

**Effect of Different Concentration of IBA and NAA on
Rooting and Growth of Air Layers in Guava. (*Psidium
guajava L.*)**

THESIS



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Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya

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MASTER OF SCIENCE

In

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(FRUIT SCIENCE)

by

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2017

CERTIFICATE – I

*This is to certify that the thesis entitled, “Effect of Different Concentrations of IBA and NAA on Rooting and Growth of Air-Layers in Guava (*Psidium guajava* L.)” submitted in partial fulfilment of the requirement for the Degree of **MASTER OF SCIENCE in HORTICULTURE (Fruit Science)** of Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior. **BHURIYA VERMA** 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 degree or diploma or has been published. All the assistance and help received during the course of the investigation has been acknowledged by the Scholar.

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*This is to certify that the thesis entitled, “**Effect of Different Concentrations of IBA and NAA on Rooting and Growth of Air-Layers in Guava (*Psidium guajava* L.)**” submitted by **BHURIYA VERMA** to the Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE (Fuit Sceince)** in the **Department of Horticulture, College of Agriculture, Gwalior** has been accepted after evaluation, approved by the External Examiner and approved by the Student’s Advisory Committee after an oral examination on the same.*

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ABBREVIATIONS

Abbreviations/ Acronyms	Meaning
Ag.	Agriculture
ANOVA	Analysis of variance
IBA	Indole-3- butyric acid
NAA	1 Naphthaleneacetic acid
PPM	Parts per million
Cm	Centimetre
°C	Degree celcius
cv.	Cultivar
C.D	Critical difference
Dist.	District
dSm ⁻¹	Deci Siemens per meter
<i>et al.</i>	And others
etc.	Etcetera
Fig.	Figure
G	Gram
Ha	Hectare
Hort	Horticulture
i.e.	In reference to; that is
Kg	Kilogram
Max.	Maximum
M	Metre
ml	Milliliter
Mm	Millimeter
Min	Minimum
M.P.	Madhya Pradesh
C.g	Chattisgarh
M.S.S	Mean Sum of Square
No.	Number

NS	Non significant
Q	Quintal
R.V.S.K.V.V.	RajmataVijayarajeScindiaKrishiVishwaVidhyalaya
I.G.K.V	Indira Gandhi KrishiVishwaVidhyalaya
S.Em \pm	Standard Error of Means
Sy.	Symbol
S	Significant
Temp.	Temperature
TSS	Totle soluble solid
Var.	Varity
Viz	Namely
Wt.	Weight
&	And
@	At the rate of
%	Per cent
/	Per

Chapter -I

INTRODUCTION

Guava (*Psidium guajava* L.), is one of the most popular fruits grown in tropical, sub-tropical and some parts of arid regions of India. Guava belongs to the family Myrtaceae. Besides, it is also a cheap and very rich source of vitamin-C, carbohydrate, iron, fat and contains a fair amount of calcium and phosphorus as well. Guava fruits are also used for preparation of salad, chutney, jam, jelly, nectar etc. These qualities make guava an important and one of the most popular fruits of India. India is the leading producer of guava in the world. The total area under guava cultivation and production of guava in India is about 2.68 lakh hectares and 31.98 lakh MT respectively, The average productivity of guava in India is 13.70 MT/ha. The total area and production of guava in Madhya Pradesh is 21.28 thousand hectares and 841.1 thousand MT, respectively. Madhya Pradesh ranks first in productivity with 36.67 MT/ha. Guava shares 3.4 per cent of area and 3.9 per cent of production in India (NHB, 2015). Major guava producing states are Maharashtra, Madhya Pradesh, West Bengal, Punjab, and Gujarat (NHB, 2015). Major guava producing districts in Madhya Pradesh are Jabalpur, Gwalior, Bhopal, Dewa, Neemuch, Ratlam, Khandwa and Mandsaur etc.

Guava is generally propagated by vegetative methods like, inarching, air layering, cutting, budding and grafting are commonly practiced. These methods have their own merits and demerits. However, cutting and layering or air-layering are easy methods of propagation of this crop. Auxins particularly IBA and IAA have been reported to induce rooting in many of the plant species with varied success. The response of different growth substances to percent success varied from species to species with changing physiological and environmental conditions. Most of the workers have reported IBA and IAA as better growth regulators than others for inducing rooting in cuttings and air-layering due to their stable nature. Air layering (Hartmann and Kester, 1972) was reported to have yielded good results. Air layering with the help of growth regulators is more efficacious and is the best method of vegetative propagation of guava as reported by Singhwa and Abbadi (1968) and Mujumdar and Mukherjee (1968).

The growth, establishment and survival of branches and seedling also depend on the quality of a rooting media. According to Loach (1988), the rooting media should be considered an integral part of the propagation system; percentage rooting and the quality of the roots produced are directly influenced by the medium. Macdonald (1986) & Hartmann *et al.* (2002) stated that the appropriateness of the medium depends on the species the cutting type, the season, the propagation system used and the cost and availability of the medium component. Good water management is also crucial for success. There are many commercial rooting media used for layering, but many are expensive and locally unavailable. These have to be imported from elsewhere and this makes them expensive. There is a need to establish appropriate and low cost rooting media. The latest advance in the knowledge of growth regulators in plant propagation has further improved the scope of their use in vegetative propagation of various fruit crops.

