations with respect to residual available nitrogen of growing media of different varieties.

On the basis of pooled analysis, maximum nitrogen content was recorded in Panniyur-7 (87.42 kg/ha) followed by Subhakara (84.89 kg/ha) at 90 days after cutting of layers respectively. Significantly lowest nitrogen content was recorded in Panniyur-1 (66.60 kg/ha). Lower residual available nitrogen in media of different varieties was also recorded in Panniyur-2 (70.62 kg/ha) at 90 days after cutting of layers. But on the basis of uptake (calculated on the basis of subtraction of initial values and values of 90 days after cutting of layers) maximum uptake was recorded in Panniyur-1 (90.71 kg/ha) followed by Panniyur-2 (86.69 kg/ha) at 90 days after cutting of layers. Similarly, minimum uptake was recorded in Panniyur-7 (69.89 kg/ha) at 90 days after cutting of layers. Minimum uptake of nitrogen was also recorded in Subhakara (72.42 kg/ha) at after 90 days of cutting of layers respectively.

The nutrient uptake by the different varieties of black pepper from the growing media reflected the root and shoots parameters recorded (Akshay *et al* 2018). Therefore, varieties with better root and shoot parameters has shown highest nitrogen uptake, whereas the varieties with least root and shoot parameters had shown least nitrogen uptake

4.3.10.2 Available residual Phosphorous in media of different varieties:

Data recorded on available residual phosphorous content in the media of different varieties at 90 days after cutting of layers have been presented in table 4.3.10.

Among the different black pepper varieties, significantly highest residual available phosphorus was recorded in the media of Panniyur-7 (65.31 kg/ha) at 90 days after cutting of layer. Higher amount of residual phosphorus was also recorded in the media where Subhakara grown (63.57 kg/ha at 90 days after cutting of layers). Significantly lowest phosphorous content was recorded in the media of Panniyur-1 (51.49 kg/ha) at 90 days after cutting followed by Panniyur-2 (53.06 kg/ha at 90 days after cutting of layers) and Pournami (56.06 kg/ha) at 90 days after cutting respectively.

Considering the uptake (calculated on the basis of subtraction of initial values and values of 90 days after cutting of layers), Panniyur-1 recorded maximum phosphorous uptake with a value of 40.92 kg/ha followed by Panniyur-2 (39.35 kg/ha) at 90 days after cutting of layers. Similarly, lowest phosphorous uptake was recorded in Panniyur-7 (27.10 kg/ha) at 90 days after cutting followed by Subhakara (28.24 kg/ha) at 90 days after cutting of layers. Likewise nitrogen, varieties with better vegetative parameters has shown highest uptake and minimum nutrient residue in the media and varieties with poor root and shoot growth recorded the lowest uptake and shown maximum nutrient residues in the media.

4.3.10.3 Available residual potassium in media of different varieties:

Data on available potassium in the media of different varieties have been presented in the table 4.3.10.

On the basis of pooled analysis, maximum residual available potassium was recorded in the media of Panniyur-7(85.99 kg/ha) at 90 days after cutting of layers which was statistically *at par* with Subhakara (84.25 kg/ha) and Panniyur-3 (82.90) at 90 days after cutting of layers. Panniyur-1 showed minimum residual available potassium (74.51 kg/ha) followed by Panniyur-2 (76.31 kg/ha) at 90 days after cutting of layers. Higher potassium uptake (calculated on the basis of subtraction of initial values and values of 90 days after cutting of layers) recorded in Panniyur-1 (48.44 kg/ha) followed by Panniyur-2 (46.64 kg/ha) at 90 days after cutting of layers. Similarly, minimum uptake was recorded in Panniyur-7 (36.96 kg/ha) followed by Subhakara (38.70 kg/ha) at 90 days after cutting of layers.

Maximum Potassium uptake was recorded in Panniyur-1 which was followed by Panniyur-2. The uptake of nutrients by the plants from the media clearly reflects the vegetative parameters of the layers recorded. Therefore, treatment with better root and shoot parameters shows the highest uptake and treatments combination with least root and shoot parameters recorded minimum uptake.

Table 4.3.10 Available residual nutrients in media of different varieties of black pepper layers

Varieties	Nitrogen at 90 days after cutting (Kg/ha)			Phosphorous at 90 days after cutting (Kg/ha)			Potassium at 90 days after cutting (Kg/ha)		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Panniyur-1	68.85	64.35	66.60	52.49	50.49	51.49	75.92	73.10	74.51
Panniyur-2	71.79	69.45	70.62	53.35	52.77	53.06	77.29	75.33	76.31
Panniyur-3	84.27	82.55	83.41	62.37	60.65	61.51	85.45	80.35	82.90
Panniyur-6	83.93	77.25	80.59	60.17	59.85	60.01	82.16	80.36	81.26
Panniyur-7	89.52	85.32	87.42	67.31	63.31	65.31	87.13	84.85	85.99
Pournami	76.51	72.35	74.43	58.06	54.06	56.06	78.17	77.35	77.76
Panchami	78.57	76.85	77.71	59.81	57.81	58.81	82.12	77.22	79.67
Subhakara	86.12	83.66	84.89	65.09	62.05	63.57	85.15	83.35	84.25
SE(m) ±	0.83	1.02	0.64	1.09	1.18	0.63	1.55	1.13	0.89
C.D. (P=0.05)	2.52	3.09	1.85	3.29	3.56	1.82	4.67	3.42	2.57
Initial	156.36	158.25	157.31	89.04	95.77	92.41	121.35	124.55	122.95



Panniyur-1 at initial stage



Panniyur-1 at 30 days after cutting of layers.



Panniyur-1 at 60 days after cutting of layers.



Panniyur-1 at 90 days after cutting of layers.



Panniyur-2 at initial stage



Panniyur-2 at 30 days after cutting of layers.



Panniyur-2 at 60 days after cutting of layers.



Panniyur-2 at 90 days after cutting of layers.

Plate-7: Layers of different black pepper varieties at different intervals (Modified serpentine method)



Panniyur-3 at initial stage



Panniyur-3 at 30 days after cutting of layers.



Panniyur-3 at 60 days after cutting of layers.



Panniyur-3 at 90 days after cutting of layers.



Panniyur-6 at initial stage



Panniyur-6 at 30 days after cutting of layers.



Panniyur-6 at 60 days after cutting of layers.



Panniyur-6 at 90 days after cutting of layers.

Plate-8: Layers of different black pepper varieties at different intervals (Modified serpentine method)



Panniyur-7 at initial stage



Panniyur-7 at 30 days after cutting of layers.



Panniyur-7 at 60 days after cutting of layers.



Panniyur-7 at 90 days after cutting of layers.



Pournima at initial stage



Pournima at 30 days after cutting of layers.



Pournima at 60 days after cutting of layers.



Pournima at 90 days after cutting of layers.

Plate-9: Layers of different black pepper varieties at different intervals (Modified serpentine method)

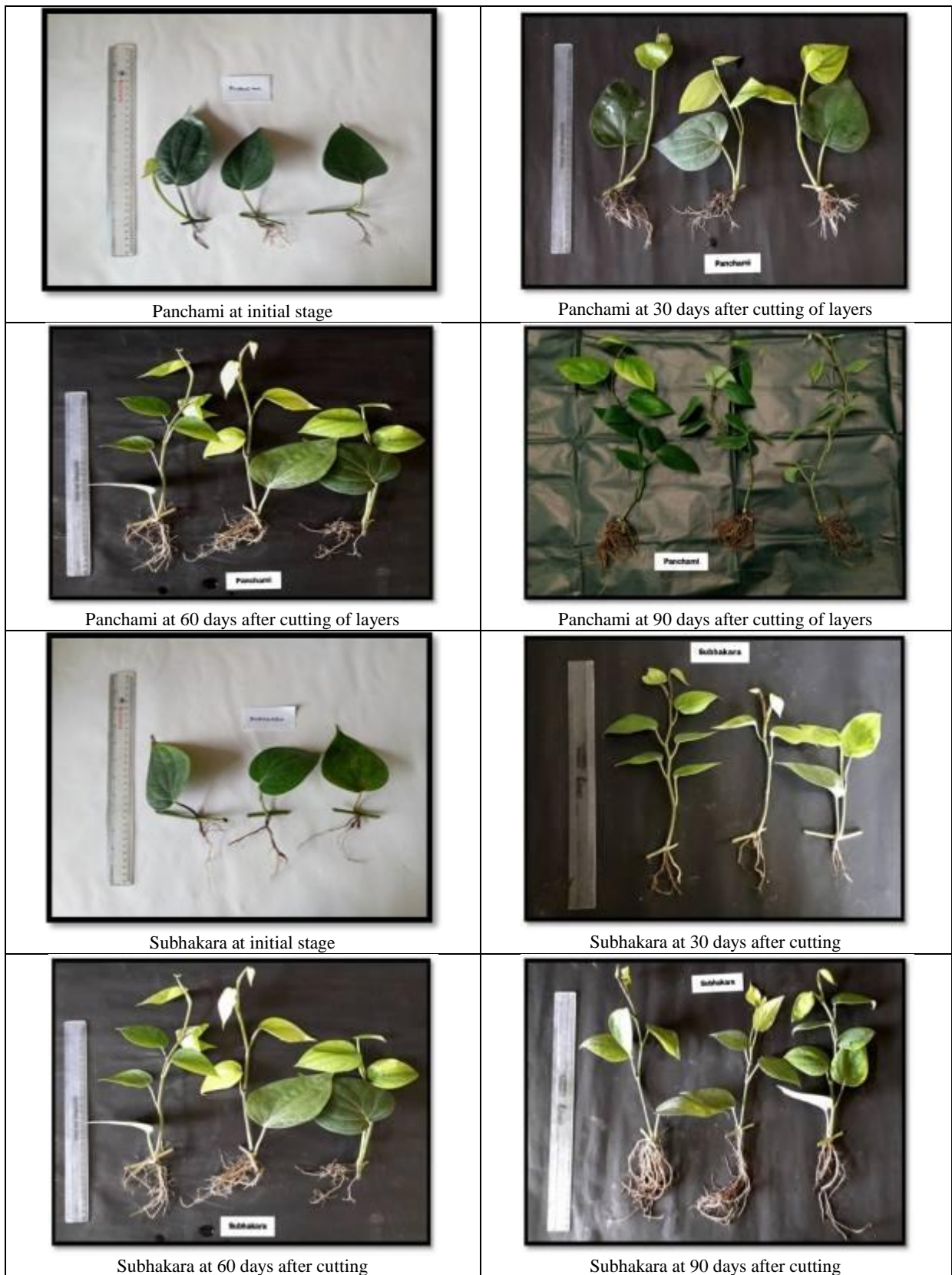
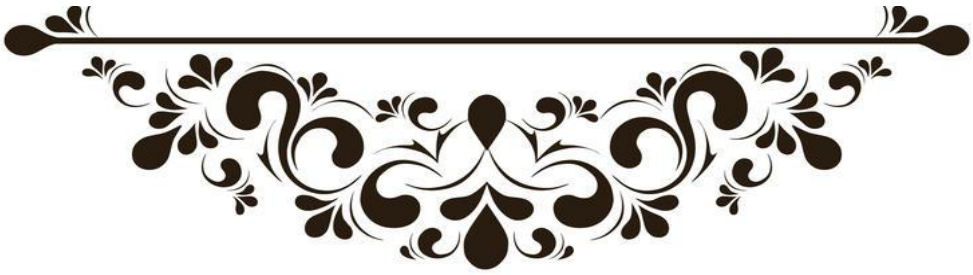


Plate-10: Layers of different black pepper varieties at different intervals (Modified serpentine method)



SUMMARY AND CONCLUSION



SUMMARY AND CONCLUSION

The present investigations on “Effect of different growing media and varieties on serpentine layering of Black Pepper” was carried out at Instructional Farm, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal during the year 2016 and 2017. Experiment was carried to study the effect of different rooting media on serpentine layering of black pepper as well as to study the response of different black pepper varieties on the production of planting material through serpentine layering and modified serpentine layering under terai zone of west Bengal. To fulfill the objectives of the research study, total three experiments were undertaken i.e. Experiment I (Effect of growing media on propagation of black pepper by serpentine cutting of layers), Experiment II (Response of variety for propagation of black pepper by serpentine cutting of layers) and Experiment III (Response of variety for propagation of black pepper by modified serpentine cutting of layers).

