Effect of different growing media, biofertilizer and plant growth regulator on growth and survivability of Guava air layers

THESIS

Submitted to the

Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya

In partial fulfillment of the requirements for the Degree of

MASTER OF SCIENCE

IN

AGRICULTURE

HORTICULTURE

(FRUIT SCIENCE)

By

VIJAYA SINGH KUSHWAH

Department of Horticulture

Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya

College of Agriculture, Gwalior (M.P.)

2021

CERTIFICATE – I

This is to certify that the thesis entitled **"Effect of different growing media, biofertilizer and plant growth regulator on growth and survivability of Guava air layers"** *submitted in partial fulfillment of the requirements for the degree of* **MASTER OF SCIENCE** *in* **AGRICULTURE HORTICULTURE (Fruit Science)** *of* **Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.)** *is a record of bona-fide research work carried out by* **Ms. VIJAYA SINGH KUSHWAH** ID.No. 19111509 *under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instruction.*

No part of the thesis has been submitted for any other degree or diploma. All the assistance and help received during the course of the investigation has been acknowledged by the scholar.

Place: Gwalior

Date: **(Dr. Karan Vir Singh)**

Chairman of the Advisory Committee

MEMBERS OF STUDENTS' ADVISORY COMMITTEE

Chairman **(Dr. Karan Vir Singh)** _____

Member **(Dr. S.K. Trivedi)** _____

Member **(Dr. Reeti Singh)** _____

Member **(Dr. P.D. Singh)** _____

Member **(Dr. V.B. Singh)** _____

CERTIFICATE – II

I.D. No.- 19111509

Aadhar no. – 7200 8892 7051

This is to certify that the thesis entitled **"Effect of different growing media, biofertilizer and plant growth regulator on growth and survivability of Guava air layers"** *submitted by* **Ms. VIJAYA SINGH KUSHWAH** to *the* **Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior** *in partial fulfillment of the requirements for the degree of* **MASTER OF SCIENCE** *in* **AGRICULTURE HORTICULTURE (Fruit Science)** *in the Department of Horticulture has been accepted after evaluation by the External Examiner and approved by the Student's Advisory Committee after an oral examination of the same.*

Place: Gwalior

Date: **(Dr. Karan Vir Singh)**

Chairman of the Advisory Committee

MEMBERS OF STUDENTS' ADVISORY COMMITTEE

Chairman **(Dr. Karan Vir Singh)** _____

Member **(Dr. S. K. Trivedi)** _____

Member **(Dr. Reeti Singh)** _____

Member **(Dr. P. D. Singh)** _____

Member **(Dr. V.B. Singh)** _____

Head of the Department _____

Dean of the College _____

Director of Instructions _____

ACKNOWLEDGEMENT

Foremost, I want to offer this endeavor to our Almighty God for the wisdom he bestowed upon me, the strength, peace of my mind and good health for providing me this opportunity of pursuing M.Sc. Ag. Horticulture (Fruit Science).

I feel very proud to say that due to keen knowledge and continuous support of my most respected mentor and chairman of my advisory committee Dr. Karan Vir Singh, Senior Scientist, and Dr. Rajesh Lekhi, Professor & Head, Department of Horticulture, College of Agriculture, R.V.S.K.V.V., Gwalior .Their timely advice, meticulous scrutiny, scholarly advice and scientific approach have helped me to a very great extent to accomplish this task. I am greatly thankful for their patience, motivation, enthusiasm, guidance, valuable suggestions and co-operation. It is a great pleasure and honor to work under their supervision.

I would like to express the deepest appreciation to the members of my advisory committee Dr. V. B. Singh, Professor & Head, Department of statistics, Dr.S.K.Trivedi, Senior Scientist, Department of Soil Science and Agri.Chemistry, Dr.P.D.Singh, Scientist, Department of Entomology and Dr. Reeti Singh, Scientist, Department of Plant Pathology, College of Agriculture, Gwalior for their noble inspiration, keen interest, suggestions and comments during the preparation and presentation of typescript of the thesis without which it would have not been possible to accomplish this astonishing task.

With profound respect, I thank Dr. S.K. Rao, Hon'ble Vice Chancellor, R.V.S.K.V.V., Gwalior, Dr. A.K. Singh, Director of Instructions with deepest sense of humility and gratefulness. I feel myself duly bound to express my heartfelt thanks to Dr. Reeti Singh, Dean College of Agriculture, Gwalior, for providing infrastructures and laboratory facilities available at the college.

I would like to express my deep and sincere gratitude to Dr.K.K. Yadav, Dr. Pravin Gurjar, Dr. Rashmi Bajpai, Dr. Arjun Kashyap, Dr. Pragya Singh Sh. Gajendra Gaur, Sh. Sonu Prajapati, Sh. Kamal, Smt. Uma Devi, College of Agriculture Gwalior for their suggestions and moral support during the course of my investigation.

I am extremely grateful to my parents for their love, prayers, care and sacrifices for educating and preparing me for my future. It is my privilege to thank my grandparents Mr. Govind Singh Kushwah and Mrs. Kamla Devi my father Mr.Nagendra Singh Kushwah, mother Late Smt. Geeta Devi, supporting me spiritually throughout my life and members of my family, especially my uncle Mr. Dheerendra Singh Kushwah and aunt Mrs. Aarti Kushwah and brother Harshvardhan Singh, my sisters Mrs. Rajnandini and Shraddha and my cousins Ankit and Aakash. I also appreciate the co-operation and encouragement of my fellow batch mates Shreetama Bhunia, Yashi Singh Tomar, Bhupendra Patidar, Vivek Sharma, Lokendra Gurjar, Arvind Patel, Hina Manjhi, Santara Balke, Vikash Sahu, Naveen Sharma, and

Ajit Patidar. I am also extremely thankful to all other staff members for their assistance and co-operation.

I also wish to record my appreciation towards my senior Mr. Amit Sharma.

Last but not the least, this thesis becomes a reality with the kind support of many individuals. I would like to extend my sincere thanks to all of them.

Place: Gwalior
Date:..../……/

(VIJAYA SINGH KUSHWAH)

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF SYMBOLS

%	Per cent
&	And
DAT	Days After Transplanting
/	Per
@	At the rate of
°C	Degree Celsius
°E	Degree East
°N	Degree North
Ag.	Agriculture
ANOVA	Analysis of variance
C.D	Critical difference
Mm	Millimeter
Cm	Centimeter
cv.	Cultivar/ Cultivated Variety
D.F	Degree of Freedom
et al.	And others
etc.	Etcetera
E-W	East-West
F_{cal}	F Calculated
Fig.	Figure
F_{tab}	F Tabulated
G	Gram
i.e.	In reference to; that is
Kg	Kilogram

M	Meter
Max.	Maximum
Min.	Minimum
Ml	Milliliter
MSS	Mean Sum of Square
No.	Number
NS	Non-Significant
N-S	North-South
PGRs	Plant Growth Regulators
CRD	Completely Randomized Design
S.E m ±	Standard Error of Means
SS	Sum of Square
Temp.	Temperature
Var.	Variety
Viz.	Namely
Wt.	Weight

CHAPTER – I

INTRODUCTION

Guava (*Psidium guajava* L.), native to Mexico, Central America and belongs to the family Myrtaceae. It is also known as “apple of tropics” and “poor man’s apple”, is a popular fruit crop in India. It can be grown in tropical and subtropical climate and it is adopted for diverse soil and agro climatic conditions. It is relatively precocious and prolific in fruit bearing nature, could gives highly remunerative for crop production. The guava is highly nutritious, it has a rich source of vitamin ‘C’ and the content of Vitamin ‘C’ in fruits vary from 95.75 to 239.00 mg 100^{-1} g in cultivars of guava. Guava is the fifth important fruit crop of India after Banana, Mango, Citrus, and Papaya with an area of 276 thousand hectares contribute to total annual production of 4253 million tons and productivity of 14.96 MT/hac (Horticulture at a glance 2018).The total area, production and productivity of Guava in Madhya Pradesh is 139 Ha, 2920 MT, and19.58 MT/hac respectively (Anon.**).** It has been used in traditional medicine in many cultures throughout Central America, the Caribbean, Africa and Asia. It is used for inflammation, diabetes, hypertension, wounds, pain relief, fever, diarrhoea, rheumatism, lung diseases and ulcers.

Major guava producing districts in Madhya Pradesh are Indore, Khargone, Vidisha, Katni, Singrauli, Sheopur, Morena etc.Besides this guava is considered as salinity tolerant crop and can survive under high pH and salty conditions. In the state guava is commercially propagated through air layering as it is an economical and effortless method of propagation.

Guava is an inexpensive and ample source of vitamin-C (210 –305 mg/100 g fruit pulp), pectin (0.5–1.8 %) carbohydrate, and iron, fat and contains a fair amount of calcium and phosphorus as well but has low energy (66 cal /100g). There are multifarious recipes for utilizing guavas in pies, cakes, puddings, sauce, ice cream, jam, jelly, nectar, guava cheese, RTS, butter, marmalade, chutney, relish, ketchup and other products. These qualities make guava a dominant and one of the most favored fruits of India. India is the leading producer of guava in the world.

Rapid resumption of root initiation and growth are two principal processes responsible for seedling survival after transplanting (Burdett, 1987).Several studies have been attempted to predict the quality of seedlings by assessing root regeneration capacity i.e., the ability of seedlings to initiate new roots upon planting (McCreary and Duryea,1987).

Plant growth regulators are organic substances produced naturally in higher plants, controlling growth or other physiological functions at a site remote from its place of production and active in midget amounts. Plant

growth regulators include auxins, gibberellins, cytokinins, ethylene, growth retardants and growth inhibitors. During the last 50 years contemplated research work has been done in the country on various characteristics such as varieties, propagation, irrigation, training and pruning etc. to increase the yield and quality of guava fruits. The plant growth regulators are organic substances (other than nutrients), which in minute amount promote, inhibit or otherwise modify any physiological process in plants. Thus, the use of PGR_s has resulted in some outstanding achievements in several fruit crops with respect to growth, yield and quality.

Gibberellin control fruit development in various ways in different developmental stages. Fruit development is a complex and tightly regulated process. Growing fruits are very active metabolically and act as strong sinks for nutrients with hormones possibly modulating the process (Brenner and Cheikh, 1995).Gibberellin is a very potent hormone whose natural occurrence in plants controls their development. Gibberellins are in the third place with 17 % share among the most commonly used herbal hormones within the natural plant growth regulators. It regulates growth; application of very low concentrations can have profound effect. GA_3 is the most commonly used gibberellin; it has number of effects on plant growth and development. It can stimulate rapid stem and root growth, induce mitotic division in the leaves of some plants and increase seed germination rates. The successful fertilization of the ovule is followed by cell division and cell expansion resulting in the growth of the fruit. Gibberellins are known to influence both cell division and cell enlargement (Adams *et al.,* 1975).

Biofertilizers are substances that contain living microorganisms. Biofertilizers also synthesizes some biologically active substances including some phytohormones such as auxin, thereby stimulating plant growth. This definition separates biofertilizers from organic fertilizers, green manure, intercrop or organic- supplemented chemical fertilizers (Vessey, 2003).Bio-fertilizers containing beneficial bacteria and fungi improve soil chemical and biological characteristics, phosphate solubility and agricultural production (El-Habbasha *et al*., 2007; Yosefi *et al.,* 2011). Bio-fertilizers comprised of nitrogen fixers, phosphate and potash dissolvers. (Ezz *et al.,* 2011). Because it is the most important for plant production and soil health in general as they play an important and complex role in plant growth, improving fruit quality and yield components of crops by way of various biochemical activities in the soil such as increases the soil fertility naturally, add nutrients through the natural processes biological N fixation, solubilizing phosphorus, the availability of nutrients by their biological activity and uptake of nutrients (Saraswati and Smarno, 2008). Hence, to increase the productivity of the soil, the use of biofertilizer is must and also helps in stimulating the plant growth hormones, providing better nutrient uptake and increased tolerance towards drought and moisture stress.

Hence, it is a matter of great interest to find out the best concentration of the growth regulators and suitable biofertilizer for growing media and treatment which can induce better survival of guava air layers after detachment. Keeping the above facts in view, an experiment entitled “Effect of different growing media, biofertilizer and plant growth regulator on growth and survivability of Guava air layers (*Psidium guajava* L.). *Cv*. Gwalior-27” was conducted at Experimental block, College of Agriculture, Gwalior (MP) during 2020-21 with the following objectives:

1. To find out the suitable growing media for growth and survivability of air layers.
2. To find out the best suitable combination of growing media, biofertilizer and PGR among all treatments for growth and survivability of air layers.
3. To estimate economics of the treatments.

CHAPTER – II

REVIEW OF LITERATURE

This chapter documents the important findings from the previous research to various aspects of this present experiment. The purpose of this chapter is to establish the background and context for the findings from the previously different investigations and case studies. This chapter provides a framework for understanding previously published works about the effect of plant growth regulators, growing media and biofertilizers on air layered plants of different fruit crops.

Air- layering is one of the oldest techniques used by gardeners to propagate many woody plants. The traditional, simple and usual method of guava propagation is layering but research works on the effects of growth regulators and different rooting media for air layering in guava in Madhya Pradesh are very limited.

Vegetative propagation methods produce plants with identical genotype with the mother plant .The present study, aimed to produce air layers from mother plants of guava *cv.* Gwalior- 27.

Therefore, the effects of these factors on air layered plants have been reviewed here under on guava and some confederated crops with the hope that this might contribute to the present investigation.

2.1 Effect of growing media, GA_3 and *Azotobacter* on air layered plants of guava and some federated crops-

Ramteke (1998) recorded in a trial in Akola district, Maharashtra, India, guava (*cv.* Sardar) shoots were layered in polythene bags at fortnightly intervals between 8 June and 23 October 1992. Layering on 23 June gave the best results in terms of root and shoot growth and survival percentage (85.71%). Survival percentage declined with later layering dates and was lowest (47.62%) with layering on 23 October

Manna *et al*., (2001) evaluated the response of different guava cultivars to air layering. Among the 12 guava cultivars, Lucknow-49, Kerala and Chittidar noted good response to air layering as evidenced by high rooting and good field establishment under semi- arid conditions of West Bengal. Apple Colour, Allahabad Safeda, Banarasi and Baruipur exhibited poor responses to air layering, while Allahabad (U.P.), Behat Coconut, Seedless and Supreme exhibited moderate responses.

Kakon *et al*., (2005) studied that planting air layer after detached from the mother plant and planted under different nursery conditions showed

significant variation in success of air layers. Open condition increased the percentage of survivability then under shade condition. Layers *in situ* (both shade and open condition) increased the number of shoots and leaves of the detached air layers than layers in poly bag. The highest percentage of survivability (100%) was observed from layers *in situ* under open condition which was statistically similar to layers in poly bag under open condition.

Rymbai and Reddy (2011) studied the plantlets of different layering methods under open field nursery for their survival and growth characters. The minimum record in all parameters was obtained in 15th June air layering method, except for maximum number of days (11.00) taken for sprouting. Among nursery conditions, Poly house nursery performed better than open field nursery in all the parameters irrespective of methods of layerings with minimum (8.83) number of days taken for sprouting, maximum survival percentage (90.10), number of leaves (9.58) at 45 days after transplanting (DAT) and (13.08) at 60 DAT.

I. Growing media

(a)Vermicompost –

.**Singh *et al.* (2007)** found one year old shoots of guava *cv*. 'Lucknow-49' were treated on ringed surface of shoots with IBA concentration (ppm) of 3000, 4000, 5000 and 6000 along with organic media i.e. poultry manure, Vermicompost and farmyard manure. Air layering of guava with IBA concentration of 6000 ppm with soil: sand: poultry manure rooting media produced maximum percentage (76.75%) of survival of 60-days-old-plants grown in poly bags. This combination of IBA with rooting media helped in producing maximum number of primary roots (18.57), secondary roots (23.91), leaves on 60 days (14.36) and length of shoots on 60 days (5.31 cm). IBA 5000 ppm and poultry manure combination was found to be second best for survival of air layering (73.25%).

Rajpoot *et al.*,(2012) reported that the effect of IBA and Vermicompost on air layered plant production of guava and revealed that the highest survival percentage (72.17%) of guava plants was recorded in C_3 (1500ppm IBA) and in growing media M_1 (Soil+ Vermicompost + Sand in 1:1:1)(76.44%) highest plant height (23.70cm) number of leaves and stem diameter (1.78cm).

Kumar *et al.,* (2014) concluded that among different growing media Riverbed Soil + Vermicompost (2:1) + NPK (5g / sapling) or Riverbed soil + Vermicompost (2:1) + Vermiculite (50g/sapling) was identified as best potting media for mass propagation of litchi in black polythene bags under net house for obtaining maximum survival, sapling height, number of leaves and number of leaflets at 8 months of planting. Similarly maximum fresh weight, dry weight of shoots of secondary and tertiary roots and fresh root shoot ratio were

recorded in Riverbed soil + Vermicompost (2:1) + NPK (5g /sapling) whereas, dry root shoot ratio was highest in Riverbed + Vermicompost (2:1). From above studies, potting media containing Riverbed soil + Vermicompost (2:1) + NPK (5g/sapling) or Riverbed soil + Vermicompost (2:1) + Vermiculite (50g/sapling) was found most suitable alternate potting media mixtures under net house.

Kashyap *et al.,* (2016) conducted an experiment to evaluate the response of different concentration of indole butyric acid and rooting media on rooting, growth and survivability of air layers in acid lime (*Citrus aurantifolia* [Christm.]*Swingle*) var. Kagzi lime. The experiment comprising seven sources of rooting media viz., Soil, Soil+ Vermicompost, Soil + Coco peat , Soil + Soil + Leaf mould , Soil +Vermicompost + Coco peat , Soil + Vermicompost + Leaf mould and three concentration of indole butyric acid viz., 0ppm,1000ppm and 2000 ppm were laid out in factorial randomized block design with three replication. Results revealed that maximum values of callus formation (0.37cm), rooting percentage (82.39) fresh as well as dry weight of root , growth parameter viz., number of leaves, number of new sprout / layer and survival percentage (73.61%) was obtained in soil + Vermicompost + Coco peat rooting media. In case of different concentration of IBA, highest value of all the parameters was recorded with spray of 2000 ppm of IBA.

Shaikh *et al.,* (2018) the study was carried out to explore the effect of different propagation media on the growth and survival of clove (Syzygium aromaticum L. Meer.) seedlings. Different treatments of propagation media like Sand, Soil, FYM, Coco Peat, Vermicompost and Tricoderma were given alone or in combination to clove seedling. The observations on seedling height, internode length, number of leaves, leaf area, root length, total chlorophyll, vigour index and survival percent were recorded. The results revealed that the influence of T4 (Sand + Soil + Coco Peat + Tricoderma drenching) was found significantly superior over other treatments and resulted in tallest plants (11.40 cm) with longest internodes (3.80 cm), more number of leaves (9.73), peak leaf area (31.50 dm-2 plant -1) and highest total chlorophyll (1.92 mg g-1), vigour index (195.41), more root length (12.21cm)and highest survival percent(96.17%).

Sarita *et al.,* (2019) study about “Effect of different potting media on survival and growth of air layered litchi cv. Dehradun” different potting media (litchi orchard soil, sand, FYM, sawdust, Vermicompost, rhizobacteria, coco peat, perlite, neem cake and vermiculite) were used in combination with application of 500 ppm IBA. The result showed that among the different media, litchi orchard soil in combination with FYM and rhizobacteria was identified as best potting media for mass propagation of litchi in black polyethylene bags under open field conditions for obtaining highest survival

percentage (93.51%) and also gave better results with respect to all the parameters studied including increase in plant height (10.25cm), shoot length (12.32cm), shoot diameter (0.24cm), length of longest shoot (16.62cm), number of shoots per layer (6.20), fresh weight of shoot (46.49g) and dry weight of shoot (28.29g) after six months of planting.

Dawar *et al*., (2020) studied about "Effect of different rooting media for rooting success and survivability of marcottage in Pomegranate *(Punica granatum L*.) cv. Bhagwa" among different treatments Soil + Vermicompost + *Azospirillum* + IBA 5000 ppm was most effective in rooting success at DAT 60, 90 (100%, 93.33%) and survivability at 120 DAT (93.33%) followed by the treatment Soil + Vermicompost + *Pseudomonas* + IBA 5000 ppm. This treatment also resulted maximum percentage of rooted layers (97.77%) and rooting and growth parameter number of primary root (16.40), number of secondary root (32.80), length of primary root (14.20cm), length of secondary root (6.28cm), longest length of root DAL 45 (15.88cm), diameter of primary root (4.01mm), diameter of secondary root (2.20mm).

Kumar *et al.,* (2020) investigated the efficacy of arbuscular microbial inoculations in relation to organic growing media on growth and bud take of citrus nursery ,three soil solarized organic growing media, Soil + Farmyard manure and Soil + Vermicompost enriched with bioinoculant *Glomus mossae*, *Gigaspora* and *Acaulospora,* consortium of *Arbuscular Mycorrhizal* fungi (AMF) and uninoculated was kept as control. The combinational effect of soil + Vermicompost enriched with consortium of AMF recorded the maximum seedling height (68 cm), diameter (6.81 mm), number of leaves (94.23) and plant biomass (58.82%). The root growth attributes exhibited maximum length and diameter of tap root (45.88 cm and 7.12 mm respectively) and number of secondary roots (50.02).

(b) Leaf Mould –

Kaur *et al*.,(2006) the propagation studies in mango with epicotyl grafting were carried out with seven growth media. Six sub-treatments included grafting on 5, 7, 9, 11, 13 and 15-day-old rootstocks. The highest sprouting of graft scion was recorded in soil + FYM + sand followed by soil + leaf mold. Sprouting was significantly higher with the use of 7-day old rootstock for grafting followed by 9 and 5-day-old rootstock. The highest survival was observed with 7-day-old stock, the survival rate decreased when the age of the stock increased to 15-day. The graft survival was better in soil + FYM + sand followed by soil + FYM after 4 months of grafting. The survival percentage was higher in transplanted grafts than those grafted In-situ in polybags. Vegetative growth viz. sprout length and sprout diameter were the highest in plants grafted on 7-day-old rootstock followed by 9 and 11-day-old rootstocks.