It is a matter of great interest to find out the best concentration of the growth regulators. This can induce better rooting in air-layers and can improve the survival of guava after detachment. Keeping in view the potentialities of growth promoting hormone, the present experiment entitled “Effects of different concentration of IBA and NAA on rooting and growth of air layering in guava (*Psidium guajava* L.) was carried out in the rainy season of 2016-2017 under agro-climatic conditions of northern M.P. with the following objectives:

1. To determine the effect of IBA on rooting, growth and survival of guavaairlayers.
2. To assess the influence of NAA on rooting, growth and survival of guavaairlayers.
3. To find out best combination of IBA and NAA on the rooting, growth and survival of guavaair-layers.
4. To work out the economics of different treatment.

Chapter -II

REVIEW OF LITERATURE

The literature pertaining to the “Effects of different concentration of IBA and NAA on rooting and growth of air layers in guava (*Psidiumguajava L.*) is briefly given below. In this chapter, due to paucity of the adequate experimental evidences on these aspects, the similar work done on other crops has also been reviewed to understand the effect of different treatments.

Sharma (1981) concluded that NAA 10000 ppm had significantly affected the various root characters followed by NAA 7500 and IBA 10000 ppm in karonda air-layerings.

Tomar (1981) reported that among the four concentrations, IBA 5000 ppm proved significantly better for rooting of kagzi-lime air-layers.

Rathore (1982) reported that among concentration of IBA, 15000 proved significantly better in the formation of primary roots and secondary roots, length, diameter, total weight of roots and average number of primary and secondary roots in guava air-layers.

Gurjar (1983) observed that IBA 10000 was found significantly better for the rooting and survival of air-layers of kagzi-lime.

Kushwaha (1984) concluded that IBA proved significantly better than IAA and NAA for the per cent success in rooting and survival percentage of kagzi lime air-layers.

Bhadoria (1985) reported that IBA at all the levels helped in better root initiation, survival and growth, highest concentration of IBA 10000 ppm proved to be the most effective concentration.

Patel (1985) reported that IBA was better than NAA. Amongst the different concentration, IBA at 3000 ppm gave highest (100%) rooting and 76.6 per cent survival in air layers of guava.

Sharma (1985) reported that the application of IBA 10000 ppm had influenced the rooting and growth of air layers of sardar variety of guava significantly. He also reported that first date 10th July was found proper time of

operation and these results can be recommended for the propagation of guava by air-layering under northern m.p.

Prasad *et al.* (1988) reported that the best rooting (98%) was obtained with IBA at 2500 ppm. Rooting in the untreated control was 8.75 per cent.

Baghel (1989) reported that the best treatment combination was IBA with black polythene wrapper in Dusheri variety of mango, which gave 93.35% rooting and 56.00% survival of air layers.

Beohar (1989) reported that highest concentration of IBA (5000 ppm) proved significantly better for rooting and survival of air layers of kagzi lime.

Kori (1989) stated that among four concentrations of IBA 15000 ppm proved significantly better for rooting of guava air-layers.

Patel *et al.* (1989) reported that black polythene film was better than white polythene film for air-layering in guava and recorded highest percentage of rooting and survival of air-layers. They further estimated that this beneficial response obtained with black polythene due to effect of etiolation.

Yadav (1989) concluded from the overall performance that IBA 7500 ppm was significantly better for rooting and survival of air layers of kagzi lime.

Chatterjee *et al.* (1990) reported that invigorated shoots after etiolating treatment treated with 10000 ppm IBA gave 91.7 per cent rooting success and 90.9 per cent survival.

Debnath and maiti (1990) investigated on rooting behaviour of soft wood cuttings of guava v ar. Namely Baruipur, sardar and Harijha in two different seasons (spring and rain) treated with various growth regulators (IBA, NAA and IAA) at three different concentrations (1500, 2500, 3500) ppm. Among different concentrations IBA at 2500 ppm exhibited the best performance (73.3 to 83.3%) rooting success on the different rooting parameter. NAA had almost the similar responses. Rainy season was superior to spring in respect of rooting of cutting. Among the different varieties Baruipur was most responsive to the treatments of different growth regulators followed by sardar and Harijha.

Mishra (1990) reported that the concentration of growth regulators viz.:(IBA 1500 ppm) showed great improvement in most of the characters like callusing,

rooting and survival of air layers of kagzi lime which was statistically better than other treatments.

Nath(1991) observed that root formation during air layering of *M.grandiflora* was enhanced by pre-ringing (removing a 2.5 cm wide strip of bark 35-40 cm from the growing tip), etiolation of shoots 30 days before layering and treatment with 4000 p.p.m. IBA at the time of layering.

Sharma *et al.* (1991) reported that 10,000 ppm IBA treatment resulted in the highest percentage success (75.55 per cent) and number, length, diameter and weight of roots. Air-layering resulted in the highest percentage success (67.7%) and total root weight.

Gupta (1992) used IBA and NAA each of our concentrations (5000, 10000,15000 and 20000 ppm) in air-layering of guava. Amongst the four concentrations, IBA (20000 ppm) had significantly produced better rootage but survival subsequent growth was better under IBA 15000 ppm.

Mishra and Jaiswal (1993) reported that IBA 10000 ppm proved most effective and gave an average of 93.3% rooting in stool layers. The survival of roots stool layered shoots was also found highest (83.33 per cent with IBA 10000 ppm).

Patel and Pasaliya (1995) carried out a study in 1990-91 at Junagadh the effect of IBA, NAA or IAA at 3000, 6000 or 9000 ppm applied immediately after ringing or 10 or 20 days later on rooting in air layered shoots of guava cv. Lucknow-49 were studied. NAA at 900 ppm applied immediately after ringing gave the highest number of primary and secondary roots and heaviest root fresh and dry weight.