Experiment I: Effect of growing media on propagation of black pepper by serpentine layering.

Experiment was laid out in Complete Randomized Design with three replications and 10 different growing media (T₁: top soil, T₂: top soil + sand (1:1), T₃: top soil+ coir pith (1:1), T₄: top soil + FYM (1:2), T₅: top soil + FYM (1:2), T₆: topsoil + coir pith + FYM (1:1:1), T₇: top soil + vermicompost (1:2), T₈: top soil + sand + FYM (1:1:1), T₉: top soil + sand + vermicompost (1:1:1), T₁₀: top soil + coir pith + vermicompost @ 1:1:1) was undertaken for two consecutive years i.e. 2016-17 and 2017-18. The observations were recorded with respect to different growth attributes (viz. Shoot length of layer, root length, number of leaves, and number of roots), fresh weight and dry weight of layers, survival percentage, total number of planting material production and crop growth rate (CGR) as well as available N P K content of different media at different time interval (Initial, 30, 60 and 90 days after cutting of layers) and mean data were statically analyzed.

Experimental findings revealed that the different media showed a significant response on black pepper layers with respect to different growth attributes, survivability, cuttings per year and N P K content of different media. Among the different treatments, T₁₀ (Top soil + coir pith + vermicompost @ 1:1:1) recorded highest shoot length (18.65 cm at 30 days, 24.90 cm at 60 days and 32.72 cm at 90 days after cutting of layers), number of leaves (5.35 at 30 days, 7.73 at 60 days and 9.73 at 90 days after cutting of layers) whilst, T₂ (Top soil + sand @ 1:1) was less effective and recorded lowest shoot length (12.17 cm at 30 days, 14.50 cm at 60

days and 18.22 cm at 90 days after cutting of layers) and number of leaves (3.77 at 30 days, 5.18 at 60 days and 6.58 at 90 days after cutting of layers). Likewise, growing media containing top soil + coir pith + vermicompost @ 1:1:1 (T₁₀) recorded the highest root length (9.08 cm, 13.89 cm, 18.89 cm and 24.73 cm at initial, 30, 60 and 90 days after cutting of layers, respectively), number of roots (6.77, 7.03, 7.90 and 8.93 at initial, 30, 60 and 90 days after cutting of layers, respectively). On the other hand, lowest root length (6.46 cm at initial, 8.71 cm at 30 days, 11.74 cm at 60 days and 15.67 cm at 90 days after cutting of layers) and lowest number of roots 4.72 at initial stage, 4.80 at 30 days, 5.38 at 60 days and 5.78 at 90 days after cutting of layers was found in treatment T₂ (Top soil + sand @ 1:1). Regarding the weight, both fresh weight (9.55 g, 15.88 g, 23.23 g and 29.08 g) and dry weight of layers (1.48 g, 2.53 g, 4.09 g, and 6.05 g) was highest in treatment T₁₀ (Top soil + coir pith + vermicompost @ 1:1:1) at all the aforesaid stages (initial, 30, 60 and 90 days after cuttings). Whereas T₂ (Top soil + sand) recorded minimum fresh weight (7.04 g, 10.20 g, 14.65 g and 20.80 g at initial, 30, 60 and 90 days after cutting, respectively) as well as dry weight (0.93 g, 1.48 g, 2.25 g and 3.37 g) at initial, 30, 60 and 90 days after cutting of layers.

Regarding survival percentage, maximum layers were survived in T₁₀ (94.00 %, 91.17 % and 90.17 %) at 30, 60 and 90 days after cutting while lowest in treatment T₂ (86.50 %, 82.00 % and 80.67 %) at 30, 60 and 90 days after cutting of layers. Total number of planting material was produced maximum (53.67) by the plants under treatment T₁₀ media comprising of top soil + coir pith + vermicompost @ 1:1:1 which was statistically *at par* with T₉ treatment (51.17) comprising growing media of top soil + sand + vermicompost @ 1:1:1 and T₇ treatment (50.50) comprising growing media of top soil + vermicompost @ 1:2. Treatment T₆ (top soil + coir pith + FYM @ 1:1:1) and T₅ (Top soil + FYM @ 1:2) also produced higher number of planting material (50.00 in each treatment) whilst T₂ (43.50) was found to be less efficient. Maximum growth rate was recorded in T₁₀ (0.032 g/day, 0.052 g/day and 0.065 g/day at initial-30 days, 30-60 days and 60-90 days after cutting of layers) while treatment T₂ (0.015 g/day at initial- 30 days, 0.026 g/day at 30- 60 days and 0.037 g/day at 60-90 days after cutting of layers) was found to be less efficient. With respect to available N, P, K content of different media showed the significant effect. Highest available nitrogen (253.49 Kg/ha), phosphorous (104.98 Kg/ha) was recorded in T₇ growing media (Top soil + vermicompost @ 1:2) and potassium (178.27 kg/ha) was recorded in T₁₀ were as lowest available nitrogen (107.22 kg/ha), phosphorous (28.77 kg/ha) and potassium (57.53 kg/ha) at the time of media preparation was found in T₂ (Top soil + sand @ 1:1). Again data

was recorded to study the availability of residual N P K content in different media 90 days after cutting of layers. Highest residual nitrogen (168.55 kg/ha) was recorded in T₄ and phosphorous (65.35 kg/ha) was recorded in T₇ were as highest potassium residue was found in T₁₀ (129.90 kg/ha) at 90 days after cutting. Lowest available residual nitrogen (42.93 kg/ha), phosphorous (14.62) and potassium (33.75 kg/ha) was recorded in T₂ at 90 days after cutting of layers. But on the basis of uptake maximum uptake of nitrogen (114.87 kg/ha), phosphorous (44.01 kg/ha) and potassium (48.45 kg/ha) at 90 days after cutting of layers was recorded in T₁₀ whilst T₂ showed the minimum uptake of nitrogen (64.16 kg/ha), phosphorous (14.15 kg/ha) and potassium (23.84 kg/ha) at 90 days after cutting of layers respectively.

Experiment II: Response of variety for propagation of black pepper by serpentine layering.

The field experiment was undertaken to study the response of black pepper varieties for propagation through serpentine layering. Experiment was laid in Complete Randomized Block Design with three replications. Eight black pepper varieties (viz. Panniyur-1, Panniyur-2, Panniyur-3, Panniyur-6, Panniyur-7, Pournami, Panchami and Subhakara) layered in a media comprising of soil + sand + FYM @ 1:1:1 were undertaken to evaluate. Observation regarding shoot length, root length, number of roots, number of leaves, fresh weight and dry weight of layer, crop growth rate (CGR), survival percentage, total number of planting material production at initial, 30, 60 and 90 days after cutting of layers and available N P K content of media at the time of media preparation and at 90 days after cutting of layers were recorded. Mean data on all the recorded parameters were statistically analyzed.

Among the different varieties, significant variations were recorded with respect to all the observed parameters mentioned above. Maximum shoot length (12.65 cm at 30 days, 19.75 cm at 60 days and 26.44 cm at 90 days after cutting of layers) were recorded in Panniyur-1, meanwhile lowest shoot length was recorded in Panniyur-7 (8.04 cm at 30 days, 12.53 cm at 60 days and 16.63 cm at 90 days after cutting of layers). Maximum root length of 7.06 cm, 12.36 cm, 18.30 cm and 23.75 cm was recorded in Panniyur-1 at initial, 30, 60 and 90 days after cuttings, respectively. Whereas, Panniyur-7 recorded lowest root length of 6.50 cm, 8.93 cm, 12.99 cm and 17.58 cm at initial 30, 60 and 90 days after cutting of layers, respectively. Best result with respect to number of root and leaves were observed in Panniyur-1, root number of 3.78, 5.95, 7.85 and 8.73 and leaves number of 4.63, 6.90 and 8.39 at 30, 60 and 90 days after cutting of layers respectively, was highest. Similarly, like

other parameters, Panniyur-7 also recorded the lowest result with respect to number of leaves (3.43, 4.03 and 5.48) at 30, 60 and 90 days after cutting of layers and number of root (2.28, 2.50, 4.68 and 5.58) at initial, 30, 60 and 90 days after cutting of layers. Panniyur-1 also showed significant response with respect to fresh and dry weight of layers at different time intervals and recorded maximum fresh weight (9.73 g, 13.70 g, 18.81 g and 25.07 g) and dry weight (1.49 g, 2.18 g, 3.32 g and 5.10 g) at initial, 30, 60 and 90 days after cutting. Whereas Panniyur-7 found less effective and recorded lowest fresh weight (6.06 g, 7.85 g, 10.09 g and 12.63 g) and dry weight (0.93 g, 1.25 g, 1.91 g, and 2.73 g) at initial, 30 days, 60 days and 90 days after cutting respectively. Result regarding survival percentage, maximum survivability (93.00 %, 89.83 % and 88.33 %) at 30, 60 and 90 days after cutting of layers was found in Panniyur-1 whilst Panniyur-7 (85.50 %, 82.50 % and 80.67 %) found less effective and recorded lowest survival percentage at 30, 60 and 90 days after cutting.

Maximum planting material per year was produced by Panniyur-1 (51.17) which was higher than the rest of the varieties but was statically *at par* with Panniyur-2 (50.50) and Pournami (50.17). On the other hand, among the different varieties Panniyur-7 recorded lowest planting material production (45.17). Result with respect to growth rate (CGR) again Panniyur-1 showed highest rate (0.023 g/day, 0.047 g/day and 0.059 g/day) at initial - 30 days, 30 - 60 days and 60 - 90 days after cutting of layers whereas Panniyur-7 again recorded lowest growth rate (0.011 g/day, 0.024 g/day and 0.027 g/day) at initial - 30 days, 30 - 60 days and 60 - 90 days after cutting of layers respectively. Result with respect to available residual N P K at 90 days after cutting Panniyur-7 showed maximum residual N P K content of (93.89 Kg/ha nitrogen), (64.56 kg/ha phosphorous) and (97.89 kg/ha potassium) at 90 days after cutting. Similarly Panniyur-1 recorded lowest available residual nitrogen (70.53 kg/ha nitrogen), phosphorous (55.53 kg/ha phosphorous), and potassium (79.15 kg/ha potassium) at 90 days after cutting of layers, respectively. But on the basis of uptake maximum uptake 83.59 kg/ha (nitrogen), 39.14 kg/ha (phosphorous) and 42.5 kg/ha (potassium) was recorded by Panniyur-1 at 90 days after cutting. Whereas, Panniyur-7 recorded the minimum uptake of nitrogen (60.63 kg/ha) phosphorous, (26.35 kg/ha) and potassium (23.51 kg/ha) at 90 days after cutting of layers.

Experiment III: Response of variety for propagation of black pepper by modified serpentine layering

Experiment entitled “Response of variety for propagation of black pepper by modified serpentine layering” was carried out to study the response of black pepper variety for

propagation by modified serpentine layering during the consecutive year 2016-17 and 2017-18 under West Bengal condition. The field experiment was laid in Complete Randomized Design with three replications and eight varieties (viz. Panniyur-1, Panniyur-2, Panniyur-3, Panniyur-6, Panniyur-7, Pournami, Panchami and Subhakara) were undertaken to evaluate. Varieties are planted in a well prepared seed bed and later after cutting; layers are shifted in poly bag filled with a mixture of sand + soil + FYM @ 1:1:1. Observation regarding shoot length, root length, number of roots, number of leaves, fresh weight and dry weight of layer, crop growth rate (CGR), survival percentage, total number of planting material production at initial, 30, 60 and 90 days after cutting of layers and Available N P K content of media at the time of media preparation and at 90 days after cutting of layers were recorded. Mean data on all the recorded parameters were statistically analyzed.