Rymbai *et al.* (2012) conducted an experiment to study the effect of coco peat and sphagnum moss on rooting, survival and growth characters of rooted air layer plantlets under open and polyhouse nursery in guava. It was found that Coco peat + sphagnum moss recorded maximum rooting percentage (85.00), number of primary (10.80) and secondary (22.44) roots, length of longest (10.78 cm), fresh (2.72 g) and dry (0.51 g) root weight, establishment percentage (83.33), number of leaves (6.67) at 45 days after transplanting (DAT) and (13.83) at 60 DAT and minimum (8.67) number of days for buds sprouts. Polyhouse nursery performed better than open field nursery in all the parameters irrespective of methods of layering with minimum (8.83) number of days for sprouting, maximum establishment percentage (82.22), number of leaves (7.89) at 45 DAT and (13.08) at 60 DAT.

Somprabha (2014) studied on the effect of different rooting media on survival and success of air layers in Kagzi lime. Amongst the rooting media tried, Soil or Peat soil + FYM + Sand (1:1:1) caused higher rooting percentage of Kagzi lime. The number of primary roots , maximum and minimum root length , fresh and dry weight of roots per air layer after planting increased up to maximum extent due to the above mixtures of rooting media. The maximum plant height, number of branches and leaves per air layer were noted with soil or peat soil + FYM + sand. However, this was followed by soil or peat soil + FYM (1:1) without sand .Lower values of these parameters were recorded under soil alone treatment. Peat soil proved superior to soil alone in respect of these parameters.

Pratibha *et al*., (2017) concluded that effect of different concentration of growth regulators and rooting media on rooting of air layering of guava *(Psidium guajava* L.) *cv*. Gwalior-27.The experiment was laid out in Randomized Block Design with three replications and 35 treatments combinations including control,IAA,IBA both each at 10,000 and 15,000 ppm and rooting media Soil, Soil + Vermicompost ,Soil+ Coco peat, Soil + leaf mould , Soil +Vermicompost + Coco peat, Soil+ Vermicompost + Leaf mould and Soil + Coco peat + Leaf mould. The result revealed that the maximum number of primary and secondary roots, length and diameter of primary and secondary root was found in Soil + Coco peat + leaf mould rooting media. In case of hormones and its concentration, the maximum number of primary and secondary roots, length and diameter of primary and secondary root was found in 15,000 ppm IBA.

Biofertilizers –

Singh *et al.,(*2008) concluded that, 60 days after treatment , the mean maximum increase in shoot length (41.76%) was observed in Jatropha plant under Vermicompost at 10kg + 50% recommended dose of NPK +

Azotobacter at 20 g per plant followed by 100% recommended dose of NPK treatment (41.72%). Maximum increase in shoot diameter (35.63%) was recorded in Vermicompost at 10kg + 50% recommended dose of NPK + *Azotobacter* at 20 g per plant followed by Neem cake at 5 kg + 50% recommended dose of NPK + *Azotobacter* at 20 g per plant treatment (35.29%).

Sharma (2014) reported that the study was conducted in green house of the institute. Twelve months old seedlings of *Madhuca latifolia* were selected for study. Total 24 treatments were tried using bio fertilizers, and chemical fertilizers, the result indicates that bio fertilizers were found much superior to chemical fertilizers in improving the soil fertility. *Azotobacter* was found the most efficient in improving the organic matter and nitrogen whereas PSB application is the best for improving phosphorus and potash. PSB has mobilized unavailable "P" to available form to the plants, which has resulted in increasing the growth of seedlings.

Damar *et al.,* (2014) fifteen treatment combinations consisting of three treatments of biofertilizers *i.e.* Control, *Azotobacter* in powder form, *Phosphorus Solubilizing Bacteria* (PSB) in powder form and five treatments of growth regulators *i.e.* Control, 1000 ppm IBA, 2000 ppm IBA, 1000 ppm NAA and 500 ppm NAA were replicated thrice in CRD factorial. Study revealed that days taken to start sprouting and 50 % sprouting, percentage success of cutting, number of leaves per shoot, number of roots per cutting, length of root, diameter of root and dry matter percentage of roots, maximum total number of leaves per cutting and fresh weight of roots were recorded under PSB, which were significantly higher to control.

Bhandulkar *et al.,* (2017) conducted an experiment at college of Agriculture, Gwalior about the impact of IBA and bioinoculant on survivability of transplanted air layered plants of guava. The results revealed that the plants grown in the media having one part of soil and one part of sand and Vermicompost 1:1:1 ratio with *Azotobacter* + PSB (B_3) significantly proved better in improving stem diameter (1.80cm), plant height (22.54cm) number of leaves per plant (18.75), leaf area (39.47cm^2), number of new sprouts (5.91) and fresh weight of leaves (0.63g), dry weight of leaves (0.23g) of guava.

Kashyap *et al.,* (2019) revealed about effect of biofertilizer and IBA on photosynthesis efficiency and weight of leaf in air layered guava plant. The results revealed that the combination of B_5I_2 (*Azotobacter* + PSB + Potash Solubilizing Bacteria + Zinc Solubilizing Bacteria and 2000 ppm IBA dose produced maximum fresh/dry weight at 120 DAT and maximum photosynthetic efficiency in air layered guava plants.

Plant Growth Regulator (GA_3)-

Cooper (1940) presumed the application of growth substances in accumulation of certain chemical substances at the base of cutting, which stimulate the meristem to divide quickly and form roots.

Jhoolka *et al.,* (2004) a trail was conducted to study the influence of biofertilizers, GA_3 and their combinations on the growth of pecan seedlings. Maximum linear and radial growth was recorded with *VAM* + GA_3 (5000ppm) treatment. Highest internodal length, number of leaves, fresh and dry weight of shoots and root/ shoot ratio was recorded under *VAM* + *Azotobacter* + GA_3 treatment whereas, leaf size, root length, fresh and dry weight of roots and photosynthetic rate were highest with *VAM* + *Azotobacter* treatment. The highest root colonization occurred with *VAM* + *Azotobacter* treatment. Hundred per cent graftable/ buddable plants were obtained with *VAM* + *Azotobacter* +GA_3 (5000 ppm) treatment.

Haque *et al.,* (2004) examined the two factor experiment consisting of three layering methods viz, mound, trench and air layerings and ten growth regulator treatments viz. 2000, 2500 and 3000 ppm IAA; 2000, 2500 and 3000 ppm IBA; 200, 300 and 400 ppm GA_3 and a control was laid out in the Randomized Complete Block Design (RCBD) with 4 replications. Methods of layering showed significant effect on success of rooting, survivability and most of the growth parameters. The highest percentage of success in rooting (84.23%) was obtained from mound layering. Growth regulator treatments had significant effect on almost all parameters. Maximum number of shoots/plant (5.75), highest success in rooting (94.83%), maximum number of roots (40.00) per layer, longest roots (21.64cm), maximum fresh (37.49g) and dry (18.96g) weights and the highest survival percentage (95.35%) were recorded when IBA (2500 ppm) was used.

Canli *et al.,* (2008) reported that the treated seedlings were evaluated in terms of seedling diameter and length at the end of the growing season. GA_3 sprays significantly increased lengths of pear and cherry seedlings. The effects of plastic covering on seedling diameter and length were both significant for pear and cherry seedlings. None of the treatments yielded plants with higher lengths and larger diameters as compared to control in apple seedlings. The pear seedlings grown under plastic tunnel were significantly taller and thicker than the ones growing in the open field. Maximum plant height (38.11cm) and stem thickness (6.6mm) in pear seedlings were obtained with 2 x 400 ppm GA_3 and with 1 x 400 ppm GA_3 applications in combination with plastic tunneling respectively, while minimum values for the mentioned parameters were observed in control. The highest length (39.7cm) was recorded in cherry seedlings treated with 1 x 400 ppm GA_3 applications but all GA_3 applications resulted in reduced stem thickness in

cherry seedlings. No treatments yielded seedlings that could be grafted in the late fall of the same season.

Sevik *et al*., (2013) this study revealed the potential of producing *Melissa officinalis* L. using stem cuttings. Four different hormones (IAA, IBA, NAA and GA_3) were applied to the cuttings, with and without buds, in two doses (1000 mg/L and 5000 mg/L), the results of the study showed that the auxin group hormones (IAA,IBA and NAA) do not have apparent effect on rooting percentage, these hormones were detected to affect the morphological characteristics of the newly generated plants, especially root generation. GA_3 application has a considerable effect on stem height.

Muthia *et al*.,(2015) studied about effect of PGR_s like indole butyric acid (IBA), naphthalene acetic acid (NAA), Gibberellic acid (GA_3) on *Ceriops decandra* cuttings the results revealed that best growth performance was recorded when cuttings were treated with GA_3 2000 ppm. Among the treatments, GA_3 enhanced the number of leaves and roots, shoot and root length, fresh and dry weight of roots increased to a larger extent.

Ahmed *et al.,* (2018) evaluated the effect of IBA and GA_3 on Rangpur lime (*Citrus limonia Osbeck*) and suggested that IBA 1000 ppm performed the best in respect of all the parameters studied *viz*., number of roots per cutting (45.37), survival % of rooted cuttings (60.00), number of leaves per cutting (2.27), number of secondary branches per cutting (1.87) and number of leaves per secondary branch (4.60). With the increase in concentration of GA_3 adventitious root formation, consistently got inhibited.

Rolania *et al.,* (2018) investigation on effect of plant growth regulators on rooting of hardwood of grape *cv.*Thompson seedless was carried out with 3 regulators (IAA with 100, 300, 500 ppm concentration, IBA with 1000, 2000, 3000 ppm concentration and GA_3 with 50, 100, 150 ppm concentration) and control treatment. Results showed that the treatment GA_3 150 ppm (T_9) had taken least number of days (9 days) for emergence of first node and IBA-2000 (T_4) had taken minimum number of days for emergence of first node and vice versa for the first emergence of the node.

Noori *et al.,* (2019) this research was conducted in the College of Agriculture Sciences Engineering, University of Sulaimani, Kurdistan region/ Iraq, to study the possibility of propagation of pistachio Vera cv. Batoury by air layering through treating the girdling wounds with IBA, and spray of layered shoots with IBA and GA_3 .The experiment was laid out by RCBD design with three replications on six trees.20000 ppm IBA applied to the girdling wounds of layered shoots gave values of rooting percentage (63%), root number (4.6) , root length (5.7cm) and survival percentage (80%), while control gave no rooting. The rooting percentage of (33.4%) was achieved from layered shoots without spray and from those sprayed by 25 and 50 ppm IBA. A survival

percentage of (50%) was achieved from layered shoots sprayed by 25 and 50 ppm IBA and 30 ppm $GA_{3.}$ Interaction of 20000 ppm IBA treatment of girdling wound with 25 and 50 ppm IBA spray of layered shoots and without spray gave (70%) rooting percentage. 20000 ppm IBA treatment of girdling wound with spray of layered shoots by 25 , 50 ppm IBA and 30 ppm GA_3 showed the highest (100%) survival percentage.

CHAPTER – III

MATERIAL AND METHODS

This chapter comprises the particulars of the resources used and methods adopted during the experiment entitled **"Effect of different growing media, biofertilizer and plant growth regulator on growth and survivability of Guava air layers"** was conducted at Experimental block, College of Agriculture, Gwalior during 2020 -21 under agro - climatic conditions of Northern Madhya Pradesh.

The methods employed during the course of investigation and materials utilized have great significance in the research program. The details of material used and techniques employed in carrying out the investigation are described under the following heads:

3.1 Experimental site

The experiment was conducted on the guava plants at Experimental block, College of Agriculture, Gwalior, (M.P.).

3.2 Climatic Condition:

The region comes under semi-arid and sub-tropical climate with extreme weather condition having hot and dry summer and cold winter. Gwalior is situated at 26° 13' N latitude and 78° 14' E longitudes at an altitude of 211.5 m above mean sea level in Gird belt. Where maximum temperature exceeds 45 °C in May June. The winters are cold and minimum temperature reaches as low as 2 °C in December and January. Frost is expected from the last week of December to first week of February. Usually the monsoon arrives in the second fortnight of June and lasts till September. Occasionally light rains are expected during winter.

The annual rainfall ranges between 650 to 751 mm, most of which received from end of June to end of September. Drought is the common feature due to the scanty and uneven distribution of rainfall.

3.3 Weather condition during the study period:

Weather conditions during the study period 2020 – 21 recorded as per Meteorological Observatory College of Agriculture, Gwalior is given in table3.1

Table 3.1: Meteorological observations during 2020-21 the period of investigation.

S.No.	Date	Temp. (°C)		Humidity (%)		Rainfall (mm)	Evaporation (mm)
		Max.	Min.	Morning	Evening		
1	Oct. 1-7	37.0	16.4	84.3	31.0	000.0	3.5
2	Oct. 8-14	36.6	17.6	85.8	34.6	000.0	5.0
3	Oct. 15-21	35.6	18.4	76.1	33.6	000.0	4.7
4	Oct. 22-28	34.8	14.9	83.4	29.1	000.0	4.4
5	Oct. – Nov. 29-4	31.8	09.9	78.4	35.2	000.0	3.4
6	Nov. 5-11	31.5	11.8	85.8	23.2	000.0	3.5
7	Nov. 12-18	30.9	10.3	87.8	28.0	000.0	2.5
8	Nov. 19-25	29.9	09.5	84.7	27.7	002.1	2.6
9	Nov.- Dec. 26-2	28.8	11.0	79.8	35.4	000.0	3.6
10	Dec. 3-9	29.4	09.7	94.3	43.1	000.0	3.7
11	Dec. 10-16	25.3	11.7	92.7	63.4	000.0	2.8
12	Dec. 17-23	22.5	05.1	90.7	58.9	000.0	3.0
13	Dec. 24-31	22.7	05.2	93.9	73.1	000.0	2.4
14	Jan. 1-7	22.5	10.1	93.1	75.7	000.0	1.7
15	Jan. 8-14	20.8	08.2	90.3	78.4	000.0	2.0
16	Jan.15-21	22.9	05.8	94.1	78.7	000.0	2.3
17	Jan.22-28	21.3	05.5	96.5	75	000.0	2.1
18	Jan.- Feb.-29-4	25.3	05.0	89.5	63.8	000.0	2.8
19	Feb. 5-11	25.5	08.3	89.4	64.5	000.0	3.2
20	Feb.12 -18	28.6	09.2	93.2	55.5	000.0	3.2
21	Feb.19-25	30.2	09.9	89.1	42.0	000.0	4.0
22	Feb.-Mar.-26-4	32.6	12.8	75.1	38.7	000.0	6.6
23	Mar.5-11	34.5	14.6	75.8	36.0	000.0	6.0
24	Mar. 12-18	32.8	15.4	79.0	47.1	003.0	5.4
25	Mar.19 -25	36.3	17.1	76.2	47.7	004.0	7.1
26	Mar.- Apr. 26-1	37.7	18.2	72.7	41.1	000.0	9.3

Source: Meteorological observatory; RVSKVV, Gwalior (M.P.)

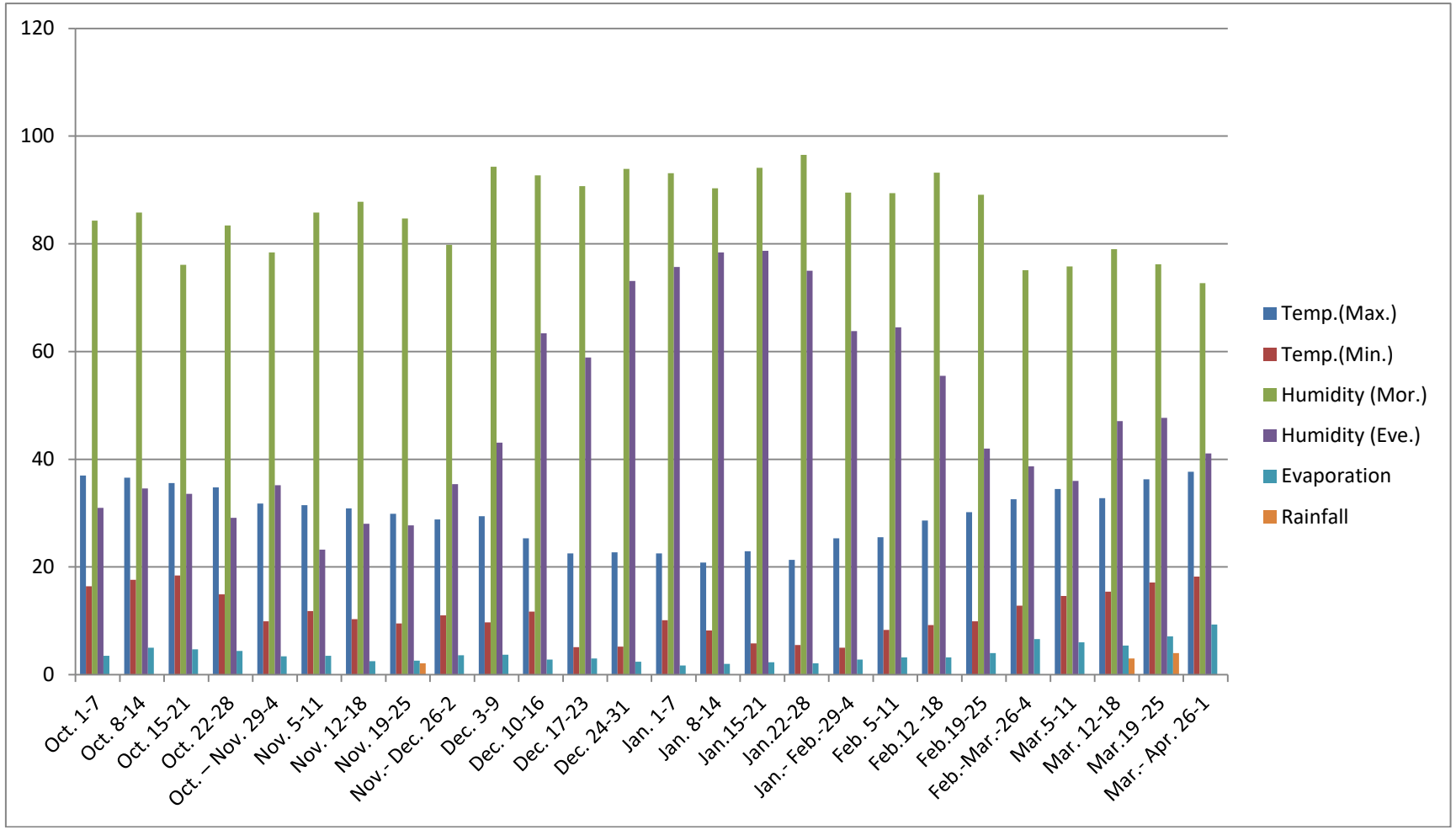


Figure3.1Meteorological observations during 2020-21 the period of investigation

3.3 Experimental materials:

Eight years old plants of Guava *cv*. Gwalior-27 were selected for this research work at Experimental block, College of Agriculture, Gwalior, (M.P.) for experiment purpose. The other materials used are enlisted below:

3.4.1 Growing media, PGR and Biofertilizer

1. Soil
2. Vermicompost
3. Leaf mould
4. *Azotobacter*
5. Gibberellic acid (GA_3)
6. Polyethylene bags

3.4.2 Chemicals were used-

1. Nano silver
2. Copper oxychloride
3. Ethanol

3.4.3 Instruments were used-

1. Secateurs
2. Scalpel
3. Electric weighing balance
4. Digital Vernier Calipers
5. Measuring Scale
6. Measuring cylinders
7. Conical flasks and Beakers
8. Watering can
9. Forceps

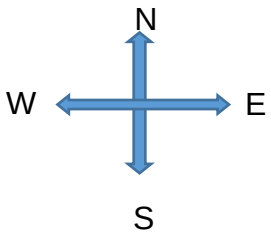
3.5 Experimental details:

The details of layout and treatment combinations are as follows:

Name of the crop	:	Guava (*Psidium guajava* L.)
Variety	:	Gwalior-27
Year	:	2020-21
Experimental design	:	CRD
No. of Replications	:	3
No. of Treatments	:	9
No. of air layers per treatment	:	21
Total number of detached air layers planted	:	567
Source of Nutrients	:	Growing media, Biofertilizer and PGR **Growing Media** 1.Soil 2.Vermicompost 3.Leaf mould **Biofertilizer** 1.*Azotobacter* **Plant Growth Regulator** 1.Gibberellic Acid (GA_3)
Date of planting	:	05/11/2020
End of experiment	:	05/03/2021

Detail of treatments: -

T_0	Soil (Control)
T_1	Soil + Vermicompost (2:1)
T_2	Soil + Vermicompost (2:1) + GA_3 + 100 ppm + *Azotobacter* (0.5 ml)
T_3	Soil + Vermicompost (2:1) + GA_3 + 150 ppm + *Azotobacter* (0.5 ml)
T_4	Soil + Vermicompost (2:1) + GA_3 + 200 ppm + *Azotobacter* (0.5 ml)
T_5	Soil + Leaf mould (2:1)
T_6	Soil + Leaf mould (2:1) + GA_3 + 100 ppm + *Azotobacter* (0.5 ml)
T_7	Soil + Leaf mould (2:1) + GA_3 + 150 ppm + *Azotobacter* (0.5 ml)
T_8	Soil + Leaf mould (2:1) + GA_3 + 200 ppm + *Azotobacter* (0.5 ml)



R – I	R – II	R – III
T_7	T_0	T_4
T_8	T_1	T_2
T_6	T_2	T_1
T_5	T_7	T_3
T_3	T_5	T_5
T_2	T_8	T_7
T_1	T_4	T_0
T_4	T_3	T_6
T_0	T_6	T_8

Layout of the experiment

Preparation of GA_3 solution:

The GA_3 solution was prepared for the experiment by using the following way according to the table as shown below:

S.No.	Solution prepared		GA_3 powder
	Concentration	Volume	
1.	100 ppm	1 lit	100 mg
2.	150 ppm	1 lit	150 mg
3.	200 ppm	1 lit	200 mg

Preparation of growing media:

120 kg sterilized Soil was taken by removing small stones and pebbles. Soil and Vermicompost were mixed in the ratio 2:1 by volume and Soil and Leaf mould were mixed in the ratio 2:1 by volume, after that biofertilizer i.e., *Azotobacter* @ 0.5 ml per poly bag is mixed. The sizes of the polybags were 15 x 10 cm.