Singh *et al.* (1995) reported that black polythene wrappers with IBA + NAA (16000 ppm) of growth regulators were found significantly superior to 12000 and 8000 ppm. Layering on 1st August was more successful as compared to 15th July in jack fruit (*Artocarpus heterophyllus*).

Singh *et al.* (1995) reported that 5000 ppm IBA +NAA was found optimum for better success and survival of air-layers, while 10000 ppm resulted in better growth attributes. Among the wrapper, black wrapper was found significantly

superior to white wrapper in enhancing most of the attributes to air-layers in guava.

Kale (1996) reported that application of IBA particularly 15000 ppm had significantly proved better for rootage as well as survival and subsequent growth of air layerage of guava.

Pandey (1996) conducted study to investigation the effect of different concentration of IBA and NAA on the propagation of feizoa cv. Nikitkii through stooling .rooting percentage and survival were highest (71.96% and 75.83%, respectively) with the application of 1000 ppm IBA.

Patel *et al.* (1996) reported that the effects of plant growth regulators (NAA and or IBA at 2000,3000, or 4000 pmm) and wrappers (black or white) on rooting percentage, root characters, survival and growth of air layers of guava cv. Allahabad safeda were investigated in the field at rewa, Madhya Pradesh, india during 1994-95. Plant growth regulators promoted rooting compared with control treatment. IAA+IBA promoted percentage rooting, number of roots, length of roots, percentage survival of air layers and shoot growth. IBA alone was better than IAA alone. The best concentration of growth regulators for promoting rooting and growth of air layers was 3000 ppm. Rooting and growth of air layers was better in treatment with black wrappers than with white wrappers.

Singh (1996) reported that the concentration of the growth regulators IBA 5000 ppm showed great improvement in most of the characters like callusing, rooting and survival of air layers in kagzi lime.

Singh and jain (1996) reported that percentage rooting and survival were highest (78.75 and 75 %) for etiolated shoots treated with IBA at 6000 ppm.

Hatibarua *et al.* (1997) observed that etiolation, IBA and NAA enhanced rooting, Number of roots, length of the longest root and root dry weight per layer increased with increasing plant growth regulator concentration. The best root growth and development was observed after etiolation and treatment with IBA at 5000 ppm. Following transplanting in the field, the highest survival rates (80%) was observed in etiolated air layers treated with IBA at 1000 or 5000 ppm. Etiolated shoots exhibited better rooting and field establishment than untreated controls.

Chandrappa (1998) reported that the effects of applying IBA and NAA alone or with 1000 ppm 1, 2, 4 acid (a phenolic compound) on air layering in May-September were studied. Rooting was best in air layers taken in June treated with 10000 IBA+1000 ppm 1, 2, 4 acids. It is of crop

Mukhtaret *al.* (1998) found maximum rooting (93%) with IBA at 4000 ppm. They observed that rooting percentage increased as the concentration increased. They also reported that the establishment percentage in all the treatments was significantly higher than in the control.

Ramteke (1998) reported in a trial in Akola district, Maharashtra, India, guava (cv. Sardar) shoots were layered in polyethylene 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.

Saroj and Pathak (1998) reported that combined application of IBA +NAA (7500) induced profuse rooting (90 to 100%) in (*Psidium chinensis* L.) However, longer roots were recorded at lower concentration (5000 ppm) of either IBA alone or in combination with NAA.

Bhagat *et al.* (1999) reported that the highest percentage of rooting (91.6%), most roots per layer (14.8), the greatest length of the longest root (13.4 cm) and most leaves per layer (30.8) were obtained in layers treated with 4500 ppm IBA (control values were 68.3%, 7.5 roots, 9.0 cm and 34.8 leaves, respectively). This treatment also resulted in the greatest percentage survival (88.0% compared with 65% in untreated control) NAA in combination with IBA reduced rooting compared to IBA alone.

Sharma (1999) reported that the application of growth regulators IBA @5000 ppm with sphagnum moss showed great improvement in most of the characters like callusing, rooting and survival of air layers of Kagzi lime.

Tomar *et al.* (1999) reported that during the trials in 1995-1996 at Gwalior, of guava cultivar-27 were tested with 5000, 10000, 15000 and 20000 ppm NAA and IBA before air layering in guava. Air layers were detached after 60 days and transferred to nursery beds. Rooting success increased with the increasing growth

regulators concentration. Survival rates were highest (71.65%) with 15000 ppm NAA in 1995 whereas in 1996 they were highest (70.29) with 15000 ppm IBA.

Shrivatava (2000) reported that the treatment combination (IBA + NAA 7500 each) with sphagnum moss showed the greatest improvement in all the characters like callusing, rooting and survival of air layering of guava.

Manna *et al.* (2001) evaluated the response of different guava cultivars to air layering. Among the 12 guava cultivars, Lucknow-49, Kerala and Chittidar showed 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.

Singh (2001) observed that IBA was beneficial in enhancing the callus formation, number length and diameter of both primary and secondary roots and survival of air layered twigs. 20000 ppm of plant growth regulators was found optimum for better rooting success and survival and was significantly superior to 5000, 10000 and 15000 ppm of plant growth regulators. The use of black polyethylene as wrapper resulted in better rooting success and survival of air layered guava twigs compared to white polythene.

Singh (2002) studied on the effects of different concentrations (5000, 10000, 15000 and 20000 ppm) of IAA, IBA and NAA in combination with white or black polyethylene film on air-layered guava cv. Allahabad Safeda plants were examined in a field experiment conducted in Madhya Pradesh, India during the monsoon seasons. All the treatments resulted in higher growth and survival of the air layers compared to the control. Among the plant growth regulators, IBA was the most effective for the rooting, establishment, survival and vegetative growth of the air layers.