On the basis of pooled analysis, result recorded on different parameters at different time interval showed positive response and varied significantly among different varieties. Highest shoot length was recorded in Panniyur-1 (13.00 cm at 30 days after cutting, 22.67 cm at 60 days after cutting and 30.66 cm at 90 days after cutting) and it was 41.70 % higher in magnitude as compared to Panniyur-7. Panniyur-7 found less effective and recorded lowest shoot length (8.65 cm, 14.29 cm and 20.08 cm) at 30, 60 and 90 days after cutting of layers. Highest result with respect to root length 8.70 cm at initial, 13.44 cm at 30 days, 18.97 cm at 60 days and 25.48 cm at 90 days after cutting of layers was recorded in Panniyur-1 and showed differences of 33.53% in comparison with Panniyur-7. Lowest root length was recorded in Panniyur-7 (7.75 cm at initial, 9.17 cm at 30 days, 12.75 cm at 60 days and 17.47 cm at 90 days after cutting of layers). Result with respect to number of root and number of leaves, Panniyur-1 recorded maximum root number (4.50 at initial, 6.85 at 30 days, 7.83 at 60 days and 8.96 at 90 days after cutting of layers) and maximum leaves number (6.01 at 30 days, 7.78 at 60 days and 8.98 at 90 days after cutting of layers). Whereas minimum number of roots (3.13 at initial, 3.63 at 30 days, 4.27 at 60 days and 5.25 at 90 days after cutting of layers) and minimum number of leaves (3.78, 4.88, 6.54) at 30, 60 and 90 days after cutting of layers, respectively were recorded in Panniyur-7.

As Panniyur-1 recorded highest results for root and shoot parameters therefore, Panniyur-1 recorded maximum fresh weight (9.21 g, 14.58 g, 20.71 g and 27.62 g) and dry weight (1.76 g, 2.52 g, 3.73 g and 5.94 g) at initial, 30, 60 and 90 days after cutting of layers. Result regarding survival percentage showed that Panniyur-1 recorded maximum survivability (94.50 % at 30 days, 92.50 % at 60 days and 91.83 % at 90 days after cutting of

layers) respectively, whereas it was minimum in Panniyur-7 (88.67 %, 83.17 %, and 82.33 % at 30, 60 and 90 days after cutting of layers, respectively). Panniyur-1 produced maximum planting material (52.17) which was also statistically *at par* with Panniyur-2 (50.83), Pournami (49.83) and Panchami (48.33). Minimum number of planting material was produced by Panniyur-7 (47.17). Result with respect to growth rate (CGR) highest growth rate was recorded in Panniyur-1 (0.025 g/day, 0.040 g/day and 0.074 g/day) at initial - 30 days, 30 - 60 days and 60 - 90 days after cuttings of layers. Panniyur-7 recorded lowest growth rate (0.010 g/day, 0.021 g/day and 0.053 g/day) at initial - 30 days, 30 - 60 days and 60 - 90 days after cuttings of layers.

Maximum residual N P K content was recorded in Panniyur-7 with nitrogen 87.42 Kg/ha, phosphorous 65.31 Kg/ha and potassium 85.99 Kg/ha at 90 days after cutting of layers. Significantly lowest residual N P K content was recorded in Panniyur-1 with nitrogen 66.60 kg/ha, phosphorous 51.49 kg/ha and potassium 74.51 kg/ha at 90 days after cutting of layers. But on the basis of uptake, maximum uptake was recorded in Panniyur-1 (90.71 kg/ha of nitrogen, 40.92 kg/ha of phosphorous and 48.44 kg/ha of potassium at 90 days after cutting of layers). Similarly, minimum uptake was recorded in Panniyur-7 with 69.89 kg/ha of nitrogen, 27.10 kg/ha of phosphorous and 36.96 kg/ha of potassium at 90 days after cutting of layers. Panniyur-1 recorded maximum values for growth attributes parameters and showed maximum uptake and minimum availability of nutrients whereas Panniyur-7 recorded minimum for growth attributing parameters and showed minimum uptake and highest availability of nutrients in media.

CONCLUSION

From the above studies, it may be concluded that among different treatment, maximum number of planting material was produced by the growing media comprising of top soil + coir pith + vermicompost @ 1:1:1 along with higher number of roots and leaves number and shoot length followed by the growing media comprising of top soil + sand + vermicompost @1:1:1 and growing media comprising of top soil + vermicompost @ 1:2 may be used over conventional growing media for production of more than fifty number of healthy planting material.

Among the different varieties of black pepper Panniyur-1, Panniyur-2 and Pournami may be used as mother plant for production of quality planting material of black pepper

through serpentine layering as well as modified serpentine layering method of propagation for production of more number of planting material with higher root and shoot growth.



FUTURE SCOPE OF RESEARCH



FUTURE SCOPE OF RESEARCH

The main objective of this research work was to investigate the effect of growing media of serpentine layering on production of quality planting material as well as to study the response of variety on the production of planting material through serpentine layering and modified serpentine layering with respect to growth and production of layers parameters under terai Zone of West Bengal conditions. Future research may be undertaken on the following aspects-

1. Identification of suitable potting media by inclusion of bio-inoculants for planting material production in a large scale.
2. Studies on tissue culture techniques for quality planting material production of black pepper.
3. Identification of suitable varieties for quality planting material production with respect to different agro climatic region of the West Bengal.
4. Identification of the suitable growing media for organic cultivation.
5. Studies on the performance of different media grown black pepper layers in the main field.
6. Studies on the performance of different varieties in the different parts of the West Bengal.
7. Studies on nursery seedling disease under serpentine layering and modified serpentine layering for healthy planting material production.



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ANNEXURE VII

VITA

Name of the student: : Adarsh Thapa
Father's name: : Bijay Thapa
Mother's name : : Indira Thapa
Nationality : : Indian
Date of birth : : 25.02.1991
Home Permanent address :

EDUCATIONAL QUALIFICATION

Bachelor degree

Name of the University: : Hemwati Nandan Bhauguna Gharwal
University.
Year of award: : 2013
OGPA % : : 73.70

Master degree

Name of the University : : Uttar Banga Krishi Viswavidyalaya
Year of award : : 2015
OGPA : : 7.66

Doctor of Philosophy

OGPA : : 8.19
Title of Master's Thesis : : Effect of growing media and variety on
serpentine layering of black pepper
Scholarship : : University Research Scholarship (URS)

ANNEXURE VIII

Punctuation marks and proof reading symbols

,	Comma	;	Semicolon
:	Colon	.	Full stop
–	Dash	!	Exclamation mark
?	Interrogation or doubt	-	Hyphen; as in knick-knack
'	Apostrophe; as in master's	()	Parenthesis or circular bracket
[]	Brackets or square brackets	{ }	Brace, to enclose two or more lines
“”	Quotation marks	#	Paragraph
+	Plus, the sign of addition	–	Minus, the sign of subtraction
x	The sign of multiplication	÷	The sign of division
∴	Because	∴	Therefore
.		∴	
=	Equal, the sign of equality	>	Greater than
<	Less than	√	Square root

* Asterism, used to call attention to a particular passage

ANNEXURE IX
ABBREVIATION USED

%	:	Percentage
°C	:	Degree centigrade
CD	:	Critical difference
cm	:	Centimetre
DAC	:	Days after cutting
<i>et al.</i>	:	and others
FYM	:	Farmyard Manure
ha	:	Hectare
i.e	:	That is
kg	:	Kilogram
g	:	Gram
mg	:	Milligram
mm	:	Millimetre
m	:	Meter
NS	:	Non significant
S.E(m±)	:	Standard error of mean

ANNEXURE-X

EXPERIMENT-I

ANNOVA for Shoot length of layers (2016-17)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
30 DAC					
Treatment	9	116.103	12.900	12.183	0.000
Error	20	21.177	1.059		
Total	29	137.281			
60 DAC					
Treatment	9	305.104	33.900	16.737	0.000
Error	20	40.509	2.025		
Total	29	345.613			
90 DAC					
Treatment	9	565.261	62.807	13.082	0.000
Error	20	96.022	4.801		
Total	29	661.283			

ANNOVA for Shoot length of layers (2017-18)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
30 DAC					
Treatment	9	117.550	13.061	7.352	0.000
Error	20	35.532	1.777		
Total	29	153.081			
60 DAC					
Treatment	9	270.150	30.017	14.446	0.000
Error	20	41.557	2.078		
Total	29	311.707			
90 DAC					
Treatment	9	474.285	52.698	21.829	0.000
Error	20	48.284	2.414		
Total	29	522.569			

ANNOVA for Shoot length of layers (Pooled)

Source of Variation	Dependent Variable	Sum of Squares	DF	Mean Squares	F-Calculated	Significance
Year	30 DAC	33.645	1	33.645	22.857	.000
	60 DAC	150.258	1	150.258	84.968	.000
	90 DAC	102.390	1	102.390	29.434	.000
Replication * Year	30 DAC	5.237	4	1.309	.890	.480
	60 DAC	18.402	4	4.600	2.601	.052
	90 DAC	19.076	4	4.769	1.371	.263
Treatment	30 DAC	227.146	9	25.238	17.146	.000
	60 DAC	562.001	9	62.445	35.311	.000
	90 DAC	1010.421	9	112.269	32.274	.000
Treatment * Year	30 DAC	7.359	9	.818	.555	.824
	60 DAC	13.253	9	1.473	.833	.591
	90 DAC	29.120	9	3.236	.930	.511
Error	30 DAC	52.992	36	1.472		

	60 DAC	63.663	36	1.768		
	90 DAC	125.229	36	3.479		
Total	30 DAC	12709.584	60			
	60 DAC	22204.283	60			
	90 DAC	36165.692	60			

ANNOVA for number of leaves of layers (2016-17)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
30 DAC					
Treatment	9	5.397	0.600	2.634	0.034
Error	20	4.553	0.228		
Total	29	9.950			
60 DAC					
Treatment	9	13.551	1.506	4.030	0.005
Error	20	7.472	0.374		
Total	29	21.022			
90 DAC					
Treatment	9	23.385	2.598	8.482	0.000
Error	20	6.127	0.306		
Total	29	29.511			

ANNOVA for number of leaves of layers (2017-18)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
30 DAC					
Treatment	9	8.340	0.927	2.726	0.030
Error	20	6.798	0.340		
Total	29	15.138			
60 DAC					
Treatment	9	15.714	1.746	3.427	0.010
Error	20	10.190	0.509		
Total	29	25.904			
90 DAC					
Treatment	9	25.693	2.855	4.641	0.002
Error	20	12.303	0.615		
Total	29	37.997			

ANNOVA for number of leaves of layers (Pooled)

Source of Variation	Dependent Variable	Sum of Squares	DF	Mean Squares	F-Calculated	Significance
Year	30 DAC	19.895	1	19.895	49.045	.000
	60 DAC	63.551	1	63.551	147.628	.000
	90 DAC	15.504	1	15.504	34.450	.000
Replication * Year	30 DAC	.148	4	.037	.091	.985
	60 DAC	2.164	4	.541	1.257	.305
	90 DAC	2.228	4	.557	1.238	.312
Treatment	30 DAC	12.362	9	1.374	3.386	.004
	60 DAC	28.711	9	3.190	7.411	.000
	90 DAC	48.313	9	5.368	11.928	.000
Treatment * Year	30 DAC	1.375	9	.153	.377	.939
	60 DAC	.554	9	.062	.143	.998

	90 DAC	.765	9	.085	.189	.994
Error	30 DAC	14.603	36	.406		
	60 DAC	15.497	36	.430		
	90 DAC	16.202	36	.450		
Total	30 DAC	1300.108	60			
	60 DAC	2452.353	60			
	90 DAC	3756.850	60			

ANNOVA for root length of layers (2016-17)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
INITIAL					
Treatment	9	17.923	1.991	3.569	0.009
Error	20	11.159	0.558		
Total	29	29.082			
30 DAC					
Treatment	9	76.507	8.501	9.197	0.000
Error	20	18.485	0.924		
Total	29	94.992			
60 DAC					
Treatment	9	176.720	19.636	6.288	0.000
Error	20	62.451	3.123		
Total	29	239.171			
90 DAC					
Treatment	9	270.278	30.031	15.262	0.000
Error	20	39.355	1.968		
Total	29	309.632			

ANNOVA for root length of layers (2017-18)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
INITIAL					
Treatment	9	21.821	2.425	4.655	0.002
Error	20	10.417	0.521		
Total	29	32.238			
30 DAC					
Treatment	9	61.015	6.779	4.036	0.004
Error	20	33.596	1.680		
Total	29	94.611			
60 DAC					
Treatment	9	106.068	11.785	8.133	0.000
Error	20	28.982	1.449		
Total	29	135.050			
90 DAC					
Treatment	9	175.550	19.506	10.260	0.000
Error	20	38.023	1.901		
Total	29	213.573			

ANNOV for root length of layers (Pooled)