Detachment of air layers:

Air layers were detached by making a cut just below the lowest end of the ring surface with the help of sharp secateurs. The air layers were brought under shade after detachment and their polyethylene were removed gently without hurting the roots.

Preparation and planting of air layers in poly bags:

The air layers were detached from eight year old mother plants and unwrapped from polyethylene thereafter. They were cut into equal length (15 cm) and made entirely leafless before planting. Initially leafless air layers were dipped into the solution of Copper oxychloride for fungus control after that the layers were dipped in different concentrations of GA_3 solution for about two minutes and then planted in the prearranged growing media filled poly bags thereafter. After the planting of detached air layers, the poly bags were placed in open conditions and individually irrigated. On the next day, the genuine treatment specific tagging with laminated tags on poly bags was performed.

In the experiment, the layers were detached in November and subjected to various treatments after treating the growing media with nano-silver @ 35 ml/L of water.

3.6 Observations recorded:

For the present study, 21 air layers of guava (*Psidium guajava* L.) *cv.* Gwalior-27 per treatment were randomly selected and replicated thrice. The observations were recorded from 5 air layers that were selected randomly and tagged in each replication. The observations were determined and their means were worked out for statistical analysis.

3.6.1 Observations recorded:

(A) Growth Characters

1. Number of sprouts
2. Number of leaves
3. Stem length (cm)
4. Stem thickness (mm)
5. Plant survival percentage

(B) Root parameters

1. Number of primary roots
2. Number of secondary roots
3. Length of primary root (cm)
4. Length of secondary root (cm)
5. Diameter of primary root (mm)
6. Diameter of secondary root (mm)
7. Fresh weight of primary roots (g)
8. Fresh weight of secondary roots (g)

3.6.1 Growth Parameters:

1. Number of sprouts

The number of sprouts observed from five selected plants from each treatment and each replication after 15 days of transplanting. The average of five selected plants was recorded.

2. Number of leaves:

The number of leaves was recorded from randomly selected five layers from each treatment and each replication at different intervals 45, 90 & 135 days after transplanting.

3. Stem length (cm):

The stem length was measured with the help of meter scale at 45, 90 &135 days after their planting. The average of five selected air layers in each treatment were computed and presented in cm.

4. Stem thickness (mm):

The stem diameter was measured with Digital Vernier Calipers at monthly intervals 45, 90 &135 days after planting and expressed in mm. The average of five selected layers in each treatment was recorded.

5. Plant survival percentage:

The air layers were planted in the polyethylene bags and it was observed that whether the layers were established in the polyethylene bags after transplanting or not. The survival percentage of air layers was calculated by the following formula-

$$\text{Survival \%} = \frac{\text{Total no. of survived layered plants} \times 100}{\text{Total no. of layered plants}}$$

3.6.2 Root Parameters:

1. Number of primary roots

Five rooted layers were randomly sampled from each treatment. The polythene sheet was removed carefully using forceps and care was taken to avoid damage to roots. Number of primary roots was counted in each layer, averaged and expressed in number.

2. Number of secondary roots

The same five roots were used for primary roots used for counting for secondary roots. The polythene sheet was removed carefully using forceps and care was taken to avoid damage to roots.

3. Length of primary roots (cm)

Five rooted transplanted layers were randomly sampled from each treatment. The polythene sheet was removed carefully using forceps and care was taken to avoid damage to roots. With the help of scale length of primary roots was measured from the collar region to the tip of primary root in centimeters (cm).

4. Length of secondary roots (cm)

The layers which were used for the measurement of length primary roots, the same were used for the length of secondary roots. The care was taken while measuring the length so that roots did not get hurt. The length was measured with the help of scale in centimeters (cm).

5. Diameter of primary roots (mm)

Five roots per layer were selected randomly and their diameter was taken with the help of Digital Vernier Calipers and average was calculated and expressed in mm.

6. Diameter of secondary roots (mm)

The five roots per layer were selected randomly and their diameter was taken with the help of Digital Vernier Calipers and average was calculated and expressed in mm.

7. Fresh weight of primary roots (g)

The fresh weight of primary roots was measured with the help of digital weighing balance from randomly selected five layers from each treatment and each replication, averaged and expressed in numbers.

8. Fresh weight of secondary roots (g)

The fresh weight of secondary roots was also measured with the help of digital weighing balance from randomly selected five layers from each treatment and each replication, averaged and expressed in numbers.

3.6.3 Economics of the treatments:

3.6.3.1 Gross income (Rs/ha)

For calculation of gross income, the unit rate of each plant was multiplied with the number of plants.

3.6.3.2 Net income (Rs/ha)

Net income was calculated by subtracting the total expenditure from the gross income.

3.6.3.3 Benefit: Cost (B: C) ratio

The B: C of the treatments was computed by dividing gross income by the total cost with the following formula:

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

3.7 Cultural practices:

Weeding: Three hand weeding were done at 15 days of interval after transplanting of air layers and proper care was taken during weeding not to harm or cause any injury to root system.

Irrigation: Irrigation given at interval of 8 to 10 days after transplanting of air layers of guava plants.

3.8 Plant protection measures:

Soil drenching with fungicide (Copper oxychloride @ 1g/l of water) was done twice at interval of 15 days in the month of January, for protection of guava air layers from various diseases.

3.9 Statistical analysis:

The data recorded on different observations were tabulated and analyzed statistically by using the techniques of analysis of variance as suggested by Fisher (1954) in his book "Design of Experiment". Skeleton of analysis of variance (ANOVA) table of the experiment is given below-

Table 3.2 Skeleton of analysis of variance (ANOVA) table

Source of variation	**Degree of freedom**	**Sum of square**	**Mean sum of square**	**"F" Value Calculated**	**F_{tab} (5%)**	**F_{tab} (1%)**
Treatment	8	SST	MST	MST/MSE		
Error	18	SSE	MSE			
Total	26	TSS				

The significance of the treatment was judged by employing 'F' test. The treatment mean were distinguished with the help of critical difference (C.D.) which was computed as follows

(1) S. E. m and C.D. for treatment:

S. E. m ± = Error/treatment

C.D. = $\sqrt{2}$ × S.E .m × t (at 5%) for error d. f.

(2) S. E. m and C.D. for replication:

S. E. m ± = Error/replication C.D. = $\sqrt{2}$ × S.E. m × t (at 5%) for error d. f.

Where,

Error variance = MSS due to error

The mean sum of square (MSS) was calculated by dividing the sum of square (SS) by corresponding degree of freedom (d. f.). The ratio 'F' was calculated by the following formula:

F = MSS/EMSS.

CHAPTER – IV

RESULTS

The present investigation entitled **"Effect of different growing media, biofertilizer and plant growth regulator on growth and survivability of Guava air layers"** was carried out during 2020-21. The experiment was conducted at Research area, College of Agriculture, Gwalior (MP).

The experiment was laid out in Completely Randomized Design (CRD) with three replications. Each replication consists of 9 treatments. The experiment comprised of nine treatments consisting of different levels of GA_3 and *Azotobacter* with Vermicompost and Leaf mould. The observations on different aspects such as growth parameters, root parameters and economical parameters were calculated.

The data reconnoitered on growth and root parameters were analyzed statistically and are propounded in this chapter under following headings. All the characters under study are described and presented in tables and graphically illustrated. The analysis of variance has been appended.

4.1 Growth parameters:

4.1.1 Number of sprouts

4.1.1.1 Effect of *Azotobacter*, GA3 and growing media on number of sprouts after 15 days

The data recorded for number of sprouts recorded at 15 DAT is presented in table 4.1.1. This is also statistically analyzed and graphically demonstrated in figure 4.1.1. The analysis of variance (ANOVA) is given in appendix- I.

It is perceptible from the observations recorded that, various treatments containing growing media, PGR and biofertilizer had significant effect on the number of sprouts. The table clearly reveals that T_4 (Soil +Vermicompost (2:1) + GA_3 200 ppm + *Azotobactor* (0.5ml)) was significantly superior to other treatments, and closely followed by treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobactor* (0.5ml)).

The maximum no. of sprouts (8.67) were recorded under treatment T_4 (Soil +Vermicompost (2:1) + GA_3 200 ppm + *Azotobactor* (0.5ml)). It was at par to treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)). The minimum no. of sprouts (2.67), (2.33) were observed in treatment T_5 (Soil + Leaf mould (2:1)) and T_0 (Soil (control)) respectively.

Table: 4.1.1 Effect of *Azotobacter*, GA_3 and growing media on number of sprouts

S.No.	Treatment	Number of sprouts at 15 days
T_0	Soil (Control)	2.33
T_1	Soil + Vermicompost (2:1)	3.33
T_2	Soil + Vermicompost (2:1) + GA_3 100 ppm + *Azatobacter* (0.5 ml)	4.67
T_3	Soil + Vermicompost (2:1) + GA_3 150 ppm + *Azatobacter* (0.5 ml)	5.33
T_4	Soil + Vermicompost (2:1) + GA_3 200 ppm + *Azatobacter* (0.5 ml)	8.67
T_5	Soil + Leaf mould (2:1)	2.67
T_6	Soil + Leaf mould (2:1) + GA_3 100 ppm + *Azatobacter* (0.5 ml)	4.00
T_7	Soil + Leaf mould (2:1) + GA_3 150 ppm + *Azatobacter* (0.5 ml)	5.00
T_8	Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azatobacter* (0.5 ml)	6.00
	S.E m ±	**0.430**
	CD at 5%	**1.279**

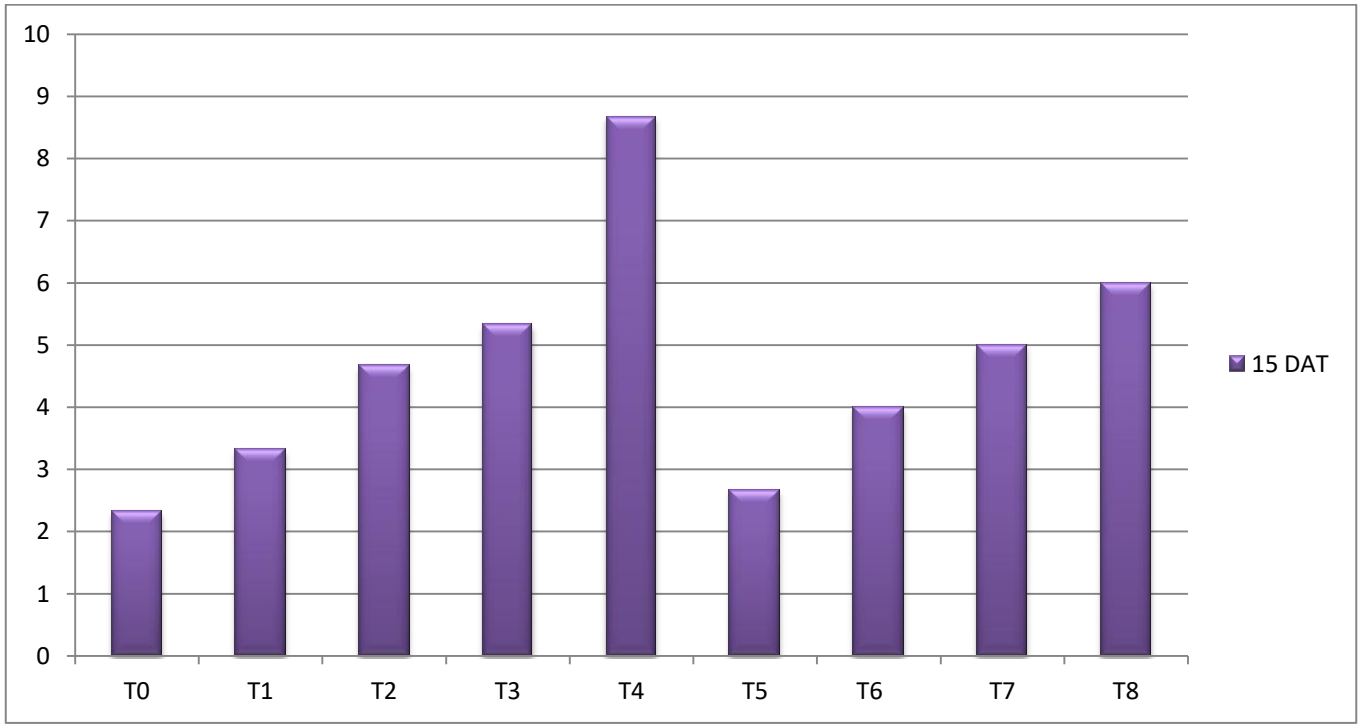


Figure 4.1Effect of *Azotobacter*, GA_3 and growing media on number of sprouts after 15 DAT

4.1.2 Number of leaves

4.1.1.2 Effect of *Azotobacter*, GA3 and growing media on number of leaves at different growth stages

The data regarding number of leaves at 45, 90 and 135 DAT is presented in table 4.1.2, illustrated in figure 4.1.2.a, 4.1.2.b and 4.1.2.c and analysis of variance given in appendix- II, III and IV.

Results revealed that the treatment T_4 (Soil + Vermicompost (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)) was found significantly superior to other treatments, and followed closely by treatment T_8 (Soil + (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)).

The maximum number of leaves (20.33, 28.67 and 37.00) at 45 , 90 and 135 DAL was found in treatment T_4 (Soil + Vermicompost (2:1)+ GA_3 200 ppm + *Azotobacter* (0.5 ml)) over control and other treatments and it was at par to treatment T_8 (Soil + (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)) at 45 DAT while T_3 also at par at 90 and 135 DAT only, whereas the minimum number of leaves (15.33 ,25.00 and 32.67), (14.33 , 21.67 and 32.00) at 45 , 90 and 135 DAT was noted in T_5 (Soil + Leaf mould (2:1)) and T_0 (Soil (control) respectively.

Table: 4.1.2 Effect of *Azotobacter*, GA_3 and growing media on number of leaves

S.No.	Treatment	Number of leaves		
		45 days	**90 days**	**135 days**
T_0	Soil (Control)	14.33	21.67	32.00
T_1	Soil + Vermicompost (2:1)	16.33	25.33	33.33
T_2	Soil + Vermicompost (2:1) + GA_3 100 ppm + *Azatobacter* (0.5 ml)	17.33	26.67	34.67
T_3	Soil + Vermicompost (2:1) + GA_3 150 ppm + *Azatobacter* (0.5 ml)	18.67	27.33	35.67
T_4	Soil + Vermicompost (2:1) + GA_3 200 ppm + *Azatobacter* (0.5 ml)	20.33	28.67	37.00
T_5	Soil + Leaf mould (2:1)	15.33	25.00	32.67
T_6	Soil + Leaf mould (2:1) + GA_3 100 ppm + *Azatobacter* (0.5 ml)	16.67	25.67	34.33
T_7	Soil + Leaf mould (2:1) + GA_3 150 ppm + *Azatobacter* (0.5 ml)	17.67	24.67	36.33
T_8	Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azatobacter* (0.5 ml)	19.33	27.00	36.67
	S.E m ±	**1.171**	**0.949**	**1.128**
	CD at 5%	**3.478**	**2.821**	**3.351**

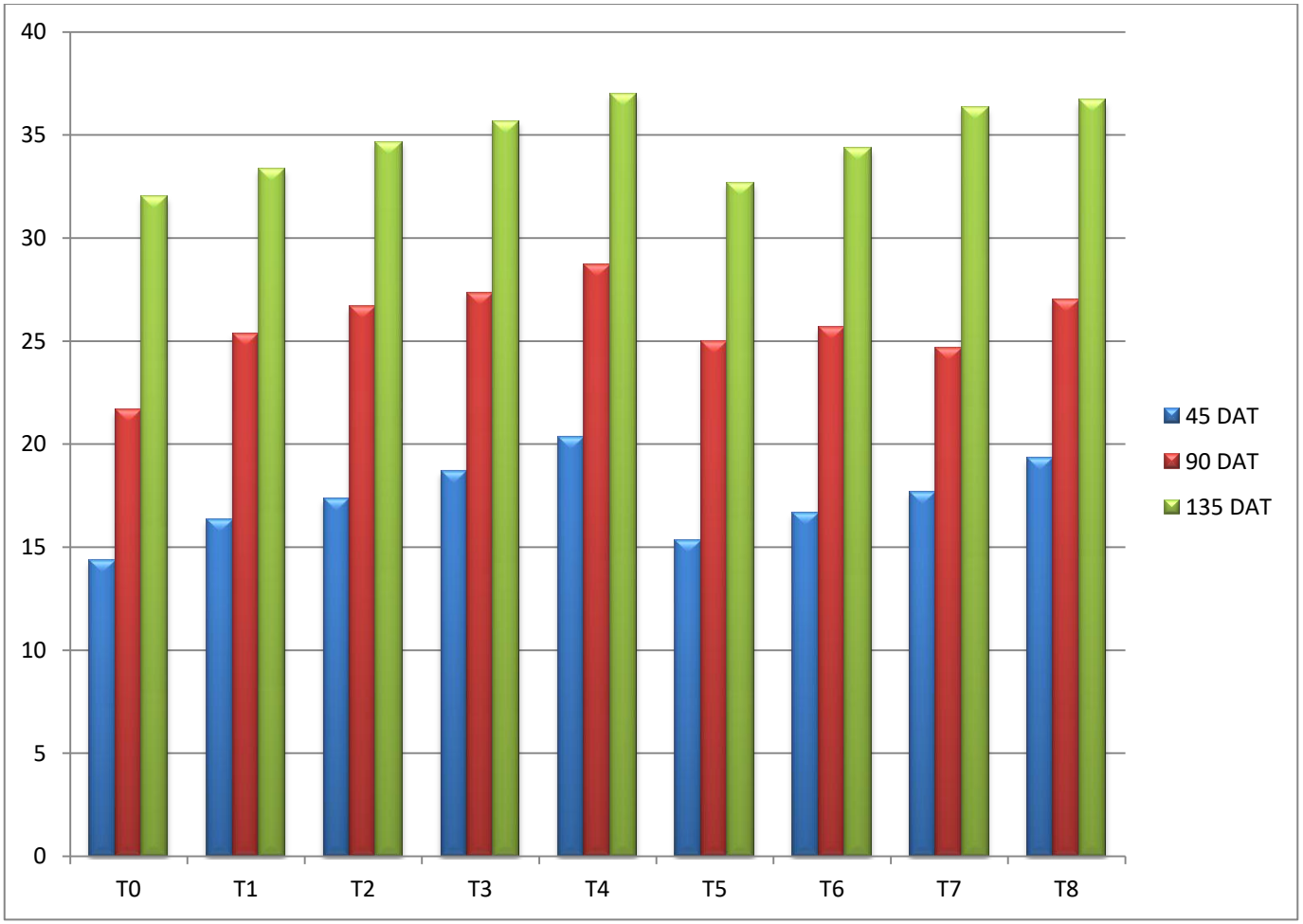


Figure 4.2 Effect of *Azotobacter*, GA_3 and growing media on number of leaves at different growth stages

4.1.3 Stem length (cm)

4.1.1.3 Effect of *Azotobacter*, GA_3 and growing media on stem length (cm) at different growth stages

The data observed for stem length (cm) at 45, 90 and 135 DAT is presented in table 4.1.3. This is also statistically analyzed and graphically demonstrated in figure 4.1.3. The analysis of variance (ANOVA) is given in appendix- V, VI and VII.

It is noticeable from the observations recorded that, various treatments containing growing media, PGR and biofertilizer had significant effect on the stem length. The table clearly reveals that T_4 (Soil +Vermicompost (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)) was significantly superior to other treatments, and closely followed by treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)).

The maximum stem length (cm) (18.00, 24.00 and 28.33) was recorded under treatment T_4 (Soil +Vermicompost (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)). It was at par to treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)) at 45 and 135 DAT and treatment T_3 (Soil + Vermicompost (2:1) + GA_3 150 ppm + *Azotobacter* (0.5ml)) at 90 DAT only. . The minimum stem length (cm) (13.90, 19.50 and 22.43), (12.97, 17.50 and 21.00) were observed in treatment T_5 (Soil + Leaf mould (2:1)) and T_0 (Soil (control)) respectively.