Albany *et al.* (2004) reported most of the guava (*Psidium guajava*L.) trees grown in the northwestern Zulia State (Venezuela) are propagated by seed, bringing about high genetic variability in commercial plantations. Air layering was evaluated as a technique of vegetative propagation of guava was performed. In the first experiment, a study was made of the application of NAA and IBA at 5000 mg/kg each and a mixture of both (2000 and 1000 mg/kg, respectively) using river

peat as substrate. In a second experiment, 5000 mg NAA/kg was applied and two substrates: river peat and the mixture of river peat + phenolic foam (3:1 v/v), were evaluated.

Tyagi and Patel (2004) studied the effects of IBA, NAA and IBA + NAA at 5000 or 10000 ppm each on the rooting of guava (cv. Sardar). The growth regulators were mixed with lanolin paste and applied to the upper portion of the cut of the ring on each plant. The combination between IBA and NAA was more effective than IBA or NAA alone, and the higher concentration was more effective than the lower concentration in the enhancement of rooting (number of primary and secondary roots, length of primary and secondary roots, diameter of primary and secondary roots, and fresh and dry weights of roots) and growth parameters (shoot length, number of branches, and number of leaves). Thus, the greatest rooting (90.0%) and establishment (76.58%) were obtained with IBA + NAA at 10 000 ppm.

Hammasselwe (2005) finds a number of grafting methods for the vegetative propagation of *Psidium guajava* in north Cameroon. Preliminary results showed that grafting and air layering were not practical at Kismatari. Terrestrial layering was the best technique for mass production of homogeneous plant material to supply research and farmers.

Kakoneti *et al.* (2005) studied the effect of variety and different nursery conditions on the survivability of air-layers of two varieties of guava. 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 (both layers in poly bag and layers *in situ*) 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 polybag. 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.

Kunal and Shyamal (2005) studied an improved technique, i.e. etiolation followed by treatment with plant growth regulators, was employed to enhance rooting and final survival of air layers. All growth regulator treatments enhanced rooting and survival of etiolated air layers compared with the untreated control. IBA at 3000 ppm recorded the highest values for mean number (14.80) and length

(11.30 cm) of primary roots per air layer, average number of secondary roots (10.72), percentage of success of air layers (93.34%) and survival of air layers (75.90%), while IBA at 4000 ppm recorded the highest value for diameter of roots (2.30 mm).

Chandrakaret *et al.* (2007) treated one-year-old shoots of guava cv. 'Lucknow-49' on ringed surface of shoots with IBA concentration (3000, 4000, 5000 and 6000 ppm) 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 at 5000 ppm and poultry manure combination was found to be second best for survival of air layering (73.25%)

Lal *et al.* (2007), reported that different concentration of IBA and NAA and its combination significantly increased the rooting percentage, average no. of roots per shoot, average root length (cm) per shoot and survival of rooted stooling shoots in field over control. The treatment IBA (7500ppm) give maximum rooting percentage (96.67%) average no. of roots per shoots (46.93%) average root length (8.45cm) and survival (75%) after transplanting in the field.

Singh *et al.* (2007) treated one year old shoots of guava cv. 'Lucknow-49' on ringed surface of shoots with IBA concentration of 3000, 4000, 5000 and 6000 ppm along with organic media i.e. poultry manure, vermi compost and farm yard 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%).

Jadhav (2009) showed early root initiation (17.33 days) and also recorded minimum number of days (25.66 days) for emerging bulk of roots. The significantly highest number of primary roots (14.00) and secondary roots (40.00) were recorded with treatment of sphagnum moss + IBA 5000 ppm (T). The treatment

combination sphagnum moss + IBA 5000 root length and fresh root weight, dry weight of root and showed maximum root length (7.5 cm), fresh root weight (0.73 g) and dry root weight (0.29 g) after 45th days. The maximum survival percentage of air layers in the nursery bed (73.33%) and in poly bag (100%) was observed in air layering with sphagnum moss + IBA 5000 ppm (T5) at 45th days. The significantly maximum number of leaves was recorded with sphagnum moss + IBA 5000ppm (Ts) in nursery bed condition (52.33 days) and in poly bags (46.66 days) at after 45th days.

Rymbai and Reddy (2010) studied the plantlets of different layering methods under open field nursery for their survival and growth characters. Layering methods used were air layering (at 15th June, 15th July and 15th August). The minimum record in all parameters were obtained in 15th June air layering method, except for maximum number of days (11.00) taken for sprouting. Among nursery conditions, Polyhouse 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.

Vilchez *et al.* (2011) evaluated the propagation by air layering of guava selections (AGROLUZ-14, AGROLUZ-18-42 AGROLUZ and AGROLUZ-43) tolerant to *Meloidogynespp.*, to measure the effect of naphthalene acid, to 5000 mg.L⁻¹, indole butyric acid at 4000 mg.L⁻¹ and a control without auxin. In a second experiment (EII), we evaluated the effect of the type of ringing: removal, scraping and strangulation of the cortex. The selection AGROLUZ-42 showed the higher rooting, with 53.3% and 80% survival (4 roots 1.96 cm long), without hormones.