Source of Variation	Dependent Variable	Sum of Squares	DF	Mean Squares	F-Calculated	Significance
Year	Initial	12.204	1	12.204	21.016	.000
	30 DAC	20.534	1	20.534	19.483	.000
	60 DAC	33.108	1	33.108	14.422	.001
	90 DAC	66.781	1	66.781	34.538	.000
Replication * Year	Initial	.670	4	.168	.289	.883
	30 DAC	14.139	4	3.535	3.354	.020
	60 DAC	8.786	4	2.196	.957	.443
	90 DAC	7.770	4	1.942	1.005	.418
Treatment	Initial	39.205	9	4.356	7.501	.000
	30 DAC	135.541	9	15.060	14.289	.000
	60 DAC	275.121	9	30.569	13.316	.000
	90 DAC	436.630	9	48.514	25.091	.000
Treatment * Year	Initial	.539	9	.060	.103	.999
	30 DAC	1.982	9	.220	.209	.991
	60 DAC	7.665	9	.852	.371	.941
	90 DAC	9.195	9	1.022	.528	.844
Error	Initial	20.905	36	.581		
	30 DAC	37.942	36	1.054		
	60 DAC	82.647	36	2.296		
	90 DAC	69.608	36	1.934		
Total	Initial	3116.897	60			
	30 DAC	7378.031	60			
	60 DAC	13986.342	60			
	90 DAC	24470.135	60			

ANNOVA for number of roots of layers (2016-17)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
INITIAL					
Treatment	9	8.939	0.993	4.974	0.001
Error	20	3.993	0.200		
Total	29	12.932			
30 DAC					
Treatment	9	17.222	1.914	8.405	0.000
Error	20	4.553	0.228		
Total	29	21.775			
60 DAC					
Treatment	9	24.740	2.749	4.692	0.002
Error	20	11.717	0.586		
Total	29	36.457			
90 DAC					
Treatment	9	23.209	2.579	10.116	0.000
Error	20	5.098	0.255		
Total	29	28.308			

ANNOVA for number of roots of layers (2017-18)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
INITIAL					
Treatment	9	15.878	1.764	8.193	0.000
Error	20	4.307	0.215		
Total	29	20.184			
30 DAC					
Treatment	9	9.886	1.098	3.147	0.016
Error	20	6.982	0.349		
Total	29	16.868			
60 DAC					
Treatment	9	17.047	1.894	5.036	0.001
Error	20	7.522	0.376		
Total	29	24.568			
90 DAC					
Treatment	9	31.021	3.447	6.553	0.000
Error	20	10.520	0.526		
Total	29	41.541			

ANNOVA for number of roots of layers (Pooled)

Source	Dependent Variable	Sum of Squares	DF	Mean Squares	F-Calculated	Significance
Year	Initial	23.688	1	23.688	99.422	.000
	30 DAC	21.962	1	21.962	136.254	.000
	60 DAC	84.372	1	84.372	421.802	.000
	90 DAC	36.426	1	36.426	221.111	.000
Replication * Year	Initial	.143	4	.036	.150	.962
	30 DAC	5.893	4	1.473	9.140	.000
	60 DAC	.861	4	.215	1.076	.383
	90 DAC	.728	4	.182	1.104	.370
Treatment	Initial	18.212	9	2.024	8.493	.000
	30 DAC	35.210	9	3.912	24.272	.000
	60 DAC	17.855	9	1.984	9.918	.000
	90 DAC	7.826	9	.870	5.278	.000
Treatment * Year	Initial	.350	9	.039	.163	.997
	30 DAC	.057	9	.006	.039	1.000
	60 DAC	4.348	9	.483	2.415	.029
	90 DAC	.847	9	.094	.571	.811
Error	Initial	8.577	36	.238		
	30 DAC	5.803	36	.161		
	60 DAC	7.201	36	.200		
	90 DAC	5.931	36	.165		
Total	Initial	1978.770	60			
	30 DAC	2726.265	60			
	60 DAC	3571.883	60			
	90 DAC	4336.753	60			

ANNOVA for fresh weight of layers (2016-17)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
INITIAL					
Treatment	9	24.936	2.771	2.429	0.047
Error	20	22.816	1.141		
Total	29	47.752			
30 DAC					
Treatment	9	108.509	12.057	14.947	0.000
Error	20	16.133	0.807		
Total	29	124.642			
60 DAC					
Treatment	9	247.637	27.515	11.996	0.000
Error	20	45.873	2.294		
Total	29	293.510			
90 DAC					
Treatment	9	470.631	52.292	17.232	0.000
Error	20	60.692	3.035		
Total	29	531.323			

ANNOVA for fresh weight of layers (2017-18)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
INITIAL					
Treatment	9	24.917	2.769	2.562	0.038
Error	20	21.613	1.081		
Total	29	46.529			
30 DAC					
Treatment	9	68.062	7.562	3.766	0.006
Error	20	40.160	2.008		
Total	29	108.222			
60 DAC					
Treatment	9	204.420	22.713	9.440	0.000
Error	20	48.122	2.406		
Total	29	252.542			
90 DAC					
Treatment	9	291.844	32.427	13.417	0.000
Error	20	48.337	2.417		
Total	29	340.181			

ANNOVA for fresh weight of layers (Pooled)

Source of Variation	Dependent Variable	Sum of Squares	DF	Mean Squares	F-Calculated	Significance
Year	Initial	16.318	1	16.318	18.200	.000
	30 DAC	16.089	1	16.089	13.027	.001
	60 DAC	38.288	1	38.288	17.250	.000
	90 DAC	53.280	1	53.280	18.808	.000
Replication * Year	Initial	.652	4	.163	.182	.946
	30 DAC	11.832	4	2.958	2.395	.068
	60 DAC	14.093	4	3.523	1.587	.199
	90 DAC	7.046	4	1.762	.622	.650
Treatment	Initial	49.475	9	5.497	6.131	.000
	30 DAC	172.388	9	19.154	15.509	.000
	60 DAC	448.761	9	49.862	22.465	.000
	90 DAC	737.983	9	81.998	28.945	.000
Treatment * Year	Initial	.378	9	.042	.047	1.000
	30 DAC	4.183	9	.465	.376	.939
	60 DAC	3.296	9	.366	.165	.996
	90 DAC	24.491	9	2.721	.961	.488
Error	Initial	32.277	36	.897		
	30 DAC	44.461	36	1.235		
	60 DAC	79.904	36	2.220		
	90 DAC	101.983	36	2.833		
Total	Initial	1824.484	60			
	30 DAC	8501.947	60			
	60 DAC	21631.992	60			
	90 DAC	41360.078	60			

ANNOVA for dry weight of layers (2016-17)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
INITIAL					
Treatment	9	2.994	0.333	2.527	0.040
Error	20	2.633	0.132		
Total	29	5.628			
30 DAC					
Treatment	9	16.795	1.866	7.513	0.000
Error	20	4.968	0.248		
Total	29	21.763			
60 DAC					
Treatment	9	62.144	6.905	9.775	0.000
Error	20	14.128	0.706		
Total	29	76.272			
90 DAC					
Treatment	9	154.317	17.146	11.682	0.000
Error	20	29.356	1.468		
Total	29	183.673			

ANNOVA for dry weight of layers (2017-18)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
INITIAL					
Treatment	9	3.108	0.345	3.279	0.013
Error	20	2.107	0.105		
Total	29	5.215			
30 DAC					
Treatment	9	9.660	1.073	4.878	0.002
Error	20	4.400	0.220		
Total	29	14.060			
60 DAC					
Treatment	9	30.353	3.373	5.452	0.001
Error	20	12.372	0.619		
Total	29	42.724			
90 DAC					
Treatment	9	80.623	8.958	13.516	0.000
Error	20	13.255	0.663		
Total	29	93.878			

ANNOVA for dry weight of layers (Pooled)

Source of Variation	Dependent Variable	Sum of Squares	df	Mean Squares	F-Calculated	Significance
Year	Initial	1.653	1	1.653	13.017	.001
	30 DAC	.960	1	.960	4.383	.043
	60 DAC	1.247	1	1.247	1.873	.180
	90 DAC	3.151	1	3.151	3.384	.074
Replication * Year	Initial	.167	4	.042	.330	.856
	30 DAC	1.482	4	.370	1.691	.173
	60 DAC	2.537	4	.634	.953	.445
	90 DAC	9.092	4	2.273	2.441	.064
Treatment	Initial	6.056	9	.673	5.297	.000
	30 DAC	25.821	9	2.869	13.097	.000
	60 DAC	89.229	9	9.914	14.895	.000
	90 DAC	227.632	9	25.292	27.164	.000
Treatment * Year	Initial	.047	9	.005	.041	1.000
	30 DAC	.634	9	.070	.322	.962
	60 DAC	3.268	9	.363	.545	.831
	90 DAC	7.306	9	.812	.872	.558
Error	Initial	4.573	36	.127		
	30 DAC	7.886	36	.219		
	60 DAC	23.963	36	.666		
	90 DAC	33.519	36	.931		
Total	Initial	193.040	60			
	30 DAC	961.828	60			
	60 DAC	3020.757	60			
	90 DAC	7457.560	60			

ANNOVA for crop growth rate (2016-17)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
30 DAC					
Treatment	9	0.007	0.001	9.429	0.000
Error	20	0.002	0.000		
Total	29	0.008			
60 DAC					
Treatment	9	0.020	0.002	17.269	0.000
Error	20	0.003	0.000		
Total	29	0.023			
90 DAC					
Treatment	9	0.022	0.002	20.924	0.000
Error	20	0.002	0.000		
Total	29	0.025			

ANNOVA for crop growth rate (2017-18)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
30 DAC					
Treatment	9	0.002	0.000	5.802	0.001
Error	20	0.001	0.000		
Total	29	0.003			
60 DAC					
Treatment	9	0.007	0.001	8.812	0.000
Error	20	0.002	0.000		
Total	29	0.008			
90 DAC					
Treatment	9	0.023	0.003	15.718	0.000
Error	20	0.003	0.000		
Total	29	0.027			

ANNOVA for crop growth rate (Pooled)

Source of Variation	Dependent Variable	Sum of Squares	DF	Mean Squares	F-Calculated	Significance
Year	30 DAC	.000	1	.000	1.719	.198
	60 DAC	.000	1	.000	2.464	.125
	90 DAC	.000	1	.000	.748	.393
Replication * Year	30 DAC	.000	4	.000	1.168	.341

	60 DAC	.000	4	.000	.358	.837
	90 DAC	.000	4	.000	.073	.990
Treatment	30 DAC	.008	9	.001	15.288	.000
	60 DAC	.023	9	.003	23.003	.000
	90 DAC	.044	9	.005	31.215	.000
Treatment * Year	30 DAC	.001	9	.000	1.321	.261
	60 DAC	.003	9	.000	3.129	.007
	90 DAC	.002	9	.000	1.259	.292
Error	30 DAC	.002	36	.00006		
	60 DAC	.004	36	.00011		
	90 DAC	.006	36	.00016		
Total	30 DAC	.332	60			
	60 DAC	.623	60			
	90 DAC	1.080	60			

ANNOVA for survival percentage of layers (2016-17)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
30 DAC					
Replication	2.00	0.04			
Treatment	9.00	0.34	0.04	4.21	0.00
Error	18.00	0.16	0.01		
Total	29.00	0.55			
60 DAC					
Replication	2.00	0.00			
Treatment	9.00	0.58	0.07	5.23	0.00
Error	18.00	0.22	0.01		
Total	29.00	0.81			
90 DAC					
Replication	2.00	0.03			
Treatment	9.00	0.60	0.07	5.23	0.00
Error	18.00	0.23	0.01		
Total	29.00	0.86			

ANNOVA for survival percentage of layers (2017-18)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
30 DAC					
Replication	2.00	0.05			
Treatment	9.00	0.48	0.05	3.80	0.01
Error	18.00	0.25	0.01		
Total	29.00	0.78			
60 DAC					
Replication	2.00	0.03			
Treatment	9.00	0.87	0.10	7.90	0.00
Error	18.00	0.22	0.01		
Total	29.00	1.12			