Table: 4.1.3 Effect of *Azotobacter*, GA_3 and growing media on stem length (cm)

S.No.	Treatment	Stem length (cm)		
		45 days	**90 days**	**135 days**
T_0	Soil (Control)	12.97	17.50	21.00
T_1	Soil + Vermicompost (2:1)	14.83	20.00	24.00
T_2	Soil + Vermicompost (2:1) + GA_3 100 ppm + *Azatobacter* (0.5 ml)	15.67	22.60	24.83
T_3	Soil + Vermicompost (2:1) + GA_3 150 ppm + *Azatobacter* (0.5 ml)	16.67	23.50	23.50
T_4	Soil + Vermicompost (2:1) + GA_3 200 ppm + *Azatobacter* (0.5 ml)	18.00	24.00	28.33
T_5	Soil + Leaf mould (2:1)	13.90	19.50	22.43
T_6	Soil + Leaf mould (2:1) + GA_3 100 ppm + *Azatobacter* (0.5 ml)	14.80	21.00	25.10
T_7	Soil + Leaf mould (2:1) + GA_3 150 ppm + *Azatobacter* (0.5 ml)	16.33	23.00	26.57
T_8	Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azatobacter* (0.5 ml)	17.53	23.90	27.67
	S.E m ±	**0.499**	**0.513**	**1.501**
	CD at 5%	**1.483**	**1.525**	**4.461**

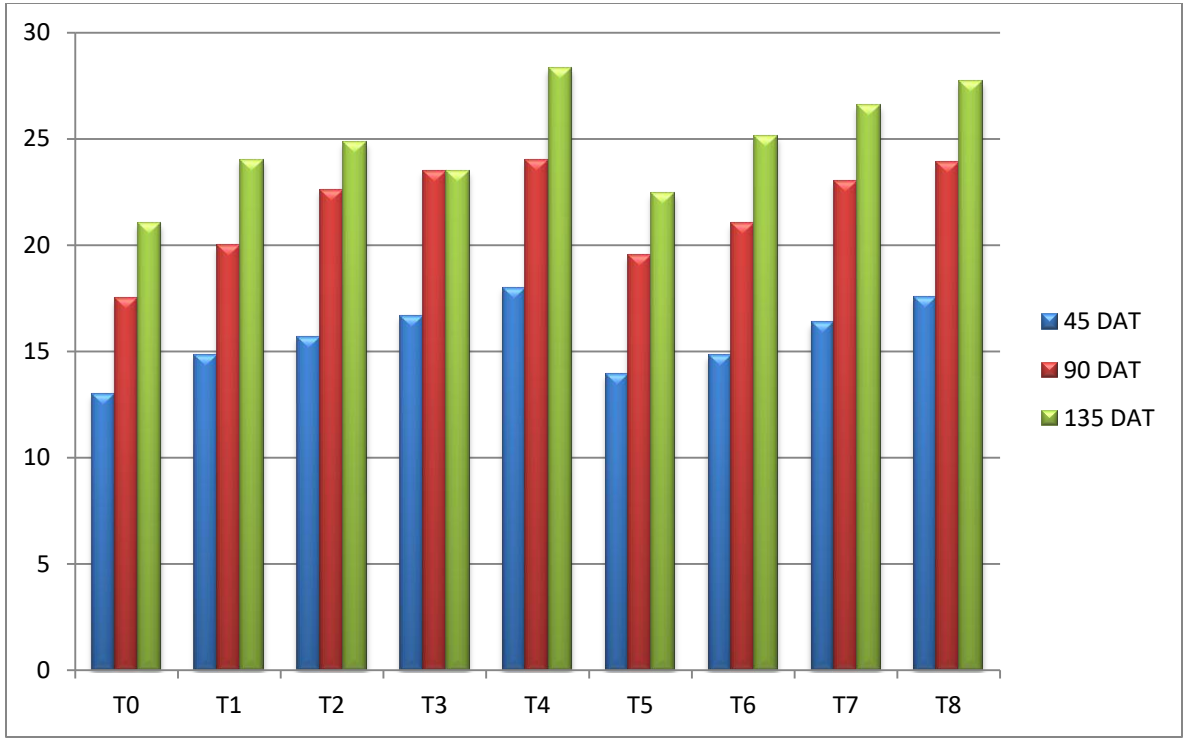


Figure 4.3Effect of *Azotobacter*, GA_3 and growing media on stem length (cm) at different growth stages

4.1.4 Stem thickness (mm)

4.1.1.4 Effect of *Azotobacter*, GA_3 and growing media on stem thickness (mm) at different growth stages

The data contemplated for stem thickness (mm) at 45, 90 and 135 DAT is presented in table 4.1.4. This is also statistically analyzed and graphically demonstrated in figure 4.1.4. The analysis of variance (ANOVA) is given in appendix- VIII, IX and X.

It is distinguishable from the investigation that, various treatments containing growing media, PGR and biofertilizer had significant effect on the stem thickness (mm). The table clearly demonstrate that T_4 (Soil+Vermicompost (2:1) +GA_3 200 ppm + *Azotobacter* (0.5ml)) was significantly superior to other treatments, and followed closely by treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)).

The maximum stem thickness (mm) (8.03, 12.77 and 16.20) was recorded under treatment T_4 (Soil +Vermicompost (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)). It was at par to treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)) at 45 and 90 DAT and treatment T_3 (Soil + Vermicompost (2:1) + GA_3 150 ppm + *Azotobacter* (0.5ml)) at 135 DAT only. The minimum stem thickness (mm) (5.50, 8.50 and 13.03), (5.00, 7.63 and 12.00) were observed in treatment T_5 (Soil + Leaf mould (2:1)) and T_0 (Soil (control)) respectively.

Table: 4.1.4 Effect of *Azotobacter*, GA_3 and growing media on stem thickness (mm)

S.No.	Treatment	Stem thickness (mm)		
		45 days	**90 days**	**135 days**
T_0	Soil (Control)	5.00	7.63	12.00
T_1	Soil + Vermicompost (2:1)	5.80	8.90	13.50
T_2	Soil + Vermicompost (2:1) + GA_3 100 ppm + *Azatobacter* (0.5 ml)	6.50	10.03	14.50
T_3	Soil + Vermicompost (2:1) + GA_3 150 ppm + *Azatobacter* (0.5 ml)	6.92	11.03	15.50
T_4	Soil + Vermicompost (2:1) + GA_3 200 ppm + *Azatobacter* (0.5 ml)	8.03	12.77	16.20
T_5	Soil + Leaf mould (2:1)	5.50	8.50	13.03
T_6	Soil + Leaf mould (2:1) + GA_3 100 ppm + *Azatobacter* (0.5 ml)	6.00	9.50	14.13
T_7	Soil + Leaf mould (2:1) + GA_3 150 ppm + *Azatobacter* (0.5 ml)	6.80	10.43	15.07
T_8	Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azatobacter* (0.5 ml)	7.50	12.33	15.73
	S.E m ±	**0.573**	**0.824**	**0.807**
	CD at 5%	**1.702**	**2.447**	**2.396**

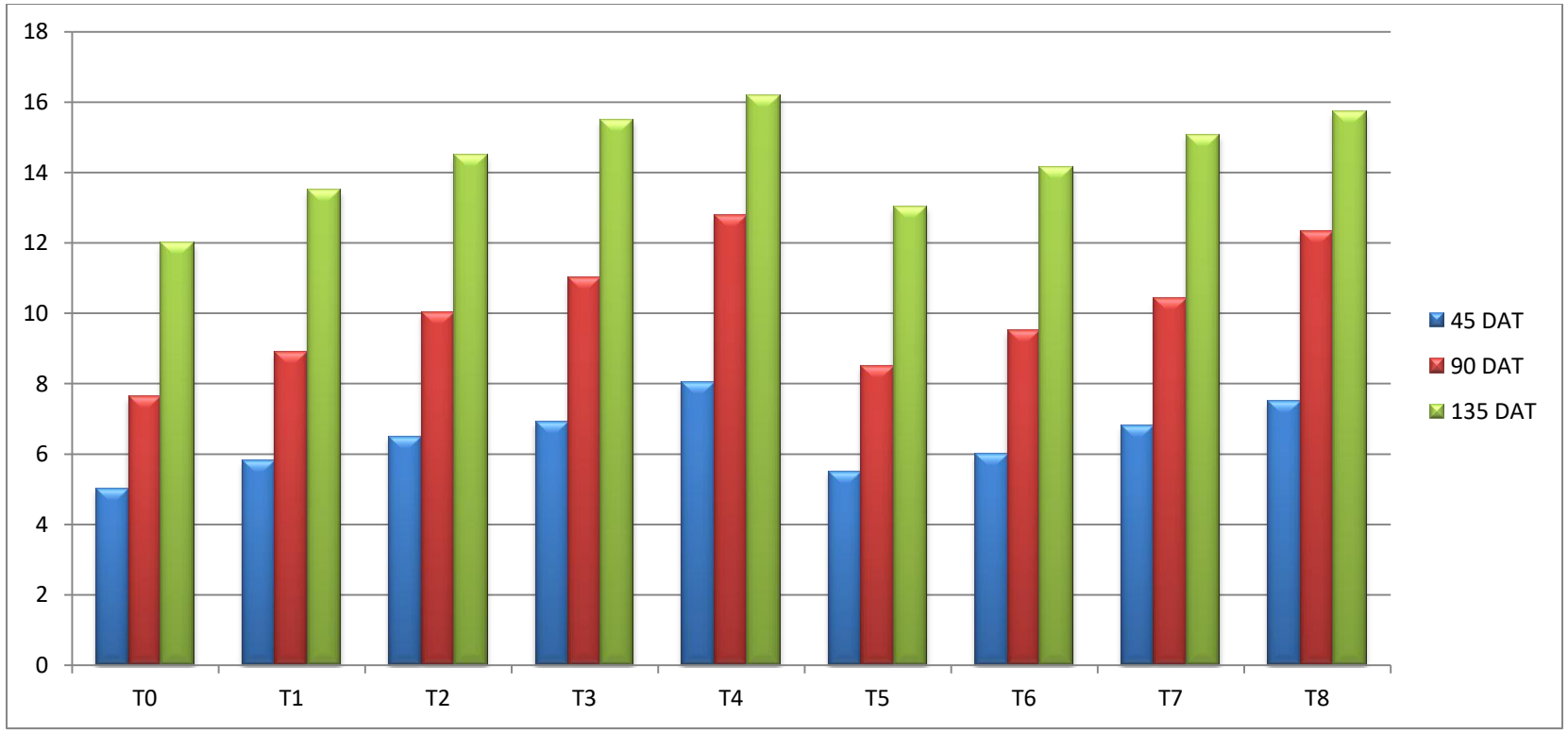


Figure 4.4Effect of *Azotobacter*, GA_3 and growing media on stem thickness (mm) at different growth stages

4.1.5 Plant survival (%)

4.1.1.5 Effect of *Azotobacter*, GA_3 and growing media on plant survival (%) at different growth stages

The data inferred for plant survival (%) at 45, 90 and 135 DAT is presented in table 4.1.5. This is also statistically analyzed and demonstrated graphically in figure 4.1.5. The analysis of variance (ANOVA) is given in appendix- XI, XII and XIII.

It is observable from the experiment that, numerous treatments had significant effect on the plant survival (%). The table clearly shows that T_4 (Soil+Vermicompost (2:1) +GA_3 200 ppm + *Azotobacter* (0.5ml)) was superior significantly over other treatments, and followed closely by treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)).

The maximum survival percentage of air layers (87.33%) was recorded under treatment T_4 (Soil +Vermicompost (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)). It was at par to treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)) at 135 DAT only and treatment T_3 (Soil + Vermicompost (2:1) + GA_3 150 ppm + *Azotobacter* (0.5ml)) at 45 and 90 DAT. The minimum survival percentages (68.10%), (64.57%) were observed in treatment T_5 (Soil + Leaf mould (2:1)) and T_0 (Soil (control)) respectively.

Table: 4.1.5 Effect of biofertilizer, GA_3 and growing media on plant survival (%)

S.No.	Treatment	Plant survival (%)		
		45 days	**90 days**	**135 days**
T_0	Soil (Control)	80.50	72.07	64.57
T_1	Soil + Vermicompost (2:1)	83.13	76.00	68.60
T_2	Soil + Vermicompost (2:1) + GA_3 100 ppm + *Azatobacter* (0.5 ml)	85.03	80.20	72.43
T_3	Soil + Vermicompost (2:1) + GA_3 150 ppm + *Azatobacter* (0.5 ml)	88.53	83.07	76.00
T_4	Soil + Vermicompost (2:1) + GA_3 200 ppm + *Azatobacter* (0.5 ml)	93.33	90.00	87.33
T_5	Soil + Leaf mould (2:1)	82.07	74.10	68.10
T_6	Soil + Leaf mould (2:1) + GA_3 100 ppm + *Azatobacter* (0.5 ml)	84.00	79.50	70.13
T_7	Soil + Leaf mould (2:1) + GA_3 150 ppm + *Azatobacter* (0.5 ml)	87.00	82.60	75.00
T_8	Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azatobacter* (0.5 ml)	89.00	83.83	77.43
	S.E m ±	**2.042**	**1.892**	**1.965**
	CD at 5%	**6.068**	**5.622**	**5.839**

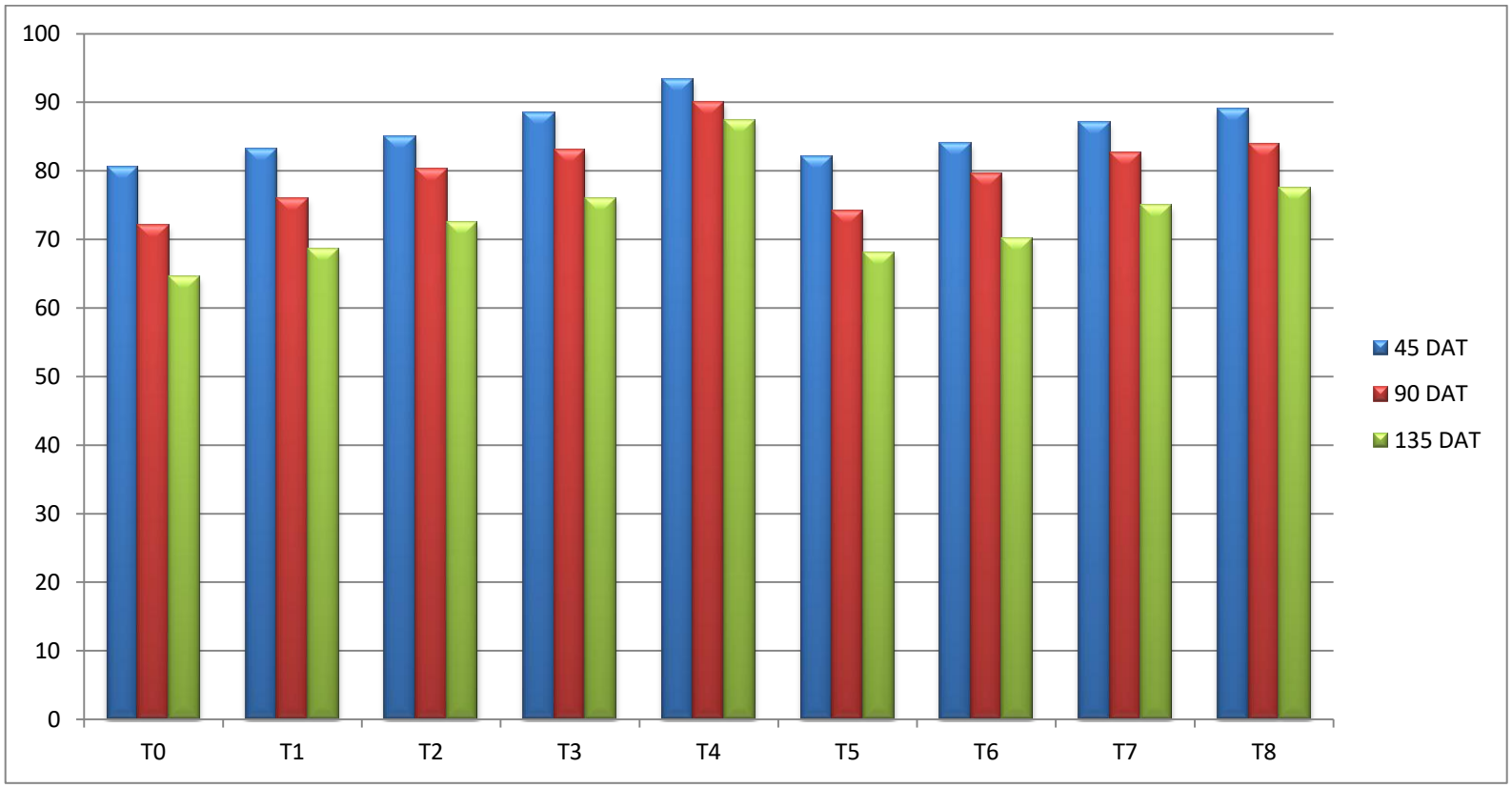


Figure 4.5Effect of *Azotobacter*, GA_3 and growing media on plant survival at different growth stages

4.2 Root parameters

4.2.1. Number of primary roots

4.2.1.1. Effect of A*zotobacter*, GA_3 and growing media on number of primary roots at different growth stages

The observations recorded for number of primary roots at 45, 90 and 135 DAT is presented in table 4.1.6. This is also statistically analyzed and graphically represented in figure 4.1.6. The analysis of variance (ANOVA) is given in appendix- XIV, XV and XVI.

It is evident from the investigation that, different treatments containing *Azotobacter*, GA_3 and growing media had significant effect on the number of primary roots. The table clearly conveys that T_4 (Soil+Vermicompost (2:1) +GA_3 200 ppm + *Azotobacter* (0.5ml)) was superior significantly over other treatments, and closely followed by treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)).

The higher number of primary roots in air layers (5.00, 7.33 and 10.00) was recorded under treatment T_4 (Soil +Vermicompost (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)). It was at par to treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)) at 45, 90 and 135 DAT. The minimum number of primary roots (2.33 , 4.67 and .67), were observed in treatment T_5 (Soil + Leaf mould (2:1)) and also in (2.00,4.33 and 6.67) T_0 (Soil (control)).

Table: 4.1.6 Effect of A*zotobacter*, GA_3 and growing media on number of primary roots

S.No.	Treatment	Number of primary roots		
		45 days	90 days	135 days
T_0	Soil (Control)	2.00	4.33	6.67
T_1	Soil + Vermicompost (2:1)	2.67	5.33	7.33
T_2	Soil + Vermicompost (2:1) + GA_3 100 ppm + *Azatobacter* (0.5 ml)	3.67	6.00	7.00
T_3	Soil + Vermicompost (2:1) + GA_3 150 ppm + *Azatobacter* (0.5 ml)	4.33	6.67	8.33
T_4	Soil + Vermicompost (2:1) + GA_3 200 ppm + *Azatobacter* (0.5 ml)	5.00	7.33	10.00
T_5	Soil + Leaf mould (2:1)	2.33	4.67	7.67
T_6	Soil + Leaf mould (2:1) + GA_3 100 ppm + *Azatobacter* (0.5 ml)	3.33	5.67	8.33
T_7	Soil + Leaf mould (2:1) + GA_3 150 ppm + *Azatobacter* (0.5 ml)	4.00	6.33	8.90
T_8	Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azatobacter* (0.5 ml)	4.67	7.00	9.00
	S.E m ±	**0.544**	**0.351**	**0.648**
	CD at 5%	**1.617**	**1.044**	**1.926**

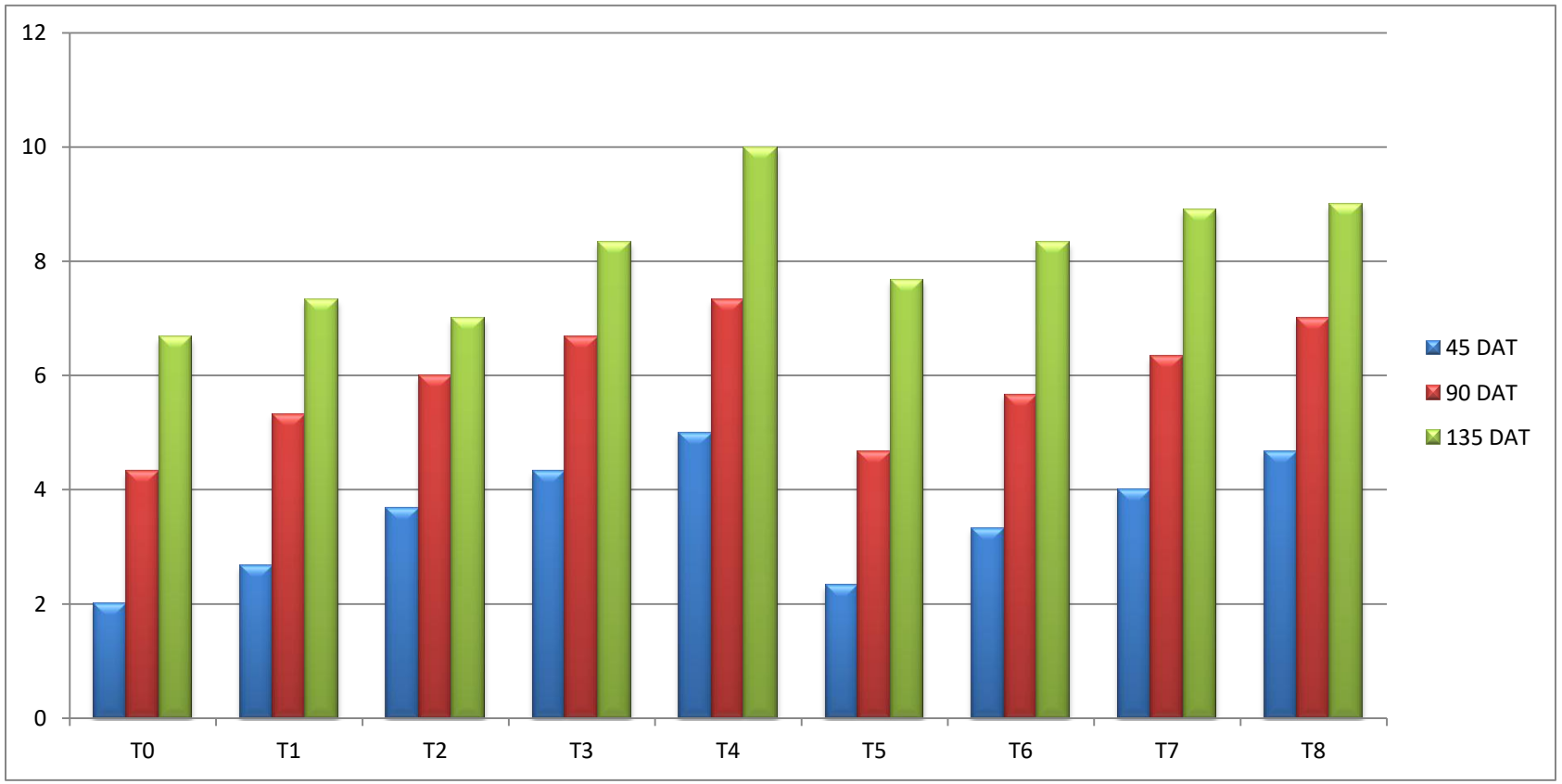


Figure 4.6Effect of *Azotobacter*, GA_3 and growing media on number of primary roots at different growth stages

4.2.2 Number of secondary roots

4.2.2.1 Effect of A*zotobacter*, GA_3 and growing media on number of secondary roots at different growth stages

The observations collected for number of secondary roots at 45, 90 and 135 DAT is presented in table 4.1.7. This is also analyzed statistically and illustrated graphically in figure 4.1.7. The analysis of variance (ANOVA) is given in appendix- XVII, XVIII and XIX.

It is manifested from the present study that, various treatments containing *Azotobacter*, GA_3 and growing media had significant effect on the number of secondary roots. The table clearly displays that T_4 (Soil+Vermicompost (2:1) +GA_3 200 ppm + *Azotobacter* (0.5ml)) found significantly superior over other treatments, and closely followed by treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)).