Maurya *et al.* (2012) carried out an experiment on evaluation of different organic media and water holding materials with IBA on rooting and survival of air layering in guava (*Psidiumguajava L.*) cv. Allahabad Safeda The treatments comprised the combinations of media *i.e.* soil, organic media (Vermicompost/Poultry manure) and water holding materials (Sphagnum moss/Coco peat) in the ratio of 40:20:5 g along with various IBA levels (4000, 5000 and 6000 mg/l) and compared with soil alone (control). The air layers made with soil + poultry manure + sphagnum moss + 6000 mg/l IBA showed early root

initiation (16.33 days), highest number of primary roots (17.49), secondary roots (47.73), maximum root length (10.20 cm), fresh root weight (3.31 g) and dry root weight (0.68 g) as compared to control and rest of the treatments. It also recorded maximum survival percentage (90.67), length of shoots (7.93 cm) and number of leaves (18.33) at 60 days of air layers in the poly bag after transferring with highest economics (Net CBR 1:3.59).

Rymbaief *al.* (2012) conducted an experiment to study the effect of cocopeat 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 days after transplanting (DAT) and (13.08) at 60 DAT.

Singh and Pathak(2012),carried out an experiment with the objective to find out optimum concentration of IBA, NAA and their combination on air layering on Barbados cherry amongst various concentration of IBA, NAA and their combination IBA 1500ppm treatment provide best treatment in respect of % rooted air layers. No. of primary roots, no. of secondary roots, root quality and percent establishment.

Das and Prasad(2014),Reported that the effect of bio regulatures either alone or in combination on rooting percentage, survival percentage, rooting ability, growth and development of air layers in litchi. In this experiment it was found that IBA 5000ppm produced maximum rooting layers (90.00 %) in litchi cv. Purbi. IBA 5000ppm also proved better in survival percentage (86.66%) fresh weight of roots (4.37g) was found more in case of IBA 5000 treated layers followed by IBA 5000ppm +NAA (4.35g) and minimum (2.24g) under control. Dry weight of roots was found maximum (1.11g) by IBA 5000ppm +NAA 5000ppm treated layers, whereas, it was minimum (0.71g) in untreated layers. The diameter of primary roots was maximum (0.83mm) in untreated layer and minimum diameter of root

(0.57mm) was found in bio regulators (IBA 5000ppm) application, IBA 5000ppm +NAA 5000ppm (T₉) were found best in various parameters of root formation, root development quality and growth of layers in the nursery.

Baghel et al.(2016), reported IBA Concentrations and Time of Air-layering in Guava cv. L-49. The results indicated that IBA 10,000 ppm was found to be the most effective for better rooting and root parameters (days required for root initiation percentage of rooted air layer, no. of primary roots and secondary roots, length of primary and secondary root, fresh and dry weight of roots, and root volume), growth parameters (number of sprouts, length of sprouts, number of leaves, average leaf area, height of rooted air layer) as well as survival percentage. Among different months of air layering, August month recorded significantly higher values for rooted air layer, number of primary and secondary roots, length of primary and secondary root, fresh and dry weight of root and survival percentage. This study revealed that for realizing higher rooting and success of guava air layers under semi arid tropical ecosystem of Vidarbha region may be performed in the month of August and IBA treatment at the rate of 10,000 ppm

Manga et al. (2017), Effect of Month and IBA Concentration of Air Layering in Guava (*Psidium guajava* L.) cv. Sardar. Results revealed that minimum days for root initiation (84 days), maximum number of roots (12.10), higher rooting (33.33 %) and survival percentage (100.00 %) in layers prepared in the month August applied with IBA-4000 ppm. Growth of these layers was vigorous as depicted by maximum number of sprouts (8.25), number of leaves (22.64) and shoot length (59.00 cm) at 90 days after separation from mother plant layers placed under shade house for hardening. This was followed by layers treated with IBA-3000 ppm prepared in August month. While in control, there was poor response for root initiation, rooting percentage and number of roots than all treatments.

Mode of action of growth regulators

Research workers have tried to understand the mode of action of plant growth regulators from the time of their discovery in the rooting of plant propagation by layering and cuttings.

Skoog (1944) reported that when ratio of auxin to certain other plant constituents especially adenine is low the meristem section tend to form bud and

leaf primordia, when the ratio is medium callus is formed and when the auxin content is high, root primordia developed.

Gautheret (1996) stated that auxin naturally or artificially applied is a requirement for initiation of adventitious roots on stem and indeed it has been showed that the division of first root initial cell is dependent upon either applied or endogenous auxin.

Haising (1971) observed that root initials in stem, is apparently dependent upon the Native auxin in plant plus auxin synergist together these lead to synthesis of ribo-nucleic acid (RNA) which is involved initiation of the root primordia.

Devlin (1974) stated that action of auxin in root is similar to that in stem, but that the concentration of auxin to stem growth is inhibitory to root growth. In other words roots are much-more sensitive to auxin than stem and real stimulation of root elongation may be achieved if low concentration are used. The application of relatively high concentration of IBA to root not only retarded root elongation but a noticeable increase in number of branch roots also.

2.2 Economics

Reddy et al. (2014) reported that the treatments comprised the combinations of rooting media i.e. soil, organic media (Vermicompost/Poultry manure) and water holding materials (Sphagnum moss/Coco peat) in the ratio of 60:30:10 g along with various IBA levels (1000, 2000 and 3000 mgL⁻¹) and compared with soil alone (control). The air layers made with soil + poultry manure + sphagnum moss + 3000 mg L⁻¹ IBA showed early root initiation (8.73 days), minimum days required for bulk appearance of roots (20.80), highest number of primary roots (39.20 and 58.87), maximum secondary roots (155.93 and 250.73), maximum primary root length (16.53 and 17.48 cm), maximum secondary root length (2.36 and 3.37 cm) at 30 and 45 days, respectively. Maximum fresh weight of shoot biomass (34.10, 35.96 and 43.53 g), maximum fresh weight of root biomass (5.63, 6.63 and 7.73 g), maximum dry weight of shoot biomass (16.49, 24.91 and 30.88 g), maximum dry weight of root biomass (1.65, 2.13 and 2.81 g), maximum survival percentage of air layers (90.93, 88.53 and 83.46) and number of new leaves (4.60, 6.53 and 8.86) at 45, 60 and 75 days of air layers in the poly bag after planting, respectively with highest economics (Net CBR 1:3.34).