90 DAC					
Replication	2.00	0.02			
Treatment	9.00	0.92	0.10	8.55	0.00
Error	18.00	0.21	0.01		
Total	29.00	1.15			

ANNOVA for survival percentage of layers (Pooled)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
30 DAC					
Year	1.00	0.16	0.16	6.93	0.06
Rep within Year	4.00	0.09	0.02		
Treatment	9.00	0.79	0.09	18.13	0.00
Year X Treat	9.00	0.04	0.01	0.41	0.92
Pooled Error	36.00	0.42	0.01		
Total	59.00	1.50			
60 DAC					
Year	1.00	0.10	0.10	11.81	0.03
Rep within Year	4.00	0.03	0.01		
Treatment	9.00	1.34	0.15	11.03	0.00
Year X Treat	9.00	0.12	0.01	1.09	0.39
Pooled Error	36.00	0.45	0.01		
Total	59.00	2.04			
90 DAC					
Year	1.00	0.13	0.13	10.99	0.03
Rep within Year	4.00	0.05	0.01		
Treatment	9.00	1.47	0.16	26.46	0.00
Year X Treat	9.00	0.06	0.01	0.50	0.87
Pooled Error	36.00	0.45	0.01		
Total	59.00	2.16			

ANNOVA for total numbers of planting material production (2016-17)

Total number of planting material production					
Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
Treatment	9	286.300	31.811	3.171	0.015
Error	20	200.667	10.033		
Total	29	486.967			

ANNOVA for total numbers of planting material production (2017-18)

Total number of planting material production					
Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
Treatment	9	252.000	28.000	4.286	0.003

Error	20	130.667	6.533		
Total	29	382.667			

ANNOVA for total numbers of planting material production (Pooled)

Source of Variation	Sum of Squares	DF	Mean Squares	F-Calculated	Significance
Year	43.350	1	43.350	4.784	.035
Replication * Year	5.133	4	1.283	.142	.966
Treatment	384.150	9	42.683	4.711	.000
Treatment * Year	154.150	9	17.128	1.890	.085
Error	326.200	36	9.061		
Total	146053.0	60			
Corrected Total	912.983	59			

ANNOVA for available nutrients (2016-17)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
Initial Nitrogen					
Treatment	9	66,531	7,392	151.37	0.00
Error	20	977	48.84		
Total	29	67,508			
60 DAC					
Treatment	9	67,789	7,532	208.085	0.000
Error	20	724	36		
Total	29	68,513			
90 DAC					
Treatment	9	16,069	1,785	160	0.000
Error	20	223	11		
Total	29	16,292			

ANNOVA for available nutrients (2017-18)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
Initial Nitrogen					
Treatment	9	51,567	5,730	204.59	0.00
Error	20	560	28.01		
Total	29	52,127			
60 DAC					
Treatment	9	48,849	5,428	189	0.000
Error	20	574	29		
Total	29	49,423			
90 DAC					
Treatment	9	9,230	1,026	146	0.000

Error	20	141	7		
Total	29	9,371			

ANNOVA for available nutrients (Pooled)

Source of Variation	Dependent Variable	Sum of Squares	DF	Mean Squares	F-Calculated	Significance
	K (90 DAC)	519613.54	1.00	519613.54	282173.71	.000
Year	N (Initial)	16.83	1.00	16.83	.68	.415
	N (90 DAC)	67.73	1.00	67.73	3.86	.057
	P (Initial)	.00	1.00	.00	.00	.985
	P (90 DAC)	1.50	1.00	1.50	.59	.448
	K (Initial)	18.07	1.00	18.07	1.01	.323
	K (90 DAC)	372.80	1.00	372.80	202.45	.000
replication * Year	N (Initial)	109.57	4.00	27.39	1.11	.369
	N (90 DAC)	208.31	4.00	52.08	2.97	.032
	P (Initial)	19.20	4.00	4.80	.42	.791
	P (90 DAC)	203.37	4.00	50.84	19.96	.000
	K (Initial)	157.14	4.00	39.29	2.19	.090
	K (90 DAC)	286.90	4.00	71.73	38.95	.000
Treatment	N (Initial)	124465.95	9.00	13829.55	558.09	.000
	N (90 DAC)	100266.07	9.00	11140.67	634.75	.000
	P (Initial)	32336.18	9.00	3592.91	316.23	.000
	P (90 DAC)	18987.65	9.00	2109.74	828.17	.000
	K (Initial)	70090.13	9.00	7787.79	433.57	.000
	K (90 DAC)	52608.97	9.00	5845.44	3174.34	.000
Treatment * Year	N (Initial)	160.80	9.00	17.87	.72	.686
	N (90 DAC)	160.12	9.00	17.79	1.01	.448
	P (Initial)	105.14	9.00	11.68	1.03	.437
	P (90 DAC)	63.90	9.00	7.10	2.79	.014
	K (Initial)	53.80	9.00	5.98	.33	.958
	K (90 DAC)	2016.25	9.00	224.03	121.66	.000
Error	N (Initial)	892.09	36.00	24.78		
	N (90 DAC)	631.84	36.00	17.55		
	P (Initial)	409.02	36.00	11.00		
	P (90 DAC)	91.71	36.00	2.55		
	K (Initial)	646.63	36.00	17.96		
	K (90 DAC)	66.29	36.00	1.84		
Total	N (Initial)	2124779.51	60.00			
	N (90 DAC)	630199.55	60.00			
	P (Initial)	312409.26	60.00			
	P (90 DAC)	99421.88	60.00			
	K (Initial)	1077323.23	60.00			
	K (90 DAC)	574964.76	60.00			
	K (90 DAC)	55351.22	59.00			

EXPERIMENT-II**ANNOVA for shoot length of layers. (2016-17)**

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
30 DAC					
Treatment	7	46.977	6.711	6.033	0.00144
Error	16	17.8	1.112		
Total	23	64.777			
60 DAC					
Treatment	7	141.817	20.26	13.107	0.00001
Error	16	24.731	1.546		
Total	23	166.548			
90 DAC					
Treatment	7	267.038	38.148	20.205	0.000
Error	16	30.209	1.888		
Total	23	297.247			

ANNOVA for shoot length of layers. (2017-18)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
30 DAC					
Treatment	7	56.935	8.134	3.684	0.01459
Error	16	35.324	2.208		
Total	23	92.259			
60 DAC					
Treatment	7	176.209	25.173	9.226	0.00013
Error	16	43.655	2.728		
Total	23	219.864			
90 DAC					
Treatment	7	400.587	57.227	24.648	0.0000
Error	16	37.148	2.322		
Total	23	437.736			

ANNOVA for shoot length of layers. (Pooled)

Source of Variation	Dependent Variable	Sum of Squares	DF	Mean Squares	F-Calculated	Significance
Year	30 DAC	14.509	1	14.509	8.796	.006
	60 DAC	32.670	1	32.670	15.527	.000
	90 DAC	37.719	1	37.719	16.437	.000
Year * Replication	30 DAC	6.939	4	1.735	1.052	.399
	60 DAC	9.471	4	2.368	1.125	.365
	90 DAC	3.102	4	.776	.338	.850
Treatment	30 DAC	102.341	7	14.620	8.864	.000

	60 DAC	247.612	7	35.373	16.812	.000
	90 DAC	571.098	7	81.585	35.552	.000
Treatment*Year	30 DAC	1.571	7	.224	.136	.995
	60 DAC	6.949	7	.993	.472	.847
	90 DAC	12.377	7	1.768	.770	.617
Error	30 DAC	46.184	28	1.649		
	60 DAC	58.914	28	2.104		
	90 DAC	64.255	28	2.295		
Total	30 DAC	4890.886	48			
	60 DAC	12821.536	48			
	90 DAC	27746.928	48			

ANNOVA number of leaves (2016-17)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
30 DAC					
Treatment	7	2.235	0.319	3.102	0.02879
Error	16	1.647	0.103		
Total	23	3.881			
60 DAC					
Treatment	7	17.472	2.496	15.136	0.00001
Error	16	2.638	0.165		
Total	23	20.11			
90 DAC					
Treatment	7	18.871	2.696	9.269	0.00013
Error	16	4.653	0.291		
Total	23	23.524			

ANNOVA number of leaves (2017-18)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
30 DAC					
Treatment	7	4.452	0.636	2.672	0.04908
Error	16	3.808	0.238		
Total	23	8.26			
60 DAC					
Treatment	7	22.444	3.206	6.212	0.00123
Error	16	8.258	0.516		
Total	23	30.702			
90 DAC					

Treatment	7	13.346	1.907	2.706	0.04700
Error	16	11.273	0.705		
Total	23	24.619			

ANNOVA number of leaves (Pooled)

Source of Variation	Dependent Variable	Sum of Squares	DF	Mean Squares	F-Calculated	Significance
Year	30 DAC	7.246	1	7.246	37.710	.000
	60 DAC	12.251	1	12.251	36.278	.000
	90 DAC	13.868	1	13.868	25.981	.000
Year * Replicationep	30 DAC	.075	4	.019	.097	.983
	60 DAC	1.441	4	.360	1.067	.391
	90 DAC	.982	4	.245	.460	.765
Treatment	30 DAC	6.400	7	.914	4.758	.001
	60 DAC	39.422	7	5.632	16.676	.000
	90 DAC	31.677	7	4.525	8.478	.000
Treatment*Year	30 DAC	.287	7	.041	.213	.979
	60 DAC	.494	7	.071	.209	.981
	90 DAC	.540	7	.077	.145	.993
Error	30 DAC	5.380	28	.192		
	60 DAC	9.456	28	.338		
	90 DAC	14.945	28	.534		
Total	30 DAC	749.858	48			
	60 DAC	1478.448	48			
	90 DAC	2840.575	48			

ANNOVA for root length of layers (2016-17)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
INITIAL					
Treatment	7	1.347	0.192	0.308	0.94008
Error	16	10.008	0.625		
Total	23	11.354			
30 DAC					
Treatment	7	34.339	4.906	3.815	0.01259
Error	16	20.571	1.286		
Total	23	54.91			
60 DAC					
Treatment	7	86.682	12.383	4.849	0.00428
Error	16	40.857	2.554		
Total	23	127.538			
90 DAC					
Treatment	7	131.211	18.744	7.842	0.00034

Error	16	38.245	2.39		
Total	23	169.456			

ANNOVA for root length of layers (2017-18)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
INITIAL					
Treatment	7	0.619	0.088	0.076	0.99898
Error	16	18.6	1.162		
Total	23	19.219			
30 DAC					
Treatment	7	30.006	4.287	2.665	0.04951
Error	16	25.736	1.608		
Total	23	55.742			
60 DAC					
Treatment	7	69.823	9.975	6.377	0.00107
Error	16	25.028	1.564		
Total	23	94.851			
90 DAC					
Treatment	7	125.578	17.94	7.673	0.00039
Error	16	37.407	2.338		
Total	23	162.985			

ANNOVA for root length of layers (Pooled)

Source of Variation	Dependent Variable	Sum of Squares	DF	Mean Squares	F-Calculated	Significance
Year	Initial	1.268	1	1.268	2.477	.127
	30 DAC	10.379	1	10.379	9.294	.005
	60 DAC	54.741	1	54.741	42.962	.000
	90 DAC	73.557	1	73.557	33.432	.000
Replication *Year	Initial	14.277	4	3.569	6.974	.001
	30 DAC	15.038	4	3.759	3.366	.023
	60 DAC	30.208	4	7.552	5.927	.001
	90 DAC	14.047	4	3.512	1.596	.203
Treatment	Initial	1.748	7	.250	.488	.835
	30 DAC	63.016	7	9.002	8.061	.000
	60 DAC	154.766	7	22.109	17.352	.000
	90 DAC	255.588	7	36.513	16.595	.000
Treatment * Year	Initial	.218	7	.031	.061	1.000
	30 DAC	1.329	7	.190	.170	.989
	60 DAC	1.740	7	.249	.195	.984
	90 DAC	1.200	7	.171	.078	.999
Error	Initial	14.330	28	.512		
	30 DAC	31.269	28	1.117		
	60 DAC	35.677	28	1.274		
	90 DAC	61.606	28	2.200		
Total	Initial	2277.276	48			
	30 DAC	5514.310	48			
	60 DAC	12103.001	48			
	90 DAC	22233.415	48			

ANNOVA for number of roots of layer (2016-17)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
INITIAL					
Treatment	7	5.453	0.779	1.698	0.17991
Error	16	7.342	0.459		
Total	23	12.795			
30 DAC					
Treatment	7	19.45	2.779	14.721	0.00001
Error	16	3.02	0.189		
Total	23	22.47			
60 DAC					
Treatment	7	19.573	2.796	14.218	0.00001
Error	16	3.147	0.197		
Total	23	22.72			
90 DAC					
Treatment	7	28.187	4.027	21.536	0
Error	16	2.992	0.187		
Total	23	31.179			