The maximum number of secondary roots in air layers (14.33, 18.00 and 21.67) was recorded under treatment T_4 (Soil +Vermicompost (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)). It was at par to treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)) at 45, 90 and 135 DAT.The minimum number of secondary roots (9.67, 14.33 and 16.00), were observed in treatment T_5 (Soil + Leaf mould (2:1)) and lowest number of primary roots were observed in (9.33,12.67 and 15.33) T_0 (Soil (control)).

Table: 4.1.7 Effect of biofertilizer, GA_3 and growing media on number of secondary roots

S.No.	Treatment	Number of secondary roots		
		45 days	**90 days**	**135 days**
T_0	Soil (Control)	9.33	12.67	15.33
T_1	Soil + Vermicompost (2:1)	10.33	15.00	18.00
T_2	Soil + Vermicompost (2:1) + GA_3 100 ppm + *Azatobacter* (0.5 ml)	11.00	16.67	19.33
T_3	Soil + Vermicompost (2:1) + GA_3 150 ppm + *Azatobacter* (0.5 ml)	12.67	17.33	20.00
T_4	Soil + Vermicompost (2:1) + GA_3 200 ppm + *Azatobacter* (0.5 ml)	14.33	18.00	21.67
T_5	Soil + Leaf mould (2:1)	9.67	14.33	16.00
T_6	Soil + Leaf mould (2:1) + GA_3 100 ppm + *Azatobacter* (0.5 ml)	11.00	15.67	18.67
T_7	Soil + Leaf mould (2:1) + GA_3 150 ppm + *Azatobacter* (0.5 ml)	12.33	16.33	19.67
T_8	Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azatobacter* (0.5 ml)	13.67	17.00	20.33
	S.E m ±	**1.024**	**0.981**	**1.054**
	CD at 5%	**3.044**	**2.916**	**3.132**

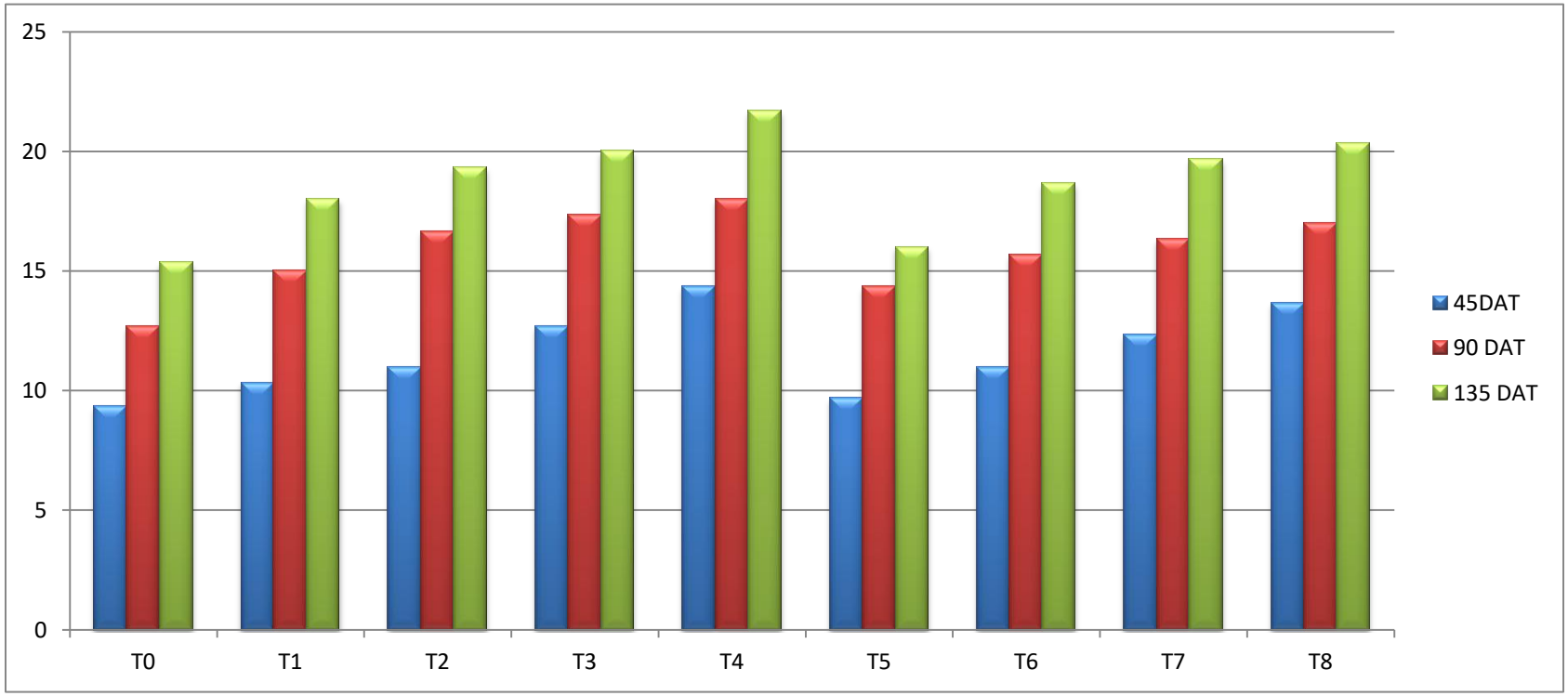


Figure 4.7Effect of *Azotobacter* ,GA_3 and growing media on number of secondary roots at different growth stages

4.2.3 Length of primary roots (cm)

4.2.3.1 Effect of A*zotobacter*, GA_3 and growing media on length of primary roots at different growth stages

The data collected for length of primary roots (cm) at 45, 90 and 135 DAT is presented in table 4.1.8. This is also analyzed statistically and depicted graphically in figure 4.1.8. The analysis of variance (ANOVA) is given in appendix- XX, XXI and XXII.

It is clear from the present investigation that, various treatments containing *Azotobacter*, GA_3 and growing media had significant effect on length of primary roots (cm). The table clearly reveals that T_4 (Soil+Vermicompost (2:1) +GA_3 200 ppm + *Azotobacter* (0.5ml)) found significantly superior over other treatments, and closely followed by treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)).

The maximum length of primary roots (cm) (8.60, 9.20 and 11.97) was observed under treatment T_4 (Soil +Vermicompost (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)). It was at par to treatment T_3 (Soil + Vermicompost (2:1) + GA_3 150 ppm + *Azotobacter* (0.5ml)) at 45 and 90 DAT and also at par to treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)) at 135 DAT only .The minimum number of secondary roots (cm) (3.67,6.00 and 7.77), were observed in treatment T_5 (Soil + Leaf mould (2:1)) and shortest length of primary roots (cm) were observed in (3.20,4.67 and 6.87) T_0 (Soil (control)).

Table: 4.1.8 Effect of biofertilizer, GA_3 and growing media on length of primary roots (cm)

S.No.	Treatment	Length of primary roots (cm)		
		45 days	**90 days**	**135 days**
T_0	Soil (Control)	3.20	4.67	6.87
T_1	Soil + Vermicompost (2:1)	5.40	6.57	8.50
T_2	Soil + Vermicompost (2:1) + GA_3 100 ppm + *Azatobacter* (0.5 ml)	6.53	8.53	9.57
T_3	Soil + Vermicompost (2:1) + GA_3 150 ppm + *Azatobacter* (0.5 ml)	7.50	8.80	10.50
T_4	Soil + Vermicompost (2:1) + GA_3 200 ppm + *Azatobacter* (0.5 ml)	8.60	9.20	11.97
T_5	Soil + Leaf mould (2:1)	3.67	6.00	7.77
T_6	Soil + Leaf mould (2:1) + GA_3 100 ppm + *Azatobacter* (0.5 ml)	6.03	7.10	9.13
T_7	Soil + Leaf mould (2:1) + GA_3 150 ppm + *Azatobacter* (0.5 ml)	7.10	8.13	10.17
T_8	Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azatobacter* (0.5 ml)	8.07	9.07	10.67
	S.E m ±	**1.056**	**0.885**	**0.985**
	CD at 5%	**3.139**	**2.628**	**2.928**

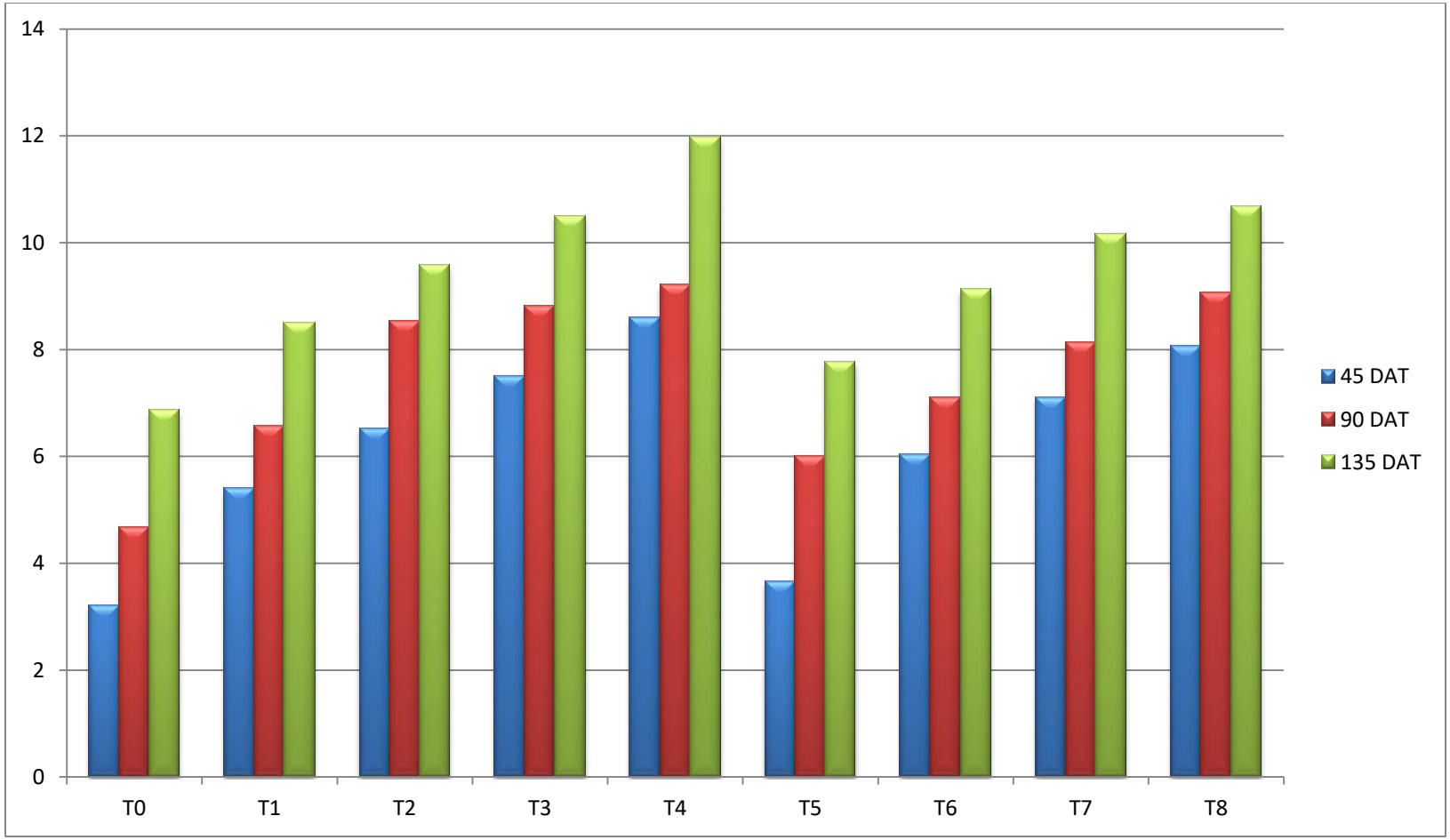


Figure4.8Effect of *Azotobacter*, GA_3 and growing media on length of primary roots (cm) at different growth stages

4.2.4 Length of secondary roots (cm)

4.2.4.1 Effect of A*zotobacter*, GA_3 and growing media on length of secondary roots at different growth stages

The observed data for length of secondary roots (cm) at 45, 90 and 135 DAT is displayed in table 4.1.9. This is statistically analyzed and presented graphically in figure 4.1.9. The analysis of variance (ANOVA) is given in appendix- XXIII, XXIV and XXV.

It is clear from the present investigation that, various treatments containing *Azotobacter*, GA_3 and growing media had significant effect on length of secondary roots. The table reveals clearly that T_4 (Soil+Vermicompost (2:1) +GA_3 200 ppm + *Azotobacter* (0.5ml)) found significantly superior over other treatments, and closely followed by treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)).

The maximum length of secondary roots (cm) (6.17, 7.60 and 8.73) was observed in treatment T_4 (Soil +Vermicompost (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)). It was at par to treatment T_3 (Soil + Vermicompost (2:1) + GA_3 150 ppm + *Azotobacter* (0.5ml)) at 45 and 90 and 135 DAT .The minimum number of secondary roots (cm) (3.53, 3.70 and 5.17) were observed in treatment T_5 (Soil + Leaf mould (2:1)) and shortest length of secondary roots (cm) were observed in (3.00, 4.10 and 4.70) T_0 (Soil (control)).

Table: 4.1.9 Effect of biofertilizer, GA_3 and growing media on length of secondary roots (cm)

S.No.	Treatment	Length of secondary roots (cm)		
		45 days	**90 days**	**135 days**
T_0	Soil (Control)	3.00	4.10	4.70
T_1	Soil + Vermicompost (2:1)	4.00	5.13	6.07
T_2	Soil + Vermicompost (2:1) + GA_3 100 ppm + *Azatobacter* (0.5 ml)	4.50	6.10	7.17
T_3	Soil + Vermicompost (2:1) + GA_3 150 ppm + *Azatobacter* (0.5 ml)	5.47	6.80	7.80
T_4	Soil + Vermicompost (2:1) + GA_3 200 ppm + *Azatobacter* (0.5 ml)	6.17	7.60	8.73
T_5	Soil + Leaf mould (2:1)	3.53	3.70	5.17
T_6	Soil + Leaf mould (2:1) + GA_3 100 ppm + *Azatobacter* (0.5 ml)	4.20	5.70	6.40
T_7	Soil + Leaf mould (2:1) + GA_3 150 ppm + *Azatobacter* (0.5 ml)	5.13	6.53	7.50
T_8	Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azatobacter* (0.5 ml)	5.87	7.13	8.50
	S.E m ±	**0.668**	**0.810**	**0.811**
	CD at 5%	**1.986**	**2.406**	**2.409**

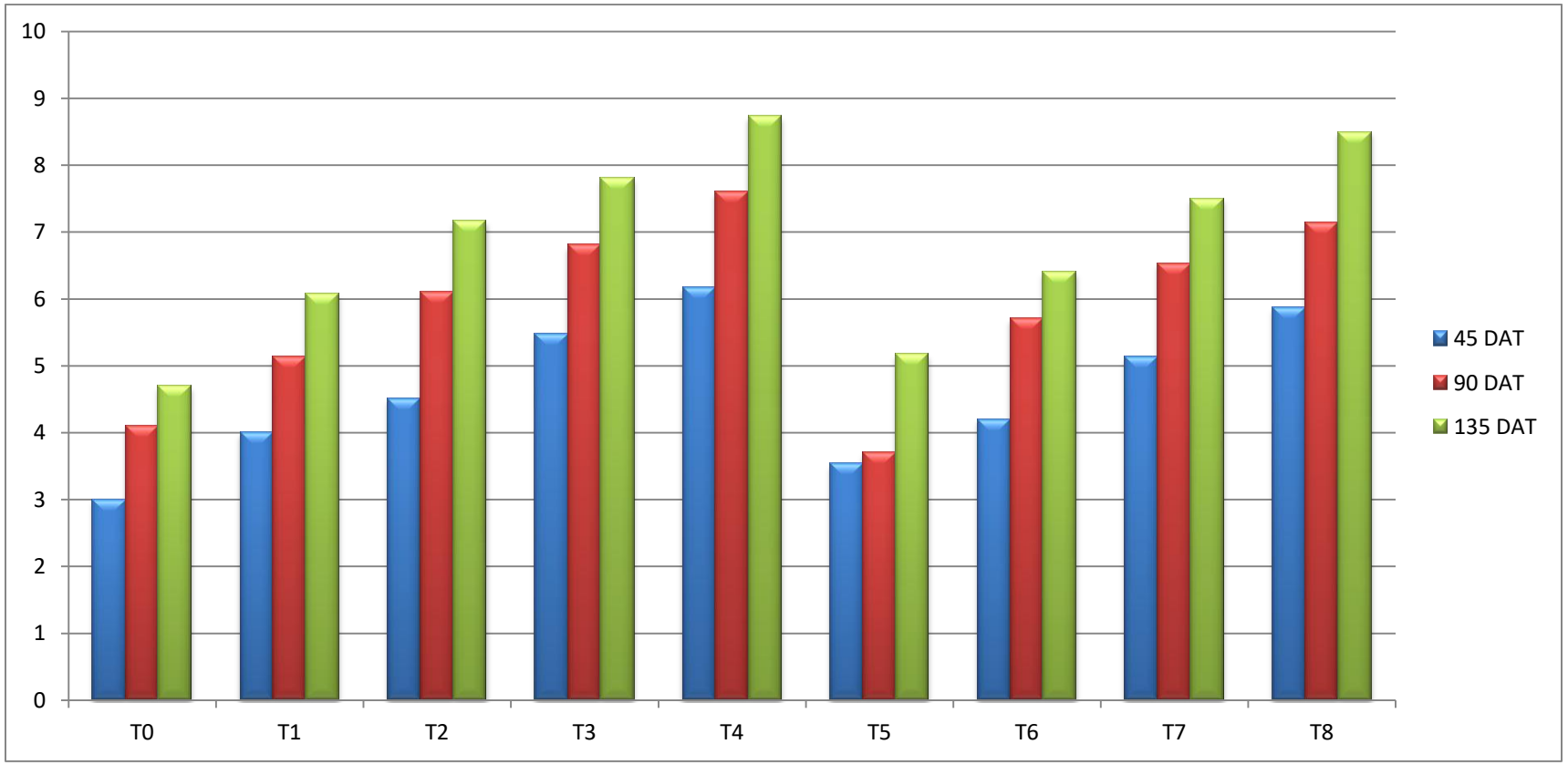


Figure4.9Effect of *Azotobacter*, GA_3 and growing media on length of secondary roots (cm) at different growth stages

4.2.5 Diameter of primary roots (mm)

4.2.5.1 Effect of A*zotobacter*, GA_3 and growing media on diameter of primary roots (mm) at different growth stages

The data recorded for diameter of primary roots at 45, 90 and 135 DAT is presented in table 4.1.10. This is also analyzed statistically and graphically demonstrated in figure 4.1.10. The analysis of variance (ANOVA) is given in appendix-XXVI, XXVII and XXVIII.

It is visible from the present study that, numerous treatments containing *Azotobacter*, GA_3 and growing media had significant effect on diameter of primary roots (mm). The table depicts clearly that treatment T_4 (Soil+Vermicompost (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)) found significantly superior over other treatments, and closely followed by treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)).

The thickest primary roots (mm) (2.13, 2.53 and 3.27) were recorded under treatment T_4 (Soil +Vermicompost (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)). It was at par to treatment T_3 (Soil + Vermicompost (2:1) + GA_3 150 ppm + *Azotobacter* (0.5ml)) at 45 DAT , treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)) at 90 DAT only and also at par to treatment T_7 (Soil + Leaf mould (2:1) + GA_3 150 ppm + *Azotobacter* (0.5ml)) .The minimum diameter of primary roots (mm) (1.03,1.40 and 1.67), were observed in treatment T_5 (Soil + Leaf mould (2:1)) and least thick primary roots were observed in (0.30,1.20 and 1.37) T_0 (Soil (control)).