Rajput and Senjaliya (2015) reported that the treatment T₁₀ (0.2% boron + GA₃ 60ppm +NAA 150ppm + ethrel750ppm) was found best for physical parameters and treatment T₅ (0.2% boron +NAA 150 ppm) for yield point of view, while for quality point of view the treatment T₉ (0.2% boron + ethrel1000ppm) was found best. As far as the relative economics of the treatment is concerned, the maximum net realization of Rs. 1,72,807 per hectare with highest 1:6.6 cost benefit ratio (CBR) was obtained by the treatment T₅ (0.2% boron + NAA 150 ppm) as compared to other treatments. Therefore, the treatment T₅ (0.2% boron + NAA 150ppm) is best among all treatment for higher production.

Azad and Matin(2015) reported that the *Swieteniamacrophyllais* very important from ecological, economical, aesthetic point of view for Bangladesh and clonal propagation through branch cutting might be effective method for its conservation. We recommended that branch cutting with 0.4% IBA treatment may be applicable for this species.

Mali et al. (2015) reported net income. Although, the high density increases the cost of cultivation per hectare, the much higher yield from close spacing indicates that the added cost is economically feasible. Increased density from 1111 to 2500 plants/ha reduced the per quintal cost of cultivation at cost C from Rs.1696/–to Rs.541/– respectively. All these findings are in close agreement with those of Yadav (1978) and according to him close planting reduce the cost of production, produce the larger profit and increase the returns on investment. The maximum (1.84) Benefit: Cost ratio at cost C was observed in treatment M2S1 while minimum (0.54) Benefit: Cost ratio was observed in treatment M4S4. It confirmed the returns per rupee invest is the greatest from the closest planting.

Soni et al. (2015) studied that production of guava plants in net house condition proved to be the best for rapid and cheapest method for multiplication of guava true-to-type plants. Significant results were obtained when guava nursery produced by semi hard and hard wood cuttings after application of 3000 ppm IBA. The plants produced by this technique can be planted in high density plane. The technique was developed in this study is simpler, rapid, less labour intensive and economical, as root promoting hormones are required for root initiation. It is useful as compared to conventional method of propagation (grafting/budding) of guava because of higher success rate, independence of season and climate, small size of cuttings, use of juvenile shoot cuttings, disease free nature and production of large number of uniform true to mother type plants in a short period of time.

Chapter - III

MATERIALS AND METHODS

The present investigation deals with the “**Effects of different concentration of IBA and NAA on rooting and growth of air layers in guava.** (*Psidium guajava L.*) was conducted at the nursery area, Department of Horticulture, College of Agriculture, Gwalior during the year 2016-17. The material used and the techniques adopted for the study was considered as the most important ones. Therefore, the ensuing account has been prepared in the same light. A detailed account of the material employed and methods followed during the course of investigation is embodied in this chapter.

3.1 Location, climate and weather data

Gwalior is located at 26° 13' N latitude and 78° 14' E longitude and 208 meters above mean sea level. The climate of Gwalior is subtropical with hot and dry summers where maximum temperature exceeds 45° C in May and June. The winters are cool and minimum temperature reaches as low as 2° C in December and January; occurrence of frost is expected from the last week of December to the 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. The total of 467 mm rainfall was received during the experimental period. The mean weather parameters viz. temperature, relative humidity and rainfall during the experimental period were recorded as per metrological observatory, College of Agriculture, Gwalior. The relevant meteorological data during crop season are presented in Table 3.1 and depicted in Fig. 3.1.

Table 3.1 Meteorological data during crop season (2016-17)

Standard meteorological week	Date	Temperature (°C)		Humidity (%)		Rainfall (mm)
		Max.	Min.	Morn	Evening	
33	Aug.13-19	32.1	25.5	90.2	73.5	065.0
34	Aug 20-26	30.9	24.5	88.7	70.8	024.0
35	Aug –sep. 27-2	34.4	26.0	88.7	70.8	010.0
36	Sep. 3-9	33.4	25.6	74.1	57.7	001.0
37	Sep.10-16	34.6	25.9	78.4	55.2	000.0
38	Sep.17-23	35.0	24.8	89.0	61.0	0009.2
39	Sep.24-30	34.6	23.7	85.8	50.1	000.0
40	Oct.1-7	35.0	25.1	87.0	56.5	014.0
41	Oct.8-14	35.6	21.1	65.6	29.8	000.0
42	Oct.15-21	25.2	16.2	80.1	22.6	000.0
43	Oct.22-28	25.0	17.1	69.7	24.0	000.0
44	Oct-Nov. 29-4	32.1	13.5	92.1	29.4	000.0
45	Nov. 5-11	31.5	11.8	85.8	23.2	000.0
46	Nov. 12-18	30.9	10.3	87.8	28.0	000.0

Source: Meteorological Observatory, College of Agriculture, Gwalior

3.2 Experimental site

The experiment was conducted at nursery area, Department of Horticulture, College of Agriculture, Gwalior (M.P.) under Horticulture unit. The soil of the experimental field was sandy loam.