ANNOVA for number of roots of layer (2017-18)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
INITIAL					
Treatment	7	6.682	0.955	2.61	0.05311
Error	16	5.852	0.366		
Total	23	12.533			
30 DAC					
Treatment	7	39.445	5.635	54.533	0.000
Error	16	1.653	0.103		
Total	23	41.098			
60 DAC					
Treatment	7	28.336	4.048	21.783	0.000
Error	16	2.973	0.186		
Total	23	31.309			
90 DAC					
Treatment	7	48.436	6.919	24.703	0.000
Error	16	4.482	0.28		
Total	23	52.917			

ANNOVA for number of roots of layer (Pooled)

Source of Variation	Dependent Variable	Sum of Squares	DF	Mean Squares	F-Calculated	Significance
Year	Initial	6.453	1	6.453	14.955	.001
	30 DAC	16.685	1	16.685	114.390	.000
	60 DAC	18.750	1	18.750	100.511	.000
	90 DAC	1.435	1	1.435	7.063	.013
Replication *Year	Initial	1.111	4	.278	.644	.636
	30 DAC	.589	4	.147	1.010	.419
	60 DAC	.897	4	.224	1.202	.332
	90 DAC	1.783	4	.446	2.194	.095
Treatment	Initial	12.050	7	1.721	3.989	.004
	30 DAC	55.741	7	7.963	54.593	.000
	60 DAC	46.176	7	6.597	35.361	.000
	90 DAC	73.901	7	10.557	51.951	.000
Treatment * Year	Initial	.085	7	.012	.028	1.000
	30 DAC	3.153	7	.450	3.088	.015
	60 DAC	1.733	7	.248	1.327	.274
	90 DAC	2.722	7	.389	1.914	.105
Error	Initial	12.083	28	.432		
	30 DAC	4.084	28	.146		
	60 DAC	5.223	28	.187		
	90 DAC	5.690	28	.203		
Total	Initial	513.115	48			
	30 DAC	855.470	48			
	60 DAC	2067.120	48			
	90 DAC	2743.695	48			

ANNOVA for fresh weight of layers (2016-17)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
INITIAL					
Treatment	7	31.232	4.462	7.491	0.00044
Error	16	9.53	0.596		
Total	23	40.762			
30 DAC					
Treatment	7	96.328	13.761	14.035	0.00001
Error	16	15.688	0.98		
Total	23	112.016			
60 DAC					
Treatment	7	210.085	30.012	17.754	0.000
Error	16	27.047	1.69		
Total	23	237.132			
90 DAC					

Treatment	7	376.004	53.715	25.485	0.0000
Error	16	33.724	2.108		
Total	23	409.728			

ANNOVA for fresh weight of layers (2017-18)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
INITIAL					
Treatment	7	34.664	4.952	9.998	0.00008
Error	16	7.925	0.495		
Total	23	42.589			
30 DAC					
Treatment	7	69.243	9.892	9.362	0.00012
Error	16	16.905	1.057		
Total	23	86.149			
60 DAC					
Treatment	7	148.396	21.199	13.255	0.00001
Error	16	25.589	1.599		
Total	23	173.985			
90 DAC					
Treatment	7	349.127	49.875	74.117	0.0000
Error	16	10.767	0.673		
Total	23	359.894			

ANNOVA for fresh weight of layers (Pooled)

Source of Variation	Dependent Variable	Sum of Squares	DF	Mean Squares	F-Calculated	Significance
Year	Initial	1.268	1	1.268	2.477	.127
	30 DAC	10.379	1	10.379	9.294	.005
	60 DAC	54.741	1	54.741	42.962	.000
	90 DAC	73.557	1	73.557	33.432	.000
Replication *Year	Initial	14.277	4	3.569	6.974	.001
	30 DAC	15.038	4	3.759	3.366	.023
	60 DAC	30.208	4	7.552	5.927	.001
	90 DAC	14.047	4	3.512	1.596	.203
Treatment	Initial	1.748	7	.250	.488	.835
	30 DAC	63.016	7	9.002	8.061	.000
	60 DAC	154.766	7	22.109	17.352	.000
	90 DAC	255.588	7	36.513	16.595	.000
Treatment * Year	Initial	.218	7	.031	.061	1.000
	30 DAC	1.329	7	.190	.170	.989
	60 DAC	1.740	7	.249	.195	.984
	90 DAC	1.200	7	.171	.078	.999
Error	Initial	14.330	28	.512		
	30 DAC	31.269	28	1.117		

	60 DAC	35.677	28	1.274		
	90 DAC	61.606	28	2.200		
Total	Initial	2277.276	48			
	30 DAC	5514.310	48			
	60 DAC	12103.00	48			
	90 DAC	22233.41	48			

ANNOVA for dry weight of layers (2016-17)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
INITIAL					
Treatment	7	2.82	0.403	7.493	0.00044
Error	16	0.86	0.054		
Total	23	3.681			
30 DAC					
Treatment	7	9.285	1.326	13.849	0.00001
Error	16	1.532	0.096		
Total	23	10.817			
60 DAC					
Treatment	7	27.031	3.862	8.65	0.00019
Error	16	7.143	0.446		
Total	23	34.174			
90 DAC					
Treatment	7	65.403	9.343	17.855	0.0000
Error	16	8.373	0.523		
Total	23	73.776			

ANNOVA for dry weight of layers (2017-18)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
INITIAL					
Treatment	7	3.326	0.475	10.044	0.00008
Error	16	0.757	0.047		
Total	23	4.083			
30 DAC					
Treatment	7	7.324	1.046	9.388	0.00012
Error	16	1.783	0.111		
Total	23	9.107			
60 DAC					
Treatment	7	14.585	2.084	12.54	0.00002
Error	16	2.658	0.166		
Total	23	17.243			
90 DAC					
Treatment	7	46.211	6.602	10.217	0.00007

Error	16	10.338	0.646		
Total	23	56.549			

ANNOVA for dry weight of layers (Pooled)

Source of Variation	Dependent Variable	Sum of Squares	DF	Mean Squares	F-Calculated	Significance
Year	Initial	5.077	1	5.077	126.560	.000
	30 DAC	6.120	1	6.120	69.832	.000
	60 DAC	10.650	1	10.650	45.066	.000
	90 DAC	18.925	1	18.925	38.734	.000
Replication *Year	Initial	.494	4	.124	3.080	.032
	30 DAC	.861	4	.215	2.457	.069
	60 DAC	3.184	4	.796	3.368	.023
	90 DAC	5.030	4	1.258	2.574	.059
Treatment	Initial	5.906	7	.844	21.034	.000
	30 DAC	16.255	7	2.322	26.495	.000
	60 DAC	39.484	7	5.641	23.868	.000
	90 DAC	108.891	7	15.556	31.838	.000
Treatment * Year	Initial	.241	7	.034	.858	.551
	30 DAC	.354	7	.051	.577	.769
	60 DAC	2.132	7	.305	1.289	.292
	90 DAC	2.722	7	.389	.796	.597
Error	Initial	1.123	28	.040		
	30 DAC	2.454	28	.088		
	60 DAC	6.617	28	.236		
	90 DAC	13.681	28	.489		
Total	Initial	292.932	48			
	30 DAC	611.108	48			
	60 DAC	1383.073	48			
	90 DAC	3203.355	48			

ANNOVA for survival percentage of layers (2016-17)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
30 DAC					
Replication	2.00	0.01			
Treatment	7.00	0.20	0.03	3.60	0.02
Error	14.00	0.11	0.01		
Total	23.00	0.32			
60 DAC					
Replication	2.00	0.05			
Treatment	7.00	0.58	0.08	2.70	0.05
Error	14.00	0.43	0.03		

Total	23.00	1.06			
90 DAC					
Replication	2.00	0.08			
Treatment	7.00	0.59	0.09	4.12	0.01
Error	14.00	0.29	0.02		
Total	23.00	0.96			

ANNOVA for survival percentage of layers (2017-18)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
30 DAC					
Replication	2.00	0.02			
Treatment	7.00	0.20	0.03	3.25	0.03
Error	14.00	0.13	0.01		
Total	23.00	0.35			
60 DAC					
Replication	2.00	0.08			
Treatment	7.00	0.60	0.09	4.57	0.01
Error	14.00	0.26	0.02		
Total	23.00	0.95			
90 DAC					
Replication	2.00	0.03			
Treatment	7.00	0.59	0.08	5.78	0.00
Error	14.00	0.20	0.01		
Total	23.00	0.82			

ANNOVA for survival percentage of layers (Pooled)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
30 DAC					
Year	1.00	0.05	0.05	7.58	0.05
Rep within Year	4.00	0.02	0.01		
Treatment	7.00	0.40	0.06	69.85	0.00
Year X Treat	7.00	0.01	0.00	0.10	1.00
Pooled Error	28.00	0.24	0.01		
Total	47.00	0.72			
60 DAC					
Year	1.00	0.05	0.05	1.54	0.28
Rep within Year	4.00	0.13	0.03		
Treatment	7.00	1.19	0.17	98.90	0.00
Year X Treat	7.00	0.01	0.00	0.07	1.00
Pooled Error	28.00	0.71	0.03		
Total	47.00	2.09			
90 DAC					
Year	1.00	0.12	0.12	4.43	0.10

Rep within Year	4.00	0.11	0.03		
Treatment	7.00	1.18	0.17	91.64	0.00
Year X Treat	7.00	0.01	0.00	0.10	1.00
Pooled Error	28.00	0.49	0.02		
Total	47.00	1.92			

ANNOVA for crop growth rate of layers (2016-17)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
30 DAC					
Treatment	7	0.001	0	3.006	0.03236
Error	16	0.001	0		
Total	23	0.001			
60 DAC					
Treatment	7	0.006	0.001	4.642	0.00526
Error	16	0.003	0		
Total	23	0.009			
90 DAC					
Treatment	7.00	0.01	0.00	34.09	0.00
Error	16.00	0.00	0.00		
Total	23.00	0.01			

ANNOVA for crop growth rate of layers (2017-18)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
30 DAC					
Treatment	7	0.001	0	3.273	0.02346
Error	16	0.001	0		
Total	23	0.002			
60 DAC					
Treatment	7	0.001	0	2.76	0.04391
Error	16	0.001	0		
Total	23	0.003			
90 DAC					
Treatment	7.00	0.01	0.00	8.59	0.00
Error	16.00	0.00	0.00		
Total	23.00	0.02			

ANNOVA for crop growth rate of layers (Pooled)

Source of Variation	Dependent Variable	Sum of Squares	DF	Mean Squares	F-Calculated	Significance
Year	30 DAC	.000	1	.000	.000	.993

	60 DAC	.001	1	.001	6.539	.016
	90 DAC	.001	1	.001	7.516	.011
Year * Replication	30 DAC	.000	4	.000	.590	.672
	60 DAC	.001	4	.000	2.485	.066
	90 DAC	.001	4	.000	1.525	.222
Treatment	30 DAC	.001	7	.000	4.421	.002
	60 DAC	.006	7	.001	8.245	.000
	90 DAC	.021	7	.003	27.430	.000
Treatment*Year	30 DAC	.000	7	.000	1.352	.264
	60 DAC	.001	7	.000	1.541	.194
	90 DAC	.000	7	.000	.293	.951
Error	30 DAC	.001	28	.000048		
	60 DAC	.003	28	.000105		
	90 DAC	.003	28	.000110		
Total	30 DAC	.079	48			
	60 DAC	.176	48			
	90 DAC	.412	48			

ANNOVA for total numbers of planting material production (2016-17)

Total number of planting material production					
Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
Treatment	7.000	80.292	11.470	8.603	0.000
Error	16.000	21.333	1.333		
Total	23.000	101.625			

ANNOVA for total numbers of planting material production (2017-18)

Total number of planting material production					
Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
Treatment	7.000	90.292	12.899	14.071	0.000
Error	16.000	14.667	0.917		
Total	23.000	104.958			

ANNOVA for total numbers of planting material production (Pooled)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
Year	1	16.333	16.333	3.213	0.148
Rep within Year	4	20.333	5.083		
Treatment	7	169.333	24.190	42.333	0.000
Year X Treat	7	4.000	0.571	0.157	0.992
Pooled Error	28	101.667	3.631		
Total	47	311.667			

ANNOVA for available nutrient of media of different varieties (2016-17)