Table: 4.1.10 Effect of biofertilizer, GA_3 and growing media on diameter of primary roots (mm)

S.No.	Treatment	Diameter of primary roots (mm)		
		45 days	**90 days**	**135 days**
T_0	Soil (Control)	0.30	1.20	1.37
T_1	Soil + Vermicompost (2:1)	1.30	1.53	1.73
T_2	Soil + Vermicompost (2:1) + GA_3 100 ppm + *Azatobacter* (0.5 ml)	1.47	1.80	2.53
T_3	Soil + Vermicompost (2:1) + GA_3 150 ppm + *Azatobacter* (0.5 ml)	1.80	2.17	2.90
T_4	Soil + Vermicompost (2:1) + GA_3 200 ppm + *Azatobacter* (0.5 ml)	2.13	2.53	3.27
T_5	Soil + Leaf mould (2:1)	1.03	1.40	1.67
T_6	Soil + Leaf mould (2:1) + GA_3 100 ppm + *Azatobacter* (0.5 ml)	1.40	1.73	2.40
T_7	Soil + Leaf mould (2:1) + GA_3 150 ppm + *Azatobacter* (0.5 ml)	1.77	2.10	2.83
T_8	Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azatobacter* (0.5 ml)	1.90	2.30	3.10
	S.E m ±	**0.340**	**0.278**	**0.426**
	CD at 5%	**1.011**	**0.825**	**1.267**

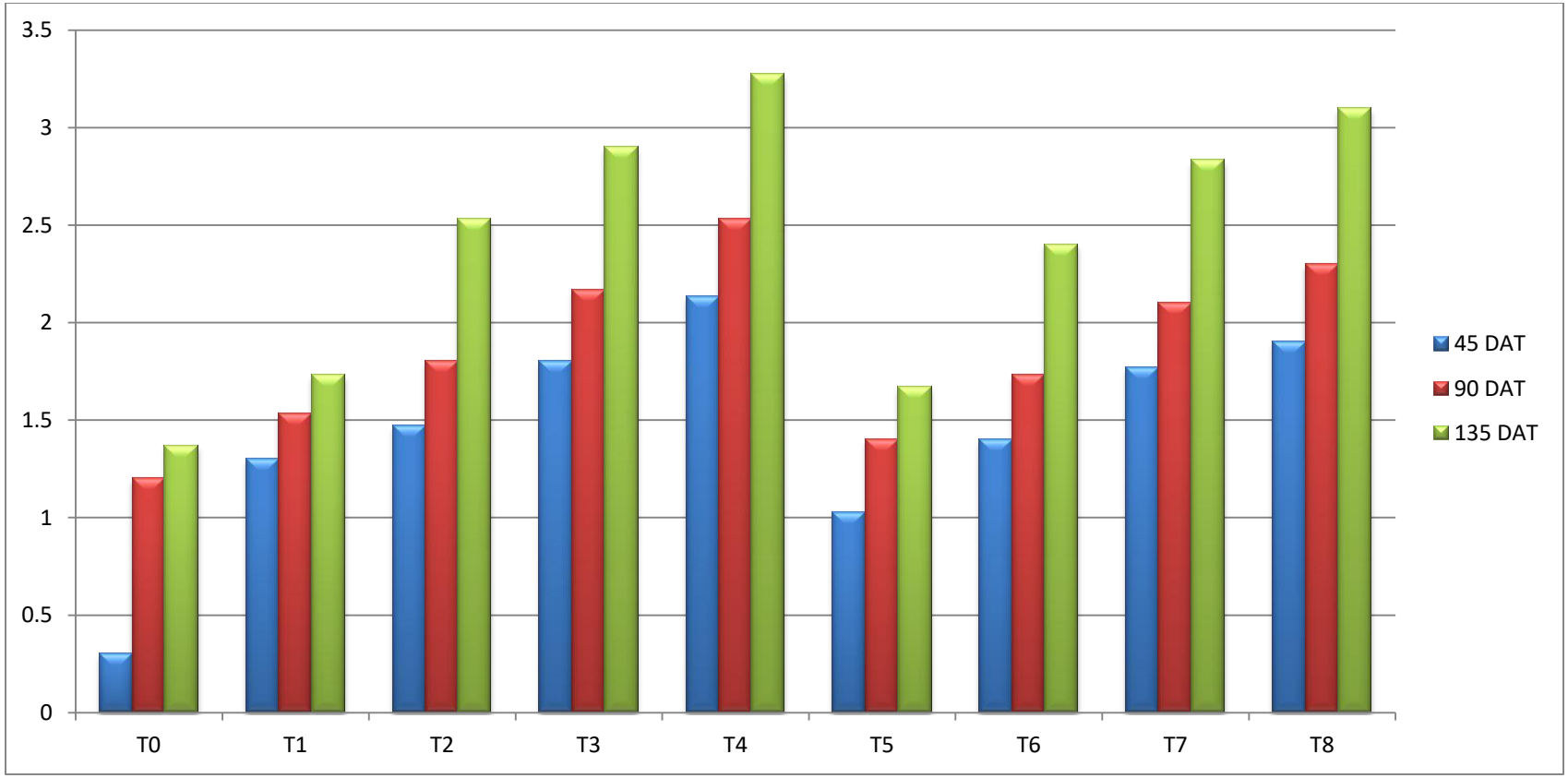


Figure4.10Effect of *Azotobacter*, GA_3 and growing media on diameter of primary roots (mm) at different growth stages

4.2.6 Diameter of secondary roots (mm)

4.2.6.1 Effect of A*zotobacter*, GA_3 and growing media on diameter of primary roots (mm) at different growth stages

The recorded observations for diameter of secondary roots at 45, 90 and 135 DAT is presented in table 4.1.11. This is also analyzed statistically and graphically demonstrated in figure 4.1.11. The analysis of variance (ANOVA) is given in appendix-XXIX, XXX and XXXI.

It is noticeable from the present experiment that, different treatments containing *Azotobacter*, GA_3 and growing media had significant effect on diameter of secondary roots (mm). The table clearly demonstrates that treatment T_4 (Soil+Vermicompost (2:1) +GA_3 200 ppm + *Azotobacter* (0.5ml)) found significantly superior over other treatments, and followed by treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)).

The maximum diameter of secondary roots (mm) (1.20, 1.37 and 2.00) were recorded in treatment T_4 (Soil +Vermicompost (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)). It was at par to treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)).The minimum diameter of secondary roots (mm) (0.67, 0.73 and 1.07), were observed in treatment T_5 (Soil + Leaf mould (2:1)) and least thick secondary roots were observed in (0.57, 0.83 and 1.32) T_0 (Soil (control)).

Table: 4.1.11 Effect of biofertilizer, GA_3 and growing media on diameter of secondary roots (mm)

S.No.	Treatment	Diameter of secondary roots (mm)		
		45 days	**90 days**	**135 days**
T_0	Soil (Control)	0.57	0.83	1.32
T_1	Soil + Vermicompost (2:1)	0.83	1.03	1.40
T_2	Soil + Vermicompost (2:1) + GA_3 100 ppm + *Azatobacter* (0.5 ml)	0.84	1.08	1.27
T_3	Soil + Vermicompost (2:1) + GA_3 150 ppm + *Azatobacter* (0.5 ml)	1.00	1.10	1.44
T_4	Soil + Vermicompost (2:1) + GA_3 200 ppm + *Azatobacter* (0.5 ml)	1.20	1.37	2.00
T_5	Soil + Leaf mould (2:1)	0.67	0.73	1.07
T_6	Soil + Leaf mould (2:1) + GA_3 100 ppm + *Azatobacter* (0.5 ml)	0.93	0.94	1.20
T_7	Soil + Leaf mould (2:1) + GA_3 150 ppm + *Azatobacter* (0.5 ml)	0.93	1.14	1.42
T_8	Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azatobacter* (0.5 ml)	1.07	1.21	1.80
	S.E m ±	**0.110**	**0.107**	**0.180**
	CD at 5%	**0.327**	**0.318**	**0.535**

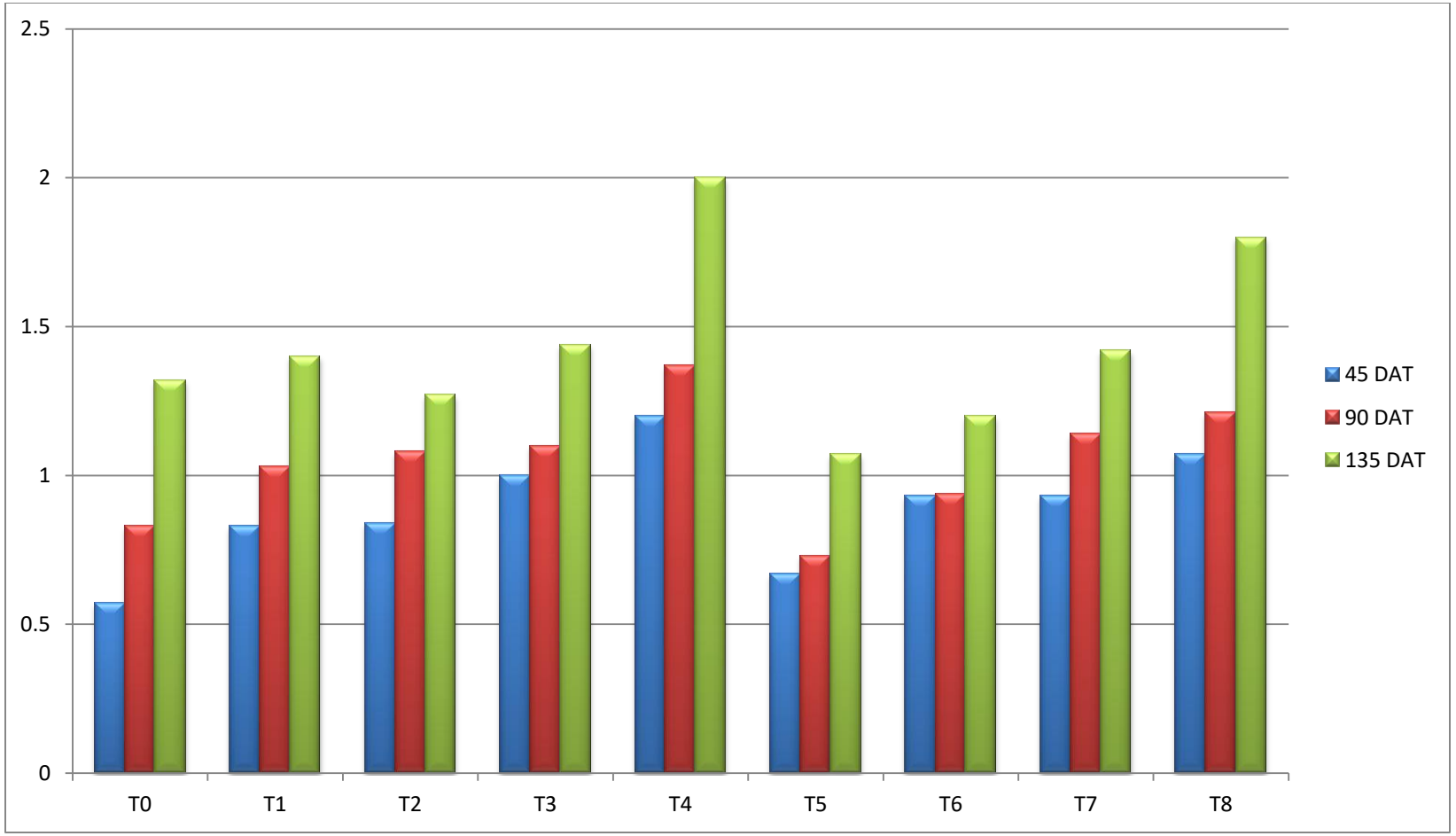


Figure4.11Effect of *Azotobacter*, GA_3 and growing media on diameter of secondary roots (mm) at different growth stages

4.2.7 Fresh weight of primary roots (g)

4.2.7.1 Effect of A*zotobacter*, GA_3 and growing media on fresh weight of primary roots (g) at different growth stages

The calculated data for fresh weight of primary roots (g) at 45, 90 and 135 DAT is presented in table 4.1.12. This is also analyzed statistically and graphically represented in figure 4.1.12. The analysis of variance (ANOVA) is given in appendix-XXXII, XXXIII and XXXIV.

It is perceptible from the investigation findings that, various treatments containing *Azotobacter*, GA_3 and growing media had significant effect on fresh weight of primary roots (g). The table shows clearly that treatment T_4 (Soil+Vermicompost (2:1) +GA_3 200 ppm + *Azotobacter* (0.5ml)) found significantly superior over other treatments, and followed closely by treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)).

The maximum fresh weight of primary roots (g) (1.38, 1.51 and 1.84) were observed in treatment T_4 (Soil +Vermicompost (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)). It was at par to treatment T_3 (Soil + Vermicompost (2:1) + GA_3 150 ppm + *Azotobacter* (0.5ml)) at 45 DAT only and also at par to treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)) at 90 and 135 DAT .The minimum fresh weight of primary roots (g) (0.54,0.81 and 1.00), were observed in treatment T_5 (Soil + Leaf mould (2:1)) and minimal fresh weight primary roots were observed in (0.49,0.72 and 0.90) T_0 (Soil (control)).

Table: 4.1.12 Effect of biofertilizer, GA_3 and growing media on fresh weight of primary roots (g)

S.No.	Treatment	Fresh weight of primary roots (g)		
		45 days	**90 days**	**135 days**
T_0	Soil (Control)	0.49	0.72	0.90
T_1	Soil + Vermicompost (2:1)	0.93	1.06	1.20
T_2	Soil + Vermicompost (2:1) + GA_3 100 ppm + *Azatobacter* (0.5 ml)	1.21	1.26	1.37
T_3	Soil + Vermicompost (2:1) + GA_3 150 ppm + *Azatobacter* (0.5 ml)	1.27	1.31	1.47
T_4	Soil + Vermicompost (2:1) + GA_3 200 ppm + *Azatobacter* (0.5 ml)	1.38	1.51	1.84
T_5	Soil + Leaf mould (2:1)	0.54	0.81	1.00
T_6	Soil + Leaf mould (2:1) + GA_3 100 ppm + *Azatobacter* (0.5 ml)	1.08	1.15	1.26
T_7	Soil + Leaf mould (2:1) + GA_3 150 ppm + *Azatobacter* (0.5 ml)	1.23	1.30	1.42
T_8	Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azatobacter* (0.5 ml)	1.32	1.40	1.63
	S.E m ±	**0.088**	**0.057**	**0.041**
	CD at 5%	**0.261**	**0.170**	**0.123**

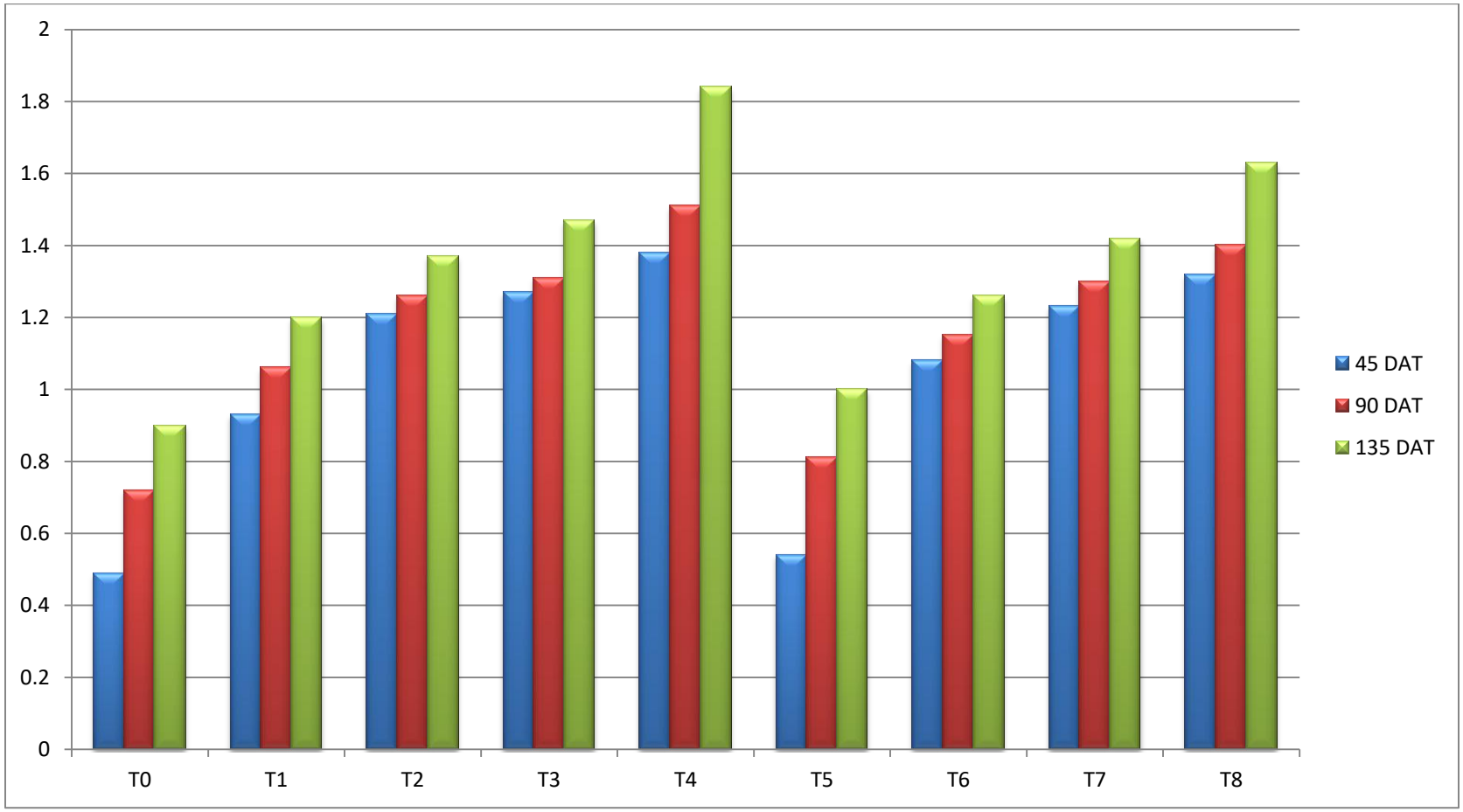


Figure4.12Effect of *Azotobacter*, GA_3 and growing media on fresh weight of primary roots (g) at different growth stages

4.2.8 Fresh weight of secondary roots (g)

4.2.8.1 Effect of A*zotobacter*, GA_3 and growing media on fresh weight of secondary roots (g) at different growth stages

The observations for fresh weight of secondary roots (g) at 45, 90 and 135 DAT is presented in table 4.1.13. This is also analyzed statistically and graphically illustrated in figure 4.1.13. The analysis of variance (ANOVA) is given in appendix- XXXV, XXXVI and XXXVII.

It is detectable from the research findings that, various treatments containing *Azotobacter*, GA_3 and growing media had significant effect on fresh weight of primary roots (g). The table significantly shows that treatment T_4 (Soil+Vermicompost (2:1) +GA_3 200 ppm + *Azotobacter* (0.5ml)) found superior over other treatments, and followed closely by treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)).

The maximum fresh weight of secondary roots (g) (0.49, 0.58 and 0.79) were recorded under treatment T_4 (Soil +Vermicompost (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)). It was at par to treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)) at 45, 90 and 135 DAT .The minimal fresh weight of secondary roots (g) (0.28,0.32 and 0.36), were recorded under treatment T_5 (Soil + Leaf mould (2:1)) and lowest fresh weight of secondary roots were observed in (0.20,0.28 and 0.40) T_0 (Soil (control)).

Table: 4.1.13 Effect of biofertilizer, GA_3 and growing media on fresh weight of secondary roots (g)

S.No.	Treatment	Fresh weight of secondary roots (g)		
		45 days	**90 days**	**135 days**
T_0	Soil (Control)	0.20	0.28	0.40
T_1	Soil + Vermicompost (2:1)	0.30	0.36	0.43
T_2	Soil + Vermicompost (2:1) + GA3 100 ppm + *Azatobacter* (0.5 ml)	0.35	0.43	0.51
T_3	Soil + Vermicompost (2:1) + GA3 150 ppm + *Azatobacter* (0.5 ml)	0.43	0.49	0.62
T_4	Soil + Vermicompost (2:1) + GA3 200 ppm + *Azatobacter* (0.5 ml)	0.49	0.58	0.79
T_5	Soil + Leaf mould (2:1)	0.28	0.32	0.36
T_6	Soil + Leaf mould (2:1) + GA3 100 ppm + *Azatobacter* (0.5 ml)	0.32	0.40	0.49
T_7	Soil + Leaf mould (2:1) + GA3 150 ppm + *Azatobacter* (0.5 ml)	0.39	0.47	0.55
T_8	Soil + Leaf mould (2:1) + GA3 200 ppm + *Azatobacter* (0.5 ml)	0.47	0.51	0.68
	S.E m ±	**0.033**	**0.019**	**0.021**
	CD at 5%	**0.097**	**0.056**	**0.061**

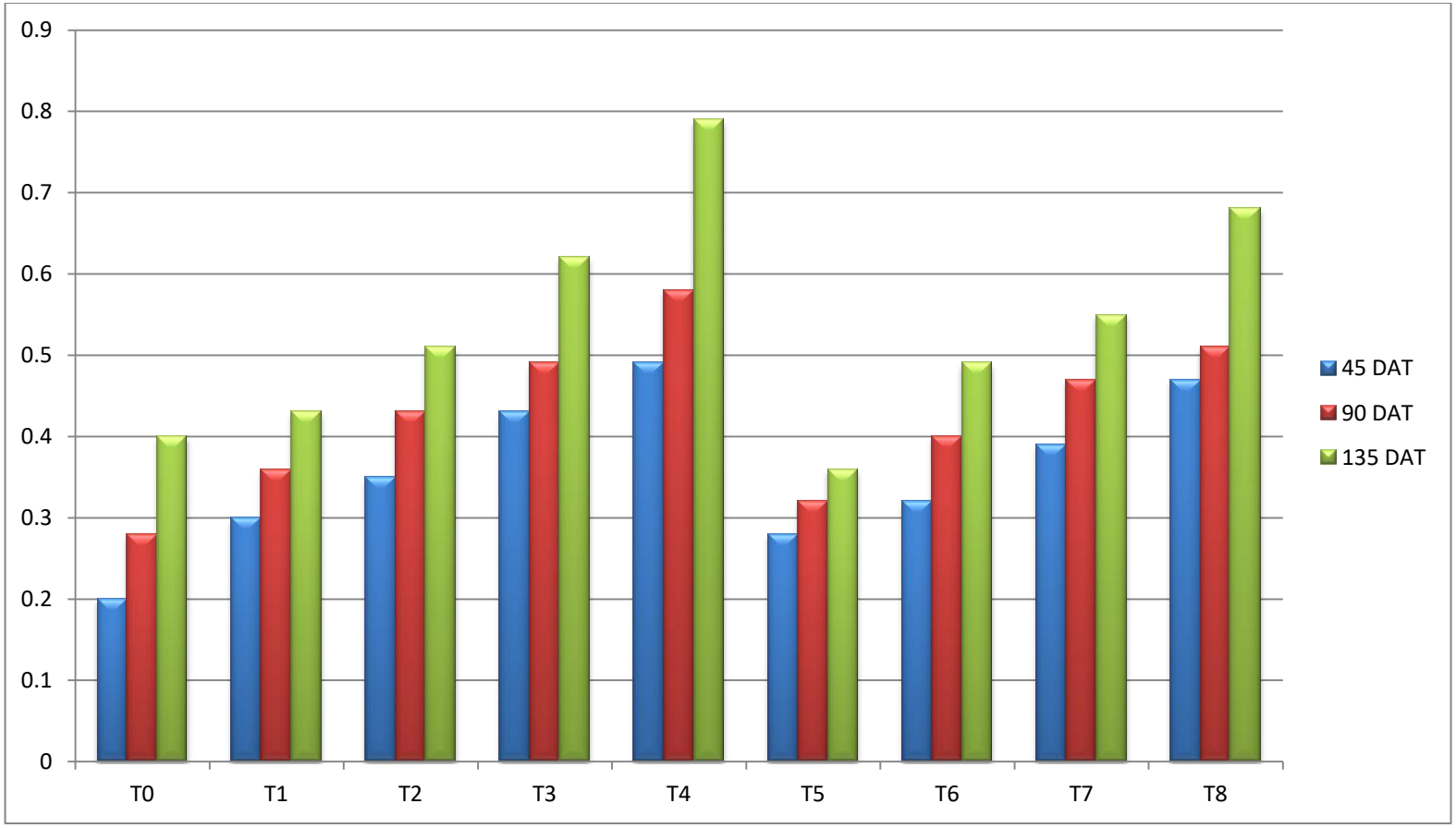


Figure4.13Effect of *Azotobacter*, GA_3 and growing media on fresh weight of secondary roots (g) at different growth stages

4.3 Economics of the treatments

The economics of the treatments are presented in table 14.14 and depicted graphically in figure 14.14.