3.3 Details of experiment:

In the present investigation ten healthy branches were selected under each treatment and replicated four times to form the Asymmetrical Factorial Randomized

Block Design. The plan of layout is given in Figure 3.2 and other details are given below:

3.4 Details of layout:

Name of crop	:	Guava (<i>Psidiumguajava</i>)
Design	:	RBD
Number of Treatments	:	16
Number of layers per plant combination	:	30 (Each treatment combination)
Well be applied in all air layers Of a plant)		
Number of replications	:	04
Totalnumber of layers	:	1920
Date of operation of air layering	:	16 th - 17 th Augst
Time of detachment of air layers	:	after 65 days of operation

Details of treatment:

Notation of treatment:

(A) Different concentration of IBA:

- I_0 = control.
- I_1 = IBA @ 5,000ppm.
- I_2 = IBA @ 10,000ppm.
- I_3 = IBA @ 15,000ppm.

(B) Different concentration of NAA:

- N_0 = control.
- N_1 = NAA @ 5,000ppm.
- N_2 = NAA @ 10,000ppm.
- N_3 = NAA @ 15,000ppm.

1.5 Treatments Combination:

I_0N_0	I_0N_1	I_0N_2	I_0N_3
I_1N_0	I_1N_1	I_1N_2	I_1N_3
I_2N_0	I_2N_1	I_2N_2	I_2N_3
I_3N_0	I_3N_1	I_3N_2	I_3N_3

3.6 Selection of plants and their branches for making air-layers

For the experiment, 64 plants of guava of uniform vigour and size were selected and about 1 (1-2) years old healthy branches of pencil thickness were selected for air-layering. The length of branches was 45-60 cm and diameter 1 cm approximately, 30 air-layers under each treatment and 1920 under the whole experiment were operated.

3.7 Preparation of Mixture of Growth Regulators

In the present experiment growth regulators were prepared in talcum powder base. First of all IBA and NAA with 5,000 ppm strength was prepared. 0.5 gm of growth regulators was weighed on electrical balance and then dissolved in about 10.00 cc absolute alcohol. This solution was then thoroughly mixed with 99.5 gm of talcum powder, IBA and NAA with 10,000 ppm strength was prepared. 1 gm of growth regulators was weighed on electrical balance and then dissolved in about 10.00 cc absolute alcohol. This solution was then thoroughly mixed with 99 gm of talcum powder and IBA and NAA with 15,000 PPM strength was prepared. 1.5 gm of growth regulators was weighed on electrical balance and then dissolved in about 10.00cc absolute alcohol. The solution was then thoroughly mixed with 98.5 gm of talcum powder.

The details of different concentrations of hormones are given below:-

IBA 5,000 ppm : 0.5 gm IBA + 99.5 gm talcum powder.

NAA 5,000 ppm : 0.5 gm NAA + 99.5 gm talcum powder.

IBA 10,000 ppm : 1 gm IBA + 99 gm talcum powder.

NAA 10,000 ppm : 1 gm IAA + 99 gm talcum powder.

IBA 15,000 ppm : 1.5 gm IBA + 98.5 gm talcum powder.

NAA 15,000 ppm . : 1.5 gm IAA + 98.5 gm talcum powder.

After preparation, the powder was kept in broad mouthed bottles covered with black paper to protect it from light. Every time fresh powder was prepared

3.8 Colour of wrapper

White colour polythene wrapper was used at the time of operation.

3.9 Rooting media

For all treatment same rooting media were used which were prepared with
(1:1) SOIL+FYM

3.10 Method of preparing and treating of air-layers

After selection of branches, a ring of bark about 2 cm wide was removed carefully from the selected shoot of guava just below the bud without injuring the under wood. Previously prepared powder containing growth regulators was applied evenly on all sides of the upper cut of the ring. The cut portion was covered with rooting media and white polythene wrapper in all treatment combinations. All plants were operated on 16 - 17 August according to the treatment. Each treatment was replicated four times.

3.11 Detachment of air-layers

After 65 days from the date of operation, air-layers were detached by making a cut just below the lowest end of the ringed surface with sharp secateurs. The air-layers were brought under shade after detachment and their polythene covers were removed gently. Care was taken to ensure that the roots were not injured at the time of removing polythene wrapper. After this, rooted air-layers were planted in polythene bags containing mixture of soil + FYM + leaf mould (2:1:1).

3.12 Observations to be recorded

Five air-layers were selected from each replication i.e. twenty from each treatment for observation at the time of detachment of air-layers. After transplanting of successful air-layers, five plants under each replication of treatment were selected for further growth studies. All observations for growth studies were recorded at 50-60 days after preparation of air layers.

(a) Rooting Studies:

(i) Callus Formation (mm)

Observations on callusing of air-layers were recorded at the time of detachment after removing all primary roots, with the help of Vernier calipers.

(ii) Number of Longest (Primary) Roots per air-layer

Observations regarding the number of Longest (primary) roots were recorded by taking five ndom samples from each replication at the time of detachment of air-layers from mother plants.

(iii) Length of Longest (primary) roots (cm)

Average length of Longest (primary) roots was recorded with the help of scale at the time of detachment of air-layered twigs from the parent plant. The length of Longest (primary) roots was measured from base up to the tip and average length of Longest (primary) roots per air-layer was calculated from each treatment under each replication for this purpose.

(iv) Diameter of Longest (primary) roots (mm)

The diameter of Longest (primary) roots of air layers was measured with the help of screw gauge just after detachment of air-layers from the mother plant and average diameter of Longest (primary) roots per air-layer was calculated.