Source of	DF	Sum of	Mean	F-Calculated	Significance
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Variation		Squares	Squares		
30 DAC					
Treatment	7.000	1137.072	162.439	77.989	0.000
Error	16.000	33.326	2.083		
Total	23.000	1170.398			
60 DAC					
Treatment	7.000	377.049	53.864	15.212	0.000
Error	16.000	56.653	3.541		
Total	23.000	433.702			
90 DAC					
Treatment	7.000	328.805	46.972	6.559	0.001
Error	16.000	114.577	7.161		
Total	23.000	443.382			

ANNOVA for available nutrient of media of different varieties (2017-18)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
30 DAC					
Treatment	7.000	1091.30	155.899	49.733	0.000
Error	16.000	50.156	3.135		
Total	23.000	1141.45			
60 DAC					
Treatment	7.000	657.758	93.965	22.563	0.000
Error	16.000	66.632	4.165		
Total	23.000	724.390			
90 DAC					
Treatment	7.000	329.163	47.023	12.241	0.000
Error	16.000	61.463	3.841		
Total	23.000	390.625			

ANNOVA for available nutrient of media of different varieties (Pooled)

Source of Variation	Dependent Variable	Sum of Squares	DF	Mean Squares	F-Calculated	Significance
Year	Nitrogen	47.333	2	23.667	19.644	0
	Phosphorus	87.6	2	43.8	36.821	0
	Potassium	105.235	2	52.618	22.297	0
Year * Replication	Nitrogen	2214.536	7	316.362	262.588	0
	Phosphorus	1012.62	7	144.66	121.61	0
	Potassium	653.42	7	93.346	39.557	0
Treatment	Nitrogen	185.929	1	185.929	154.325	0
	Phosphorus	177.601	1	177.601	149.302	0
	Potassium	51.357	1	51.357	21.763	0
Treatment*Year	Nitrogen	13.803	7	1.972	1.637	0.163
	Phosphorus	22.183	7	3.169	2.664	0.029
	Potassium	4.559	7	0.651	0.276	0.959
Error	Nitrogen	36.144	28	1.205		
	Phosphorus	35.686	28	1.19		
	Potassium	70.794	28	2.36		

Total	Nitrogen	206582.9	48			
	Phosphorus	62519.07	48			
	Potassium	245343.3	48			

Experiment-III

ANNOVA for shoot length of layers (2016-17)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
30 DAC					
Treatment	7.000	43.895	6.271	3.211	0.025
Error	16.000	31.242	1.953		
Total	23.000	75.136			
60 DAC					
Treatment	7.000	171.638	24.520	9.061	0.000
Error	16.000	43.296	2.706		
Total	23.000	214.934			
90 DAC					
Treatment	7.000	371.231	53.033	48.647	0.000
Error	16.000	17.443	1.090		
Total	23.000	388.673			

ANNOVA for shoot length of layers (2017-18)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
30 DAC					
Treatment	7.000	38.365	5.481	3.653	0.015
Error	16.000	24.004	1.500		
Total	23.000	62.368			
60 DAC					
Treatment	7.000	145.351	20.764	7.746	0.000
Error	16.000	42.890	2.681		
Total	23.000	188.242			
90 DAC					
Treatment	7.000	384.343	54.906	52.105	0.000
Error	16.000	16.860	1.054		
Total	23.000	401.203			

ANNOVA for shoot length of layers (Pooled)

Source of Variation	Dependent Variable	Sum of Squares	DF	Mean Squares	F-Calculated	Significance
Year	30 DAC	5.686	1	5.686	3.614	.068
	60 DAC	16.662	1	16.662	8.203	.008
	90 DAC	5.461	1	5.461	10.824	.003
Year * Replication	30 DAC	11.195	4	2.799	1.779	.161
	60 DAC	29.313	4	7.328	3.608	.017
	90 DAC	75.999	4	19.000	37.661	.000

Treatment	30 DAC	81.434	7	11.633	7.395	.000
	60 DAC	313.173	7	44.739	22.026	.000
	90 DAC	751.253	7	107.322	212.730	.000
Treatment*Year	30 DAC	.826	7	.118	.075	.999
	60 DAC	3.817	7	.545	.268	.961
	90 DAC	4.317	7	.617	1.222	.324
Error	30 DAC	44.050	28	1.573		
	60 DAC	56.874	28	2.031		
	90 DAC	14.126	28	.612		
Total	30 DAC	5500.491	48			
	60 DAC	15926.51	48			
	90 DAC	33329.84	48			

ANNOVA for number of leaves of layer (2016-17)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
30 DAC					
Treatment	7.000	9.242	1.320	2.762	0.044
Error	16.000	7.647	0.478		
Total	23.000	16.888			
60 DAC					
Treatment	7.000	21.807	3.115	2.824	0.041
Error	16.000	17.648	1.103		
Total	23.000	39.455			
90 DAC					
Treatment	7.000	35.780	5.111	4.381	0.007
Error	16.000	18.668	1.167		
Total	23.000	54.448			

ANNOVA for number of leaves of layers (2017-18)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
30 DAC					
Treatment	7.000	12.865	1.838	2.913	0.036
Error	16.000	10.096	0.631		
Total	23.000	22.961			
60 DAC					
Treatment	7.000	50.558	7.223	6.040	0.001
Error	16.000	19.132	1.196		
Total	23.000	69.691			
90 DAC					
Treatment	7.000	35.682	5.097	5.378	0.003
Error	16.000	15.166	0.948		
Total	23.000	50.848			

ANNOVA for number of leaves of layer (Pooled)

Source of Variation	Dependent Variable	Sum of Squares	DF	Mean Squares	F-Calculated	Significance
Year	30 DAC	9.337	1	9.337	15.863	.000

	60 DAC	11.525	1	11.525	12.843	.001
	90 DAC	7.736	1	7.736	7.287	.012
Year * Replication	30 DAC	1.262	4	.316	.536	.710
	60 DAC	11.655	4	2.914	3.247	.026
	90 DAC	4.110	4	1.028	.968	.441
Treatment	30 DAC	21.706	7	3.101	5.268	.001
	60 DAC	66.560	7	9.509	10.596	.000
	90 DAC	69.587	7	9.941	9.364	.000
Treatment*Year	30 DAC	.401	7	.057	.097	.998
	60 DAC	5.805	7	.829	.924	.503
	90 DAC	1.874	7	.268	.252	.967
Error	30 DAC	16.480	28	.589		
	60 DAC	25.125	28	.897		
	90 DAC	29.724	28	1.062		
Total	30 DAC	1135.704	48			
	60 DAC	2294.460	48			
	90 DAC	4016.708	48			

ANNOVA for root length of layer (2016-17)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
INITIAL					
Treatment	7.000	3.415	0.488	1.262	0.328
Error	16.000	6.184	0.386		
Total	23.000	9.599			
30 DAC					
Treatment	7.000	14.004	2.001	3.759	0.013
Error	16.000	8.515	0.532		
Total	23.000	22.518			
60 DAC					
Treatment	7.000	73.778	10.540	5.210	0.003
Error	16.000	32.366	2.023		
Total	23.000	106.144			
90 DAC					
Treatment	7.000	119.850	17.121	7.091	0.001
Error	16.000	38.632	2.415		
Total	23.000	158.482			

ANNOVA for root length of layer (2017-18)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
INITIAL					
Treatment	7.000	3.194	0.456	1.072	0.424
Error	16.000	6.809	0.426		
Total	23.000	10.003			
30 DAC					
Treatment	7.000	89.642	12.806	5.453	0.002

Error	16.000	37.577	2.349		
Total	23.000	127.219			
60 DAC					
Treatment	7.000	142.629	20.376	9.653	0.000
Error	16.000	33.771	2.111		
Total	23.000	176.400			
90 DAC					
Treatment	7.000	228.941	32.706	14.534	0.000
Error	16.000	36.004	2.250		
Total	23.000	264.945			

ANNOVA for root length of layer (Pooled)

Source of Variation	Dependent Variable	Sum of Squares	DF	Mean Squares	F-Calculated	Significance
Year	Initial	40.150	1	40.150	100.396	.000
	30 DAC	15.098	1	15.098	13.242	.001
	60 DAC	44.583	1	44.583	21.084	.000
	90 DAC	55.815	1	55.815	32.627	.000
Replication *Year	Initial	1.796	4	.449	1.122	.366
	30 DAC	14.167	4	3.542	3.106	.031
	60 DAC	6.929	4	1.732	.819	.524
	90 DAC	26.737	4	6.684	3.907	.012
Treatment	Initial	4.225	7	.604	1.509	.205
	30 DAC	84.485	7	12.069	10.586	.000
	60 DAC	207.905	7	29.701	14.046	.000
	90 DAC	335.894	7	47.985	28.050	.000
Treatment * Year	Initial	2.385	7	.341	.852	.555
	30 DAC	19.162	7	2.737	2.401	.047
	60 DAC	8.503	7	1.215	.574	.770
	90 DAC	12.900	7	1.843	1.077	.404
Error	Initial	11.198	28	.400		
	30 DAC	31.924	28	1.140		
	60 DAC	59.208	28	2.115		
	90 DAC	47.899	28	1.711		
Total	Initial	3174.138	48			
	30 DAC	6100.691	48			
	60 DAC	12200.76	48			
	90 DAC	21960.03	48			

ANNOVA for number of roots of layer (2016-17)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
INITIAL					
Treatment	7.000	3.958	0.565	1.491	0.240
Error	16.000	6.068	0.379		
Total	23.000	10.027			
30 DAC					

Treatment	7.000	25.232	3.605	6.281	0.001
Error	16.000	9.182	0.574		
Total	23.000	34.414			
60 DAC					
Treatment	7.000	33.171	4.739	2.687	0.048
Error	16.000	28.213	1.763		
Total	23.000	61.384			
90 DAC					
Treatment	7.000	38.613	5.516	2.907	0.037
Error	16.000	30.357	1.897		
Total	23.000	68.970			

ANNOVA for number of roots of layer (2017-18)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
INITIAL					
Treatment	7.000	3.985	0.569	1.054	0.434
Error	16.000	8.640	0.540		
Total	23.000	12.624			
30 DAC					
Treatment	7.000	28.288	4.041	5.102	0.003
Error	16.000	12.673	0.792		
Total	23.000	40.960			
60 DAC					
Treatment	7.000	35.486	5.069	3.478	0.018
Error	16.000	23.320	1.457		
Total	23.000	58.806			
90 DAC					
Treatment	7.000	67.052	9.579	5.736	0.002
Error	16.000	26.717	1.670		
Total	23.000	93.769			

ANNOVA for number of roots of layer (Pooled)

Source of Variation	Dependent Variable	Sum of Squares	DF	Mean Squares	F-Calculated	Significance
Year	Initial	4.060	1	4.060	8.445	.007
	30 DAC	10.203	1	10.203	59.683	.000
	60 DAC	5.360	1	5.360	9.205	.005
	90 DAC	17.812	1	17.812	10.926	.003
Replication *Year	Initial	1.247	4	.312	.648	.633
	30 DAC	17.068	4	4.267	24.960	.000
	60 DAC	35.229	4	8.807	15.126	.000

	90 DAC	11.425	4	2.856	1.752	.167
Treatment	Initial	7.489	7	1.070	2.225	.062
	30 DAC	53.196	7	7.599	44.454	.000
	60 DAC	68.275	7	9.754	16.751	.000
	90 DAC	100.409	7	14.344	8.798	.000
Treatment * Year	Initial	.454	7	.065	.135	.995
	30 DAC	.325	7	.046	.271	.960
	60 DAC	.382	7	.055	.094	.998
	90 DAC	5.256	7	.751	.461	.854
Error	Initial	13.461	28	.481		
	30 DAC	4.787	28	.171		
	60 DAC	16.304	28	.582		
	90 DAC	45.648	28	1.630		
Total	Initial	682.795	48			
	30 DAC	2309.043	48			
	60 DAC	3626.609	48			
	90 DAC	4343.611	48			

ANNOVA for fresh weight of layers (2016-17)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
INITIAL					
Treatment	7.000	21.672	3.096	4.563	0.006
Error	16.000	10.857	0.679		
Total	23.000	32.529			
30 DAC					
Treatment	7.000	53.940	7.706	12.005	0.000
Error	16.000	10.270	0.642		
Total	23.000	64.211			
60 DAC					
Treatment	7.000	120.972	17.282	11.120	0.000
Error	16.000	24.865	1.554		
Total	23.000	145.836			
90 DAC					
Treatment	7.000	229.490	32.784	18.441	0.000
Error	16.000	28.445	1.778		
Total	23.000	257.935			