It is perceptible from the data that various treatments had significant effect on the economics of the treatments.

The maximum gross income (4125 Rs), maximum net income (2452 Rs) and maximum B: C ratio (2.46) was recorded under treatment T_4 (Soil + Vermicompost (2:1) + GA_3 100 ppm + *Azotobacter* (0.5ml).It was found significantly superior as compared to other treatments. It was closely followed treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5 ml)) and having gross income (3675 Rs), net income (2075 Rs) and B: C ratio (2.21).

The minimum gross income (3075 Rs), net income (1475) and minimum B: C ratio (1.92) was noted under treatment T_0 (Soil (control)).

Table: 4.1.14 Effect of biofertilizer, GA_3 and growing media on economics of experiment

Treatment	Basic Cost(Rs)	Additional Cost(Rs)	Total Cost(Rs)	Number of survived plant	Gross Income (@Rs.75/plant)	Net Income(Rs)	B:C ratio
T_0	1600	00	1600	41	3075	1475	1.92
T_1	1600	44	1644	43	3225	1581	1.96
T_2	1600	64	1664	46	3450	1786	2.07
T_3	1600	68	1668	48	3600	1932	2.15
T_4	1600	73	1673	55	4125	2452	**2.46**
T_5	1600	31	1631	42	3150	1519	1.93
T_6	1600	51	1651	44	3300	1648	1.99
T_7	1600	56	1656	47	3525	1869	2.12
T_8	1600	60	1660	49	3675	2075	2.21

T_0 - Soil (control) , **T_1** – Soil + Vermicompost (2:1) , **T_2**- Soil + Vermicompost (2:1)+ GA_3 100 ppm+ *Azotobacter* (0.5 ml) **T_3** - Soil + Vermicompost (2:1)+ GA_3 150 ppm+ *Azotobacter* (0.5 ml) **T_4** - Soil + Vermicompost (2:1)+ GA_3 200 ppm+ *Azotobacter* (0.5 ml), **T_5** - Soil + Leaf mould (2:1), **T_6** – Soil + Leaf mould (2:1)+ GA_3 100 ppm+ *Azotobacter* (0.5 ml) **T_7** – Soil + Leaf mould (2:1)+ GA_3 150 ppm+ *Azotobacter* (0.5 ml) **T_8** -Soil + Leaf mould (2:1)+ GA_3 200 ppm+ *Azotobacter* (0.5 ml)

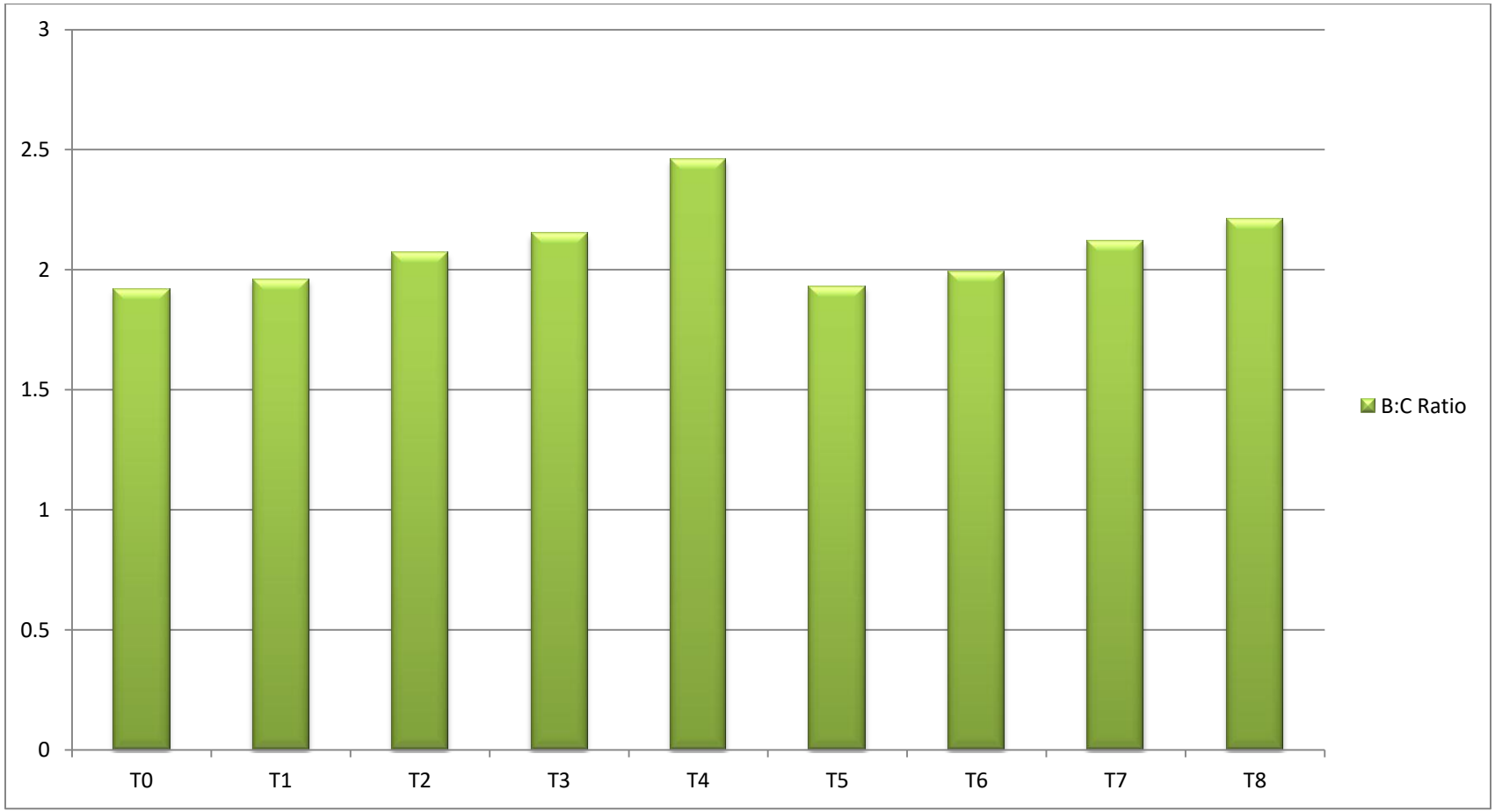


Figure4.14 Benefit: Cost ratio

PLATE-1

PLATE - 2

1. Filling polybags with Media
2.Copper oxychloride solution for detached air layers
3.Unwrapping detached air layers
4.Dipping air layers in Copper oxychloride solution

PLATE-3

PLATE – 4

1. Weighing Secondary roots (g)

2.Measuring stem diameter with Vernier calipers (mm)

3.Measuring stem length with Scale (cm)

4.Weighing primary roots (g)

5.Opening of air layer for no. of Secondary Roots

6.Number of Secondary roots

PLATE – 5

PLATE - 6

CHAPTER – V

DISCUSSION

The present investigation entitled **"Effect of different growing media, biofertilizer and plant growth regulator on growth and survivability of Guava air layers"** was carried out during 2020-21. The experiment was conducted at Research area, College of Agriculture, Gwalior.

On the basis of experiment findings, an attempt has been made in this chapter to explain the possible reasons of variations obtained due to different treatments. The result has been discussed in the light of literature available for the different characters under present investigation. The experiment was laid out in Completely Randomized Design (CRD) with three replications. Each replication consists of 9 treatments with different levels of GA_3 (100, 150 and 200 ppm) and biofertilizer (*Azotobacter* @ 0.5 ml) were applied in guava air layers *cv.* Gwalior-27 have been presented in the chapter. The findings are briefly discussed and explained in support of the findings of the previous research work concerned to "Effect of different growing media, biofertilizer and plant growth regulator on growth and survivability of Guava air layers (*Psidium guajava* L.). Cv. Gwalior-27". During the course of discussion an effort has been made to establish relationship between different growth characters, root characters and economical parameters.

Growth parameters *viz.* Number of sprouts**,** Stem length (cm)**,** Stem thickness (mm)**,** Number of leaves**,** Plant survival percentage.

Root parameters *viz.* Number of primary roots ,Number of secondary roots,Length of primary roots (cm), Length of secondary roots (cm) , Diameter of primary roots (mm) , Diameter of secondary roots (mm),Fresh weight of primary roots (g),Fresh weight of secondary roots (g)

Economics parameters *viz.* Gross income, Net income and B: C Ratio

However, the results on thesis aspects given in the antecedent chapter are being conferred as under:

5.1 Growth parameters

5.1.1Number of Sprouts

The findings of the present investigation revealed that Vermicompost and Leaf mould in combination with *Azotobacter* and GA_3 significantly increased the no. of sprouts (8.67) in treatment T_4 (Soil + Vermicompost (2:1)+ GA_3 200 ppm + *Azotobacter* (0.5ml)). Number of sprouts significantly varied by growing media as treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm +

Azotobacter (0.5ml)) which contains leaf mould was found to be second best treatment in terms of maximum sprouts (6.00) it is due to leaf mould is an excellent soil conditioner because of its ability to retain moisture and uniform texture for growing medium it also helps in assimilation of other plant nutrients.

The application of different organic manures (i.e., Vermicompost & Leaf mould), GA_3 with *Azotobacter* the positive influences in growth parameters are associated with the release of macro and micro nutrients during the course of microbial decomposition. The improvement in no. of days taken in number of sprouts with application of vermicompost and leaf mould might be due to better moisture holding capacity and availability of major and micro nutrients due to favourable soil conditions.

The minimum no. of sprouts were (2.33) treatment T_0 (Soil (control)) because the growth parameters affected by exogenous application of required source of nutrients which enhanced the nutrient uptake and results in early sprouting while soil alone as growing media results in slowest sprouting.

The present investigation findings are in accordance with earlier reports in recorded by Slakins *et al*., (1973), Tyagi and Patel (2004), Singh *et al*.,(2007),Rolaniya *et al*., (2018) on hardwood cuttings of grape *cv.* Thompson seedless , Dawar *et. al*.,(2021).

5.1.2 Number of leaves

The maximum no. of leaves per layer (20.33, 28.67 and 37.00) was found under treatment T_4 (Soil + Vermicompost (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)). It was closely followed by treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)) recorded subsequent no. of leaves (19.33, 27.00 and 36.67).

The lowest no. of leaves (14.33, 21.67 and 32.00) was obtained by treatment T_0 (Soil (control))

The similar findings were also reported by Bhandulkar *et al.,*(2017) results reported that vermicompost with *Azotobacter* had significantly greater effect on no. of leaves (18.75) Singh *et al*., (2007)results showed that vermicompost found superior and had higher no. of leaves (14.36), and superior from the study of Rymbai *et al.*, (2012) where number of leaves (7.89) at 45 DAT and (13.08) at 60 DAT. Damar *et al*., (2014) and Muthia *et al*., (2015) in *Ceriops*

decandra cuttings results revealed that when cuttings were treated with GA_3 it enhanced the number of leaves.

5.1.3 Stem length (cm)

Effect of growing media, PGR and biofertilizer *i.e.,* Soil, vermicompost, leaf mould, GA_3 and *Azotobacter* were appreciably affected the shoot parameters the maximum stem length (cm) (18.00, 24.00 and 28.33) was observed in treatment T_4 (Soil + Vermicompost (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)). It was followed closely by treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)) recorded subsequent stem length (17.53, 23.90 and 27.67). The minimal stem length (12.97, 17.50 and 21.00) was attained in treatment T_0 (Soil (control)).

Similar results for the above findings are concluded by Sevik *et al*., (2013) the results of study showed that GA_3 application has a considerable effect on stem height ,Bhandulkar *et al*.,(2017)obtained highest plant height media containing vermicompost(22.54cm), Kashyap *et al*., (2019), and recorded findings are significantly superior than Singh *et al*.,(2007) where length of shoots at 60 days (5.31cm) and Rajpoot *et al*., (2012) reported that in growing media M_1 (Soil + Vermicompost + Sand in 1:1:1) highest stem length (23.70 cm).

5.1.4 Stem thickness (mm)

The maximum stem thickness (mm) (8.03, 12.77 and 16.20) was observed in treatment T_4 (Soil + Vermicompost (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)).Treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)) found second best treatment in terms of stem thickness (7.50, 12.33 and 15.73).

The least stem thickness (5.00, 7.63 and 12.00) was observed in treatment T_0 (Soil (control)).

Similar findings for the above experiment are in agreement with Bhandulkar *et al*.,(2017)(1.80cm), Rajpoot *et al*., (2012) reported that in growing media M_1 (Soil + Vermicompost + Sand in 1:1:1) stem diameter (1.78 cm), and in some other fruit crops are reported by Canli *et al*., (2008) reported that overall stem thickness of pears seedlings significantly affected by GA_3 treatments. Ferguson *et al*.,(1987) on CO_2 enriched sour orange seedlings treated with gibberellins/cytokinins.

5.1.5 Plant survival percentage

The maximum no. of plants survived (80.30%) was recorded under treatment T_4 (Soil + Vermicompost (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)). It was closely followed by treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml)) recorded succeeding no. of survived air layers (77.43%). This may be due to pre treatment of GA_3 in plant improved root and shoot growth. Furthermore, Wang *et al*., (1995) demonstrated that application of GA_3 can promote xylem and phloem production, provided and elevated IAA at cambial region. This results in reduced mortality of transplanted air layers and hence increased the survivability percentage, ultimately gave higher ceaselessness to layers.

The equivalent results were also reported by Ramteke (1998) (85.71%) in guava, Singh *et al*., (2007)(76.75%) in guava cv. Lucknow-49, Rajpoot *et al.,*(2012) (72.17%) in guava , and also in some other fruit crops Damar *et al*., (2014)(76.48%) in pomegranate stem cuttings, Kashyap *et al*., (2016)(73.61%) in acid lime var. Kagzi lime, Shaikh *et al*., (2016) (96.17%) in clove, Sarita *et al*., (2019)(93.51) in Litchi, Rymbai *et al*., (2012)(82.22%), Noori *et al*., (2019)(100%) in layered Pistachio var. Batoury .

5.2 Root Parameters

5.2.1 Number of primary roots

The greatest no. of primary roots were found in treatment T_4 (Soil + Vermicompost (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml) which is excellent over other treatments results in maximum no. of primary roots (5.00, 7.33and 10.00) and treatment T_4 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml) was in close proximity to T_8 and it has (4.67, 7.00and9.00) no. of primary roots. It is comprehensible that vermicompost; leaf mould has significantly raised no. of primary roots combined with GA_3 and *Azotobacter* by providing essential nutrients in sufficient amount and results in enhanced growth.

The minimum number of primary roots (2.00, 4.33 and6.67) were found in T_0 (Soil (control)) this is because soil alone was unable to avail all the required nutrients to the transplanted layers which results in least no. of primary roots among all the treatments.

Our findings are in agreement with Bhandulkar *et al*., (2017) reported 7.71 no. of primary roots. Rymbai *et al.*, (2012) no. of primary roots were (10.80), Intjar *et al.,*(2020) in pomegranate (16.40), Pratibha *et al*.,(2017) and Singh *et al.,*(2007).

5.2.2 Number of secondary roots

The maximal no. of secondary roots were found in treatment T_4 (Soil + Vermicompost (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml) which is supreme over other treatments results in maximum no. of secondary roots (14.33, 18.00and 21.67) it was followed by T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml) and it has (13.67, 17.00and 20.33) no. of secondary roots. The minimal number of secondary roots (9.33, 12.67 and 15.33) was noted under T_0 (Soil (control)) this is attributed due to soil does not provide proper nutrients required during growth of the plants and hence showed reduced growth of plants.

Our findings are in compliance with Bhandulkar *et al*.,(2017) where number of secondary roots were 13, Rymbai *et al.*, (2012) no. of secondary roots were (22.44), Intjar *et al.,*(2020) in pomegranate (32.80), Pratibha *et al*.,(2017) and Singh *et al.,*(2007) reported .maximum no. of secondary roots (23.91) in media containing vermicompost.

5.2.3 Length of primary roots (cm)

The primary roots with greatest length (8.60,9.20 and 11.97) were obtained in treatment T_4 (Soil + Vermicompost (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml) which is outstanding over other treatments and results in maximum length of primary roots and followed by treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml) with root length(8.07, 9.07and10.67) maximum primary root length.

The minimum root length of primary roots (3.20, 4.67 and 6.87) was noted under T_0 (Soil (control)).

The above result is in accordance with earlier reports in Rolaniya *et al.*, (2018) with root length 28.24 cm in grape, Damar *et al.,* (2014) in pomegranate (10.36cm), Bhandulkar *et al*.,(2017) with root length of 2.77 cm.

5.2.4 Length of secondary roots (cm)

The longest secondary roots (6.17, 7.60 and 8.73) were attained under treatment T_4 (Soil + Vermicompost (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml) which is significantly superior over other treatments and closely followed by treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml) with root length (5.87, 7.13 and 8.50). The minimum root length of primary roots (3.20, 4.67 and 6.87) was noted under T_0 (Soil (control)).

The above result is in accordance with earlier reports in Rolaniya *et al.*, (2018) with root length 28.24 cm in grape, Damar *et al.,* (2014) in pomegranate (10.36cm), Bhandulkar *et al*.,(2017) with root length of 2.77 cm.

5.2.5 Diameter of Primary roots (mm)

The thickest primary roots (2.13, 2.53and 3.27) were attained under treatment T_4 (Soil + Vermicompost (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml) which is significantly superior over other treatments and closely followed by treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml) with root diameter (1.90, 2.30 and 3.10).

The minimum diameter of primary roots (0.30, 1.20 and 1.37) was noted under T_0 (Soil (control)).

The above results are in accordance with earlier reports in Rolaniya *et al.*, (2018) average root diameter 1.78 mm in grape, Damar *et al.,* (2014) in pomegranate (1.16mm), Bhandulkar *et al*., (2017) with root diameter of 2.77 mm in guava, Intjar *et al.,*(2020) with 4.01 mm diameter of primary roots.

5.2.6 Diameter of secondary roots (mm)

The secondary roots (1.20, 1.37and 2.00) were obtained under treatment T_4 (Soil + Vermicompost (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml) which is significantly superior over other treatments and closely followed by treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml) with root diameter (1.07, 1.21 and 1.80).

The minimum diameter of primary roots (0.57, 0.83 and 1.32) was noted under T_0 (Soil (control)).

The above results are in agreement with earlier reports in Rolaniya *et al.*, (2018) average root diameter 1.78 mm in grape, Damar *et al.,* (2014) in pomegranate (1.16mm), Bhandulkar *et al*., (2017) with root diameter of 2.00 mm in guava, Intjar *et al.,*(2020) with 2.20 mm diameter of secondary roots.

5.2.7 Fresh weight of Primary roots (g)

The maximal fresh weight of primary roots (1.38, 1.51and 1.84) were attained under treatment T_4 (Soil + Vermicompost (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml) which is predominantly superior over other treatments and closely followed by treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml) with root weight (1.32, 1.40 and 1.63).

The minimum fresh weight of primary roots (0.49, 0.72 and 0.90) was noted under T_0 (Soil (control)).

The above results are in accordance with earlier reports in Ramteke *et al*., (1998), Rymbai *et al*.,(2012) with fresh weight of 2.72g of primary roots. Rolaniya *et al.*, (2018) average fresh weight 0.61g in grape, Damar *et al.,* (2014) in pomegranate (1.94 g), Muthia *et al*.,(2015) showed that GA_3 has significantly superior impact on fresh weight of primary roots in *Ceriops decandra*. Sarita *et al*., (2019) where average fresh weight of primary roots was 3.60g in Litchi.

5.2.8 Fresh weight of Secondary roots (g)

The maximum fresh weight of secondary roots (0.49, 0.58and 0.79) were attained under treatment T_4 (Soil + Vermicompost (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml) which is outstanding among all treatments and closely followed by treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5ml) with fresh weight of (0.47, 0.51 and 0.68).

The minimum fresh weight of primary roots (0.20, 0.28 and 0.40) was noted under T_0 (Soil (control)).

The above results are in accordance with earlier reports in Ramteke *et al*., (1998), Rymbai *et al*., (2012) with fresh weight of 0.51g of secondary roots. Rolaniya *et al.*, (2018) average fresh weight 0.61g in grape, Damar *et al.,* (2014) in pomegranate (1.94 g).

5.3 Economics of the treatments

It is comprehensible from the calculated data that various treatments had significant effect on the economics of the treatments.

The maximum gross income (4125 Rs), maximum net income (2452 Rs) and maximum B: C ratio (2.46) was recorded under treatment T_4 (Soil + Vermicompost (2:1) + GA_3 100 ppm + *Azotobacter* (0.5ml).It was found significantly superior as compared to other treatments. It was closely followed treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200 ppm + *Azotobacter* (0.5 ml)) and having gross income (3675 Rs), net income (2075 Rs) and B: C ratio (2.21).

The minimum gross income (3075 Rs), net income (1475) and minimum B: C ratio (1.92) was noted under treatment T_0 (Soil (control)).

The above experiment findings are supported by Bhandulkar *et al*., (2017) and Kashyap *et al*., (2019).

CHAPTER – VI

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER RESEARCH WORK

The present analysis entitled **"Effect of different growing media, biofertilizer and plant growth regulator on growth and survivability of Guava air layers"** was carried out during 2020-21, at Experimental block, Department of Horticulture, College of Agriculture, Gwalior (MP).

The experiment was performed with the objectives- 1) To find out the suitable growing media for growth and survivability of air layers. 2) To find out the best suitable growing media, biofertilizer and PGR among all treatments for growth and survivability of air layers.3) To estimate the economics of the treatments.