ANNOVA for fresh weight of layers (2017-18)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
INITIAL					
Treatment	7.000	17.848	2.550	3.296	0.023
Error	16.000	12.376	0.773		
Total	23.000	30.224			

30 DAC					
Treatment	7.000	114.037	16.291	15.077	0.000
Error	16.000	17.289	1.081		
Total	23.000	131.326			
60 DAC					
Treatment	7.000	308.769	44.110	18.641	0.000
Error	16.000	37.861	2.366		
Total	23.000	346.630			
90 DAC					
Treatment	7.000	630.728	90.104	42.335	0.000
Error	16.000	34.054	2.128		
Total	23.000	664.781			

ANNOVA for fresh weight of layers (Pooled)

Source of Variation	Dependent Variable	Sum of Squares	DF	Mean Squares	F-Calculated	Significance
Year	Initial	41.144	1	41.144	53.839	.000
	30 DAC	22.141	1	22.141	29.413	.000
	60 DAC	7.069	1	7.069	5.954	.021
	90 DAC	.071	1	.071	.034	.855
Replication *Year	Initial	1.835	4	.459	.600	.666
	30 DAC	6.816	4	1.704	2.264	.087
	60 DAC	29.481	4	7.370	6.208	.001
	90 DAC	4.083	4	1.021	.489	.744
Treatment	Initial	39.334	7	5.619	7.353	.000
	30 DAC	156.223	7	22.318	29.648	.000
	60 DAC	407.576	7	58.225	49.040	.000
	90 DAC	809.094	7	115.585	55.402	.000
Treatment * Year	Initial	.185	7	.026	.035	1.000
	30 DAC	4.628	7	.661	.878	.536
	60 DAC	22.167	7	3.167	2.667	.030
	90 DAC	51.125	7	7.304	3.501	.008
Error	Initial	21.398	28	.764		
	30 DAC	21.077	28	.753		
	60 DAC	33.245	28	1.187		
	90 DAC	58.416	28	2.086		
Total	Initial	3080.646	48			
	30 DAC	6689.733	48			
	60 DAC	12415.36	48			
	90 DAC	21181.39	48			

ANNOVA for dry weight of layers (2016-17)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
INITIAL					
Treatment	7.000	2.209	0.316	4.578	0.006
Error	16.000	1.103	0.069		
Total	23.000	3.312			
30 DAC					
Treatment	7.000	5.880	0.840	11.986	0.000
Error	16.000	1.121	0.070		
Total	23.000	7.001			
60 DAC					
Treatment	7.000	14.415	2.059	11.212	0.000
Error	16.000	2.939	0.184		
Total	23.000	17.354			
90 DAC					
Treatment	7.000	28.935	4.134	18.430	0.000
Error	16.000	3.589	0.224		
Total	23.000	32.524			

ANNOVA for dry weight of layers (2017-18)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
INITIAL					
Treatment	7.000	1.944	0.278	3.337	0.022
Error	16.000	1.331	0.083		
Total	23.000	3.275			
30 DAC					
Treatment	7.000	13.186	1.884	15.137	0.000
Error	16.000	1.991	0.124		
Total	23.000	15.177			
60 DAC					
Treatment	7.000	37.889	5.413	18.769	0.000
Error	16.000	4.614	0.288		
Total	23.000	42.503			
90 DAC					
Treatment	7.000	81.785	11.684	42.396	0.000
Error	16.000	4.409	0.276		
Total	23.000	86.194			

ANNOVA for dry weight of layers (Pooled)

Source of Variation	Dependent Variable	Sum of Squares	DF	Mean Squares	F-Calculated	Significance
Year	Initial	5.576	1	5.576	69.476	.000
	30 DAC	3.956	1	3.956	46.678	.000
	60 DAC	1.442	1	1.442	10.022	.004

	90 DAC	.205	1	.205	.769	.388
Replication *Year	Initial	.187	4	.047	.582	.678
	30 DAC	.781	4	.195	2.305	.083
	60 DAC	3.524	4	.881	6.122	.001
	90 DAC	.517	4	.129	.484	.747
Treatment	Initial	4.138	7	.591	7.366	.000
	30 DAC	17.619	7	2.517	29.698	.000
	60 DAC	49.455	7	7.065	49.099	.000
	90 DAC	103.816	7	14.831	55.512	.000
Treatment * Year	Initial	.014	7	.002	.025	1.000
	30 DAC	.609	7	.087	1.027	.435
	60 DAC	2.848	7	.407	2.828	.023
	90 DAC	6.905	7	.986	3.692	.006
Error	Initial	2.247	28	.080		
	30 DAC	2.373	28	.085		
	60 DAC	4.029	28	.144		
	90 DAC	7.481	28	.267		
Total	Initial	327.350	48			
	30 DAC	753.548	48			
	60 DAC	1501.224	48			
	90 DAC	3461.264	48			
	90 DAC	118.924	47			

ANNOVA for crop growth rate of layers (2016-17)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
30 DAC					
Treatment	7.000	0.001	0.000	4.534	0.006
Error	16.000	0.000	0.000		
Total	23.000	0.001			
60 DAC					
Treatment	7.000	0.002	0.000	3.231	0.025
Error	16.000	0.001	0.000		
Total	23.000	0.004			
90 DAC					
Treatment	7.000	0.003	0.000	7.195	0.001
Error	16.000	0.001	0.000		
Total	23.000	0.004			

ANNOVA for crop growth rate of layers (2017-18)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
30 DAC					
Treatment	7.000	0.006	0.001	3.657	0.015
Error	16.000	0.003	0.000		

Total	23.000	0.009			
60 DAC					
Treatment	7.000	0.007	0.001	6.158	0.001
Error	16.000	0.003	0.000		
Total	23.000	0.010			
90 DAC					
Treatment	7.000	0.009	0.001	11.381	0.000
Error	16.000	0.002	0.000		
Total	23.000	0.011			

ANNOVA for crop growth rate of layers (Pooled)

Source of Variation	Dependent Variable	Sum of Squares	DF	Mean Squares	F-Calculated	Significance
Year	30 DAC	.000	1	.000	2.377	.134
	60 DAC	.001	1	.001	5.575	.025
	90 DAC	.001	1	.001	7.730	.010
Year * Replication	30 DAC	.002	4	.000	4.347	.007
	60 DAC	.001	4	.000	2.288	.085
	90 DAC	.001	4	.000	1.784	.160
Treatment	30 DAC	.006	7	.001	9.102	.000
	60 DAC	.009	7	.001	10.861	.000
	90 DAC	.011	7	.002	20.231	.000
Treatment*Year	30 DAC	.001	7	.000	1.579	.183
	60 DAC	.001	7	.000	1.004	.449
	90 DAC	.001	7	.000	1.821	.123
Error	30 DAC	.002	28	.00009		
	60 DAC	.003	28	.00011		
	90 DAC	.002	28	.00008		
Total	30 DAC	.104	48			
	60 DAC	.149	48			
	90 DAC	.454	48			

ANNOVA for survival percentage of layers (2016-17)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
30 DAC					
Replication	2.00	0.04			
Treatment	7.00	0.20	0.03	10.52	0.00
Error	14.00	0.04	0.00		
Total	23.00	0.28			
60 DAC					
Replication	2.00	0.03			
Treatment	7.00	0.58	0.08	22.41	0.00

Error	14.00	0.05	0.00		
Total	23.00	0.67			
90 DAC					
Replication	2.00	0.04			
Treatment	7.00	0.59	0.08	32.34	0.00
Error	14.00	0.04	0.00		
Total	23.00	0.66			

ANNOVA for survival percentage of layers (2017-18)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
30 DAC					
Replication	2.00	0.07			
Treatment	7.00	0.20	0.03	10.48	0.00
Error	14.00	0.04	0.00		
Total	23.00	0.31			
60 DAC					
Replication	2.00	0.10			
Treatment	7.00	0.60	0.09	45.79	0.00
Error	14.00	0.03	0.00		
Total	23.00	0.73			
90 DAC					
Replication	2.00	0.07			
Treatment	7.00	0.58	0.08	17.71	0.00
Error	14.00	0.07	0.01		
Total	23.00	0.72			

ANNOVA for survival percentage of layer (Pooled)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
30 DAC					
Year	2.00	0.04	0.02	6.71	0.01
Rep within Year	7.00	0.21	0.03	10.76	0.00
Treatment	14.00	0.04	0.00		
Year X Treat	2.00	0.07	0.04	12.85	0.00
Pooled Error	7.00	0.21	0.03	10.33	0.00
Total	14.00	0.04	0.00		
60 DAC					
Year	1.00	0.05	0.05	1.53	0.28
Rep within Year	4.00	0.14	0.03		
Treatment	7.00	1.19	0.17	102.74	0.00
Year X Treat	7.00	0.01	0.00	0.58	0.77
Pooled Error	28.00	0.08	0.00		
Total	47.00	1.46			
90 DAC					

Year	1.00	0.12	0.12	4.47	0.10
Rep within Year	4.00	0.11	0.03		
Treatment	7.00	1.17	0.17	98.56	0.00
Year X Treat	7.00	0.01	0.00	0.47	0.85
Pooled Error	28.00	0.10	0.00		
Total	47.00	1.51			

ANNOVA for total number of planting material production (2016-17)

Total number of planting material production					
Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
Treatment	7	92.625	13.232	3.693	0.014
Error	16	57.333	3.583		
Total	23	149.958			

ANNOVA for total number of planting material production (2017-18)

Total number of planting material production					
Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
Treatment	7	81.333	11.619	2.875	0.038
Error	16	64.667	4.042		
Total	23	146.000			

ANNOVA for total number of planting material production (Pooled)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
Year	1	16.333	16.333	3.213	0.148
Rep within Year	4	20.333	5.083		
Treatment	7	169.333	24.190	42.333	0.000
Year X Treat	7	4.000	0.571	0.157	0.992
Pooled Error	28	101.667	3.631		
Total	47	311.667			

ANNOVA for available nutrients of media of different varieties (2016-17)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
30 DAC					
Treatment	7.000	1137.072	162.439	77.989	0.000
Error	16.000	33.326	2.083		
Total	23.000	1170.398			
60 DAC					
Treatment	7.000	377.049	53.864	15.212	0.000
Error	16.000	56.653	3.541		
Total	23.000	433.702			
90 DAC					

Treatment	7.000	328.805	46.972	6.559	0.001
Error	16.000	114.577	7.161		
Total	23.000	443.382			

ANNOVA for available nutrients of media of different varieties (2017-18)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
30 DAC					
Treatment	7.000	1091.30	155.899	49.733	0.000
Error	16.000	50.156	3.135		
Total	23.000	1141.45			
60 DAC					
Treatment	7.000	657.758	93.965	22.563	0.000
Error	16.000	66.632	4.165		
Total	23.000	724.390			
90 DAC					
Treatment	7.000	329.163	47.023	12.241	0.000
Error	16.000	61.463	3.841		
Total	23.000	390.625			













ANNOVA for available nutrients of media of different varieties (Pooled)

Source of Variation	Dependent Variable	Sum of Squares	DF	Mean Squares	F-Calculated	Significance
Year	Nitrogen	47.333	2	23.667	19.644	0
	Phosphorus	87.6	2	43.8	36.821	0
	Potassium	105.235	2	52.618	22.297	0
Year * Replication	Nitrogen	2214.536	7	316.362	262.588	0
	Phosphorus	1012.62	7	144.66	121.61	0
	Potassium	653.42	7	93.346	39.557	0
Treatment	Nitrogen	185.929	1	185.929	154.325	0
	Phosphorus	177.601	1	177.601	149.302	0
	Potassium	51.357	1	51.357	21.763	0
Treatment*Year	Nitrogen	13.803	7	1.972	1.637	0.163
	Phosphorus	22.183	7	3.169	2.664	0.029
	Potassium	4.559	7	0.651	0.276	0.959
Error	Nitrogen	36.144	28	1.205		
	Phosphorus	35.686	28	1.19		
	Potassium	70.794	28	2.36		
Total	Nitrogen	206582.9	48			
	Phosphorus	62519.07	48			
	Potassium	245343.3	48			

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