The trial was assigned in Completely Randomized Design (CRD) with three replications. Each replication consists of 9 treatments with different levels of GA_3 (100, 150 and 200 ppm), biofertilizer (Azotobacter @ 0.5 ml) and growing media (vermicompost and leaf mould) were applied in guava air layers *cv.* Gwalior-27. The observations on different characteristics such as growth parameters *(viz.,* number of sprouts**,** stem length (cm)**,** stem thickness (mm)**,** number of leaves**,** plant survival percentage), Root parameters (*viz.* number of primary roots ,number of secondary roots,length of primary roots (cm), length of secondary roots (cm) , diameter of primary roots (mm) , diameter of secondary roots (mm),fresh weight of primary roots (g),fresh weight of secondary roots (g) Economical parameters *viz.* (gross income, net income and B: C Ratio) were studied.

The obtained results are epitomized below under following rubrics with noteworthy conclusions and future recommendations:

6.1.1 Effect of different growing media, *Azotobacter* and GA_3 on Growth parameters of guava air layers at 45, 90 and 135 DAT.

The highest growth parameters *(viz.,* number of sprouts**,** stem length (cm)**,** stem thickness (mm)**,** number of leaves**,** plant survival percentage) at 45, 90 and 135 DAT were recorded under treatment T_4 (Soil+ vermicompost (2:1) + GA_3 200 ppm + *Azotobacter* (0.5 ml)) and it was found outstanding among all treatments and was co-operated by treatment T_8 (Soil + Leaf mould (2:1)+ GA_3 200 ppm + *Azotobacter* (0.5ml)).

The significant enhancement in growth of guava air layers is achieved due to the combination of growing media (Soil + Vermicompost) might be attributing to proper aeration and peat like material with high porosity,

drainage, water holding capacity, microbial activities, excellent nutrient status of vermicompost and buffering capacity and increased level of growth promoting substances and other nutrients with the application of *Azotobacter* and due to the synergistic effects of both GA_3 and growing media in various ways, more uptake and utilization of nitrogen, phosphorus, soluble potassium, calcium and magnesium made available to layers by vermicompost and *Azotobacter,*GA_3 regulates growth and applied in very minute concentrations shown profound effect on early sprouting number of leaves; stem length, stem thickness and most importantly on survival of air layers.

The minimal growth on above characteristics was noted under treatment T_0 (Soil (control)) this is just because soil alone was unable to provide essential nutrients in required amount and thus resulted in lesser growth.

6.1.2 Effect of different growing media, *Azotobacter* and GA_3 on Root parameters of guava air layers at 45, 90 and 135 DAT

Root parameters (*viz.* number of primary roots ,number of secondary roots,length of primary roots (cm), length of secondary roots (cm) , diameter of primary roots (mm) , diameter of secondary roots (mm),fresh weight of primary roots (g),fresh weight of secondary roots (g) maximally observed under treatment T_4 (Soil + Vermicompost + GA_3 200 ppm + *Azotobacter* (0.5 ml)) and it was significantly followed by treatment T_8 (Soil + Leaf mould (2:1) + GA_3 200ppm + *Azotobacter* (0.5 ml)).

The application of *Azotobacter* improves nitrogen status of the soil because it is a free nitrogen fixer & resulted in greater fixation of atmospheric nitrogen and consequently use by the plant resulting in vigorous growth. The better efficiency of organic manures could have provided the micronutrients such as zinc, copper, manganese etc., in optimum levels. This is also imputed because GA_3 promote growth and cell elongation and *Azotobacter* provided better nutritional environment in the root zone as well as in the plant system. The assured impacts in rooting due to growing media which allowed macro and micro nutrients in optimal amount for vigorous growth of the detached air layers.

The minimum root parameters were attained in treatment T_0 (Soil (control)) because soil alone found inappropriate for growth of roots in guava air layers.

6.1.3 Effect of different growing media, *Azotobacter* and GA_3 on Economical parameter of guava air layers at 45, 90 and 135 DAT

- The application of T_4 (Soil + Vermicompost (2:1) + GA_3 200 ppm + *Azotobacter* (0.5 ml)) reported most economical with respect to Benefit: Cost ratio.
- The maximal gross income and net income was also recorded under the application of treatment T_4 (Soil + Vermicompost (2:1) + GA_3 200 ppm + *Azotobacter* (0.5 ml)).

6.2 CONCLUSION

- On the basis of the present trial it is concluded that 200 ppm GA_3 significantly increased the survivability of detached guava air layers in comparison to other concentrations.
- *Azotobacter* in minute amount was also helpful in reduced mortality of detached guava air layers.
- Among the growing medias Vermicompost found superior over leaf mould.
- Leaf mould when mixed with GA_3 (200 ppm) and *Azotobacter* gave results equivalent to vermicompost.
- Collectively, the combination of Vermicompost, GA_3 (200 ppm) and *Azotobacter* (0.5 ml) proved to be the most promising combination for increased survival percentage of air layers.
- Also, combination of Vermicompost, GA_3 (200 ppm) and *Azotobacter* (0.5 ml) proved to be the most economic treatment for transplanted guava air layers.

6.3 SUGGESTIONS FOR FUTURE WORK:

- The increased dose of PGR (GA_3) and biofertilizer (*Azotobacter*) should also be tested to establish the appropriate concentration for application.
- The growing media Vermicompost and Leaf mould may also retry in combination for further research work.
- Study of other bio fertilizers such as *Azospirillum* may be included.
- The present investigation may also retry with the combination of IBA and GA_3.
- The same research work should be tried on different fruit crops which are propagated vegetatively or specifically by air layering.

BIBLIOGRAPHY

Adams, P.A., Montague, M. J., Tepfer, M., Rayle, D. L., Ikuma, H., Kaufman, P. B. 1975. Effect of gibberellic acid on the plasticity and elasticity of Avena stem segments. *Plant Physiology,* **56 (**2):757-760.

Anonymous (2018). National Horticulture database. National Horticulture Board. Govt. of India, Gurgaon, India. http://www.nhb.gov.in

Bhandulkar, K. (2017). Impact of Indole butyric acid and bioinoculant on survivability of transplanted air layered plants of guava (*Psidium guajava* L.) M.Sc. thesis department of Horticulture , RVSKVV Gwalior.

Burdett, A.N. (1987). Understanding root growth capacity Theoretical consideration in assessing planting stock quality by means of root growth tests. *Can. J For Res* **17**: 768-775.

Brenner, M. L, Cheikh, N. (1995). The role of hormones in photosynthate partitioning and seed filling. In: Davies PJ(ed), Plant Hormones: Physiology, Biochemistry and Molecular Biology, *Kluwer Academic Publishers*, *Dordrecht,* 649-670.

Cooper, W.C. (1940). Rooting of citrus cuttings with synthetic substance. *Florida State Hort. Sci.* **53**: 174-177.

Canli, F. A. and Orhan, H. (2009) Effects of Foliar Gibberellic Acid Applications on Vegetative Growth of Pear, Apple and Cherry Seedlings *International Journal of Natural and Engineering Sciences* **3** (1): 95-98.

Damar, Dina & Barholia, A.K. & Lekhi, R. & Haldar, A.. (2014). Effect of growth regulators and biofertilizers on survival of pomegranate (Punica granatum L.) stem cuttings. Plant Archives. **14**. 347-350.

Dawar I.S., T. R. Sharma, Nagar O.P. and Pal. S. (2020). Effect of Different Rooting Media for Rooting Success and Survivability of Marcottage in Pomegranate (*Punica granatum* L.) *C.V*. Bhagwa. *Int.J.Curr.Microbiol.App.Sci.* **9**(12): 1858-1867.

Ezz, T.M., Aly, M.A., Saad, M.M., and El-Shaieb, F. (2011). Comparative study between bio- and phosphorus fertilization on growth, yield, and fruit quality of banana (*Musa spp*.) grown on sandy soil. *J Saudi Soc. Agric. Sci.*

El-Habbasha, S.F., Hozayn, M. and Khalafallah, M.A. (2007). Integration effect between phosphorus levels and bio-fertilizers on quality and quantity yield of faba bean (vicia 180 fabal.) in newly cultivated sandy soils. *Research journal of Agriculture and Biological Sciences* **3** (6): 966-971.

Fisher, R. A. (1954) On the mathematical foundations of theoretical statistics" , *Philosophical Transactions of the Royal Society of London, A,* **222**, 309-68.

G. Muthia & Arumugam, Arunprasath. (2015). Growth Performance of Ceriops decandra propagules as influenced by PGR and #8211; A conservation effort. *Journal of Plant Stress Physiology*. **1**. 1-5. 10.5455.

Haque, T., Farooque, A.M., Rahim, M.A. and Islam, S. (2004) Effect of layering methods and growth regulators on guava propagation. *Journal of the Bangladesh Society for Agricultural Science & Technology*, **1** (1-2). pp. 13-17.

Kashyap, A., Lekhi, R., Raghuwanshi, K.S., Jatav, P. and Agrawal, S. (2016). Interaction effect of different rooting media and IBA concentration on growth and survivability of air layers in acid lime, *Bhartiya Krishi Anushandhan Patrika*, **31**(1), 39-41.

Kashyap, A., Effect of Bio- fertilizer and IBA on photosynthesis efficiency and weight of leaf in air layered guava (*Psidium guajava* L.) cv. Gwalior-27. Ph.D Thesis, Rajmata VijayarajeScindia Krishi Vishwa Vidayalaya,Gwalior , Madhya Pradesh (India). (2019).

Kumar, A. Pandey, Patel D.,Rai, R.R. Nath, Vishal. (2014). EVALUATION OF ALTERNATE POTTING MEDIA MIXTURES FOR RAISING QUALITY PLANTING MATERIAL OF LITCHI IN POLYBAGS. *The Bioscan*. **9**:(1). 381-384.

Kumar, H., Arora, R., Thakur, A. and Sharma, S., 2020. Impact Assessment of Growing Media and Bioinoculents on Growth and Bud take of Rough Lemon. *Indian Journal of Horticulture*, **77**(3), pp.439-449.

Kaur G, Malhi CS. Effect of Age of Rootstock and Growing Medium on the Success of Epicotyl Grafting in Mango. *Indian Journal of Horticulture.* 2006 Sep; **63**(3).

Kunal, M.M.(2005). Effect of etiolation and plant growth substances on rooting and survival of air-layers of guava. *Indian Journal of Horticulture,* **62**(3): 290-292.

Kakon, A.J., Haque,M.A., Mohsin, M.G. (2008).Effect of three growth regulators on mound layering in the three varieties of guava. *SAARC Journal of Agriculture***. 6**(2): 39-47.

Mishra, S.K. (2014). Effect of Different Rooting Media on Survival and Success of Air Layers in Kagzi Lime (Citrus aurantifolia Swingle).*Annals of Plant and Soil Research* **16** (3): 264-267.

Mccreary, Doug & Duryea, Mary. (1987). Predicting field performance of Douglas-fir seedlings: comparison of root growth potential, vigor and plant moisture stress. *New Forests.* **1.** 153-169. 10.1007/BF00118754.

Manna, S. Mathew, B.and Ghosh, S.N. (2001). Air layering in guava cultivars. *Journal of Interacedemicia*; **5**: 278-281.

Noori, Ibrahim & Karim, Faraidun & Aziz, Rasul & Mohammed, Aram. (2019). Propagation of pistachio *Pistacia vera* L. by air layering under the effects of IBA and GA3 treatments**. 13**. 2001-2004.

Rajpoot, M. (2012) Effect of IBA and bio fertilizers augmented growing media on air layered plant of guava (*Psidium guajava* L.) cv. Gwalior 27 M.Sc.thesis department of horticulture RVSKVV Gwalior.

Rolaniya, M.K., Bairwa, M., Khushbu, & Sarvanan, S. (2018). Effect of Plant Growth Regulators (IIA, IBA, GA3) on Rooting of Hardwood Cutting of Grape (*Vitis venifera* L.) cv.Thompson Seedless. *Journal of Pharmacognosy and Phytochemistry,* **7**, 398-400.

Ramteke, N.H., Verma, R.M. Damke, M.M. Patil, V.S. and Panchbhai, D.M.(1998).Studies on propagation in guava (Psidium guajava L.) under Akola conditions. *PKV Research Journal*; **22** (2): 180-182.

Rymbai, H. and Reddy, G.S. (2010). Effect of IBA, time of layering and rooting media on air layers and plantlets survival under different growing nursery conditions in guava. *Indian Journal of Horticulture*. **67**: *Special Issue*, 99- 104.

Rymbai, H., Sathyanarayana, Reddy G. and Reddy, K.C.S. (2012). Effect of cocopeat and sphagnum moss on guava air layers and plantlets survival under open and polyhouse nursery. *Agric. Sci. Digest*, **32** (3): 241 - 243.

Sarita & Bakshi, P. Kour, K. & Sinha, B. Mehla, Unique, B. (2019). Effect of Different Potting Media on Survival and Growth of Air Layered Litchi cv. Dehradun. *International Journal of Current Microbiology and Applied Sciences*. **8**. 1196-1204.

Shaikh, N., Ramteke, S. D., Mane, A. V., Pethe, U. B., & Urkude, V. 2018. STUDIES on EFFECT of DIFFERENT PROPAGATION MEDIA on GROWTH and SURVIVAL of CLOVE (Syzygium Aromaticum L. Meer) SEEDLINGS. *International Journal of Agriculture Sciences,* **10**(19), 7328-7330.

Sevik, H., Güney, K. (2013). Effects of IAA, IBA, NAA, and GA3 on rooting and morphological features of Melissa officinalis L. Stem cuttings. *TheScientificWorldJournal.* **10**.1155/2013/909507.

Sharma, A. (2014). Application of Chemical and Biofertilizers on Growth and Biomass Production of *Madhucalatifolia* (Mahua) Seedlings International Journal of Bio-Science and Bio-Technology**, 6**(4) : 25-32

Singh, P., Chandrakar, J., Singh, A. K., Jain, V. and Agrawal, S. (2007). Effect on rooting in guava cv. Lucknow-49 through PGR and organic media under Chhattisgarh condition. *Acta Horticulturae*. **7**(35):197-200.

Slakins, V. (1973). Hormonal relationship in mycorrhizal development*. Academic Press*, London, Orland. 231-298.

Tyagi, S.K.andPatel , R.M.(2004) Effect of growth regulators on rooting of air layering of guava (*Psidium guajava* L.) cv.Sardar . *Orissa J. Hort*.,**32** (1): 58-62

Vessey, J.K. (2003).Plant growth promoting rhizobacteria as bio fertilizers. *Plant and soil* **255**: 571-586.

Yosefi, K. Galavi M, Ramrodi, M. and Mousavi, S.R. (2011). Effect of bio-phosphate and chemical phosphorus fertilizer accompanied with micronutrient foliar application on growth, yield and yield components of maize (Single Cross 704).*Aust. J . Crop Sci.***5** (2): 175-180.

APPENDICES

APPENDIX - I
Number of sprouts at 15 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	90.000	11.2500**	20.2500	2.51	3.71
Error	18	10.000	0.5556			
Total	26	100.000				

APPENDIX – II
Increase in number of leaves at 45 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	88.000	11.0000**	2.6757	2.51	3.71
Error	18	74.000	4.1111			
Total	26	162.000				

APPENDIX – III
Increase in number of leaves at 90 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	96.000	12.0000**	4.4384	2.51	3.71
Error	18	48.667	2.7037			
Total	26	144.667				

APPENDIX – IV
Increase in number of leaves at 135 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	78.519	9.8148**	2.5728	2.51	3.71
Error	18	68.667	3.8148			
Total	26	147.185				

APPENDIX – V

Increase in stem length at 45 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	66.660	8.3325**	11.1430	2.51	3.71
Error	18	13.460	0.7478			
Total	26	80.120				

APPENDIX – VI

Increase in stem length at 90 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	125.160	15.6450**	19.8038	2.51	3.71
Error	18	14.220	0.7900			
Total	26	139.380				

APPENDIX – VII

Increase in stem length at 135 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	138.839	17.3548**	2.5666	2.51	3.71
Error	18	121.713	6.7619			
Total	26	260.552				

APPENDIX – VIII

Increase in stem thickness at 45 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	22.747	2.8433**	2.8902	2.51	3.71
Error	18	17.708	0.9838			
Total	26	40.455				

APPENDIX – IX

Increase in stem thickness at 90 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	70.572	8.8215**	4.3337	2.51	3.71
Error	18	36.640	2.0356			
Total	26	107.212				

APPENDIX – X

Increase in stem thickness at 135 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	45.572	5.6965**	2.9191	2.51	3.71
Error	18	35.127	1.9515			
Total	26	80.699				

APPENDIX – XI

Plant survival (%) at 45 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	386.553	48.3192**	3.8619	2.51	3.71
Error	18	225.213	12.5119			
Total	26	611.767				

APPENDIX – XII

Plant survival (%) at 90 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	734.067	91.7584**	8.5445	2.51	3.71
Error	18	193.300	10.7389			
Total	26	927.367				

APPENDIX – XIII

Plant survival (%) at 135 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	1081.133	135.1417**	11.6650	2.51	3.71
Error	18	208.533	11.5852			
Total	26	1289.667				

APPENDIX – XIV

Number of primary roots at 45 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	26.667	3.3333**	3.7500	2.51	3.71
Error	18	16.000	0.8889			
Total	26	42.667				

APPENDIX – XV

Number of primary roots at 90 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	25.185	3.1481**	8.5000	2.51	3.71
Error	18	6.667	0.3704			
Total	26	31.852				

APPENDIX – XVI

Number of primary roots at 135 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	27.590	3.4487**	2.7355	2.51	3.71
Error	18	22.693	1.2607			
Total	26	50.283				

APPENDIX – XVII

Number of secondary roots at 45 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	73.852	9.2315**	2.9324	2.51	3.71
Error	18	56.667	3.1481			
Total	26	130.519				

APPENDIX – XVIII

Number of secondary roots at 90 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	66.667	8.3333**	2.8846	2.51	3.71
Error	18	52.000	2.8889			
Total	26	118.667				

APPENDIX – XIX

Number of secondary roots at 135 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	100.667	12.5833**	3.7750	2.51	3.71
Error	18	60.000	3.3333			
Total	26	160.667				

APPENDIX – XX

Length of primary roots at 45 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	83.793	10.4742**	3.1283	2.51	3.71
Error	18	60.267	3.3481			
Total	26	144.060				

APPENDIX – XXI

Length of primary roots at 90 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	59.330	7.4162**	3.1593	2.51	3.71
Error	18	42.253	2.3474			
Total	26	101.583				

APPENDIX – XXII

Length of primary roots at 135 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	59.859	7.4823**	2.5690	2.51	3.71
Error	18	52.427	2.9126			
Total	26	112.285				

APPENDIX – XXIII

Length of secondary roots at 45 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	27.894	3.4868**	2.6028	2.51	3.71
Error	18	24.113	1.3396			
Total	26	52.007				

APPENDIX – XXIV

Length of secondary roots at 90 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	43.080	5.3850**	2.7381	2.51	3.71
Error	18	35.400	1.9667			
Total	26	78.480				

APPENDIX – XXV

Length of secondary roots at 135 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	47.852	5.9815**	3.0340	2.51	3.71
Error	18	35.487	1.9715			
Total	26	83.339				

APPENDIX – XXVI

Diameter of primary roots at 45 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	7.217	0.9021**	2.5994	2.51	3.71
Error	18	6.247	0.3470			
Total	26	13.464				

APPENDIX – XXVII

Diameter of primary roots at 90 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	4.716	0.5895**	2.5468	2.51	3.71
Error	18	4.167	0.2315			
Total	26	8.883				

APPENDIX – XXVIII

Diameter of primary roots at 135 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	11.227	1.4033**	2.5723	2.51	3.71
Error	18	9.820	0.5456			
Total	26	21.047				

APPENDIX – XXIX

Diameter of secondary roots at 45 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	0.910	0.1137**	3.1313	2.51	3.71
Error	18	0.654	0.0363			
Total	26	1.563				

APPENDIX – XXX

Diameter of secondary roots at 90 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	0.887	0.1109**	3.2197	2.51	3.71
Error	18	0.620	0.0345			
Total	26	1.508				

APPENDIX – XXXI

Diameter of secondary roots at 135 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	2.057	0.2571**	2.6449	2.51	3.71
Error	18	1.750	0.0972			
Total	26	3.807				

APPENDIX – XXXII

Fresh weight of primary roots at 45 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	2.630	0.3287**	14.1603	2.51	3.71
Error	18	0.418	0.0232			
Total	26	3.048				

APPENDIX – XXXIII

Fresh weight of primary roots at 90 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	1.669	0.2086**	21.2457	2.51	3.71
Error	18	0.177	0.0098			
Total	26	1.846				

APPENDIX – XXXIV

Fresh weight of primary roots at 135 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	2.081	0.2602**	50.9768	2.51	3.71
Error	18	0.092	0.0051			
Total	26	2.173				

APPENDIX – XXXV

Fresh weight of secondary roots at 45 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	0.221	0.0276**	8.6032	2.51	3.71
Error	18	0.058	0.0032			
Total	26	0.279				

APPENDIX – XXXVI

Fresh weight of secondary roots at 90 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	0.224	0.0281**	26.6708	2.51	3.71
Error	18	0.019	0.0011			
Total	26	0.243				

APPENDIX – XXXVII

Fresh weight of secondary roots at 135 DAL

ANOVA

S.V.	DF	SS	MS	Fcal	F tab (5%)	F tab (1%)
Treat	8	0.475	0.0593**	46.4478	2.51	3.71
Error	18	0.023	0.0013			
Total	26	0.498				

** Significant at p=0.01

VITAE

Name **:** Vijaya Singh Kushwah

Father's Name **:** Mr. Nagendra Singh Kushwah

Date of Birth **:** 28/09/1995

Place – Post **:** Nasrullaganj, Distt. - Sehore (M.P.)

Degree awarded	**Major subject**	**Year of passing**	**Board / University**	**% of marks / OGPA**
High School	**-**	2012	CBSE,Delhi	7.6
Higher Secondary	Biology	2014	CBSE,Delhi	73.2
B.Sc. (Ag)	Agriculture Science	2019	RVSKVV,Gwalior (M.P.)	76.20
M.Sc. Ag (Hort.) Fruit Science	Fruit Science	2021	RVSKVV,Gwalior (M.P.)	7.79

For the partial fulfillment of the Master degree programme she was allotted a field research experiment on **"Effect of different growing media, biofertilizer and plant growth regulator on growth and survivability of guava air layers"** was successfully conducted by her and being submitted in the form of this thesis.

(VIJAYA SINGH KUSHWAH)