(v) Number of secondary roots per air-layer

Secondary roots were detached from the primary roots and their number was calculated as per procedure adopted with the primary roots.

(vi) Length of Secondary roots (cm)

Average length of Secondary roots of five random samples was recorded for each treatment under each replication with the help of scale and average length of secondary roots per air-layer was calculated.

(vii) Diameter of secondary roots (mm)

The diameter of secondary roots of air layers was measured with the help of screw gauge just after detachment of air-layers from the mother plant and average diameter of secondary roots per air-layer was calculated.

(viii) Fresh weight of roots / Air-layer (gm)

The fresh weight of root was recorded with the help of electric balance just after detachment of air layers and removal of roots average fresh weight /air-layer was calculated.

(ix) Success in rooting percentage (%)

The number of rooted air-layers were counted after detachment of air-layered twigs from the mother plants after sixty days of operation. The data were compiled and success in rooting percentage was calculated by the following formula:

$$\text{Success in rooting percentage} = \frac{\text{No. of rooted air layers}}{\text{Total no. of air layers}} \times 100$$

(b) Growth Studies

(1.) Number of leaves per layer:

The numbers of leaves were counted after 60 days of transplanting of successful air layers, five plants under each replication of treatment were selected then mean number of leaves per air layer was calculated.

(2.) Number of branches per layer

Observations on the number of new branches / sprouts were recorded after sixty days of planting of air-layered twigs in polythene bags. Five established plant were taken at random from each treatment under each replication.

(3.) Survival percentage after planting (%)

The air-layered branches were planted in the polythene bags. It was also observed whether these branches have been established in the polythene bags or not at fifteen days interval after 90 days of their planting. The data so obtained was recorded. The survival percentage of air-layers was calculated by the following formula.

$$\text{Survival percentage} = \frac{\text{Total number of established plant}}{\text{Total number of planted layered plant}} \times 100$$

3.13 Irrigation

Fifteen days interval of irrigation was given to the plants in the nursery, starting from the date of transplanting of air-layers regularly without delay.

3.14 Weeding

All weeding were done at 15 days after transplanting of air layers keeping care not to cause any injury to root system.

3.15 Statistical analysis:

For judging the effect of different treatments on shoot and root characters, the data of different character were recorded and statically analyzed using the method of analysis of variance as described by R. A. Fisher (1954).

The analysis of variance has been given in appendix and the skeleton of variance is presented in table given below:

Table 3.2: Skeleton of ANOVA for the design of experiment

S.V	df	SS	MS	Fcal	Ftab
Replication	3	SSR	$MSR = \frac{SSR}{3}$		
IBA concentration(I)	3	SSI	$MSI = \frac{SSI}{3}$	$\frac{MSI}{MSE}$	F(3,45)
NAA concentration(N)	3	SSN	$MSN = \frac{SSN}{3}$	$\frac{MSN}{MSE}$	F(3,45)
I x N	9	SS(I x N)	$MS(IxN) = \frac{SS(IxN)}{9}$	$\frac{MS(IxN)}{MSE}$	F(9,45)
ERROR	45	SSE	$MSE = \frac{SSE}{45}$		
TOTAL	63				

Where,

SSR = Sum of square due to replication

SSI = Sum of square due to IBA concentration

SSN = Sum of square due to NAA concentration

SS IxN = Sum of square due to I x N

SSE = Sum of square due to error

CD = Critical difference

Chapter-IV

RESULTS

In this chapter an endeavour has been made to elicit the influence of various treatments of plant growth regulators IBA, and NAA and their combination on success percent of air-layers, callus formation, number of primary and secondary roots, length of primary and secondary roots, diameter of primary and secondary roots, fresh weight of roots per air-layer and growth studies viz., survival percentage, number of branches per plant, number of leaves per layer and Various observations recorded on the crop were processed statistically to assess the degree of variance due to various treatments. The pattern of crop behavior under various treatments is illustrated by using tables and substantiated with suitable figures incorporated at appropriate places.

4.1 Root character studies

4.1.1 Callus formation

Callus formation in the air-layers is the first apparent symptom of root formation process in auxin adenine balance. Growth regulators especially auxin help in the fast healing of wound caused by development of callus cells and ultimately roots.

In the present investigation, observations were recorded with the help of vernier calipers on the callus formation in air-layers under each treatment by taking random sample. The data pertaining to callusing were recorded and statistically analyzed. The results are presented in Table 4.1, and graphically depicted in Fig.4.1 perusal of the analysis of variance (appendix I) clearly shows that different concentrations of IBA, NAA and their combinations had significant effect on the callusing.

Observation data on callusing had been affected by different concentrations of IBA, which significantly increased the callusing over the control. IBA₃ (IBA 15,000 ppm) showed maximum callusing (5.74mm) followed by (5.22 mm) in I₂ (10,000 ppm IBA), and (4.21 mm) in I₁ (5,000 ppm IBA) and was significantly better than all the other treatments as well as control (I₀) with minimum callusing of 4.09 mm.

In case of effect of NAA, it was seen that the maximum callusing (5.35 mm) was observed in N₃ (15,000 ppm NAA), followed by (5.19 mm) in N₂ (10,000 ppm NAA) and (4.62 mm) in N₁ (5,000 ppm NAA) and was significantly better than all the other treatments as well as control (N₀) with minimum callusing of 4.11 mm.

The interaction of IBA and NAA was also found significant which indicate that, the maximum callusing (6.06 mm) were observed in I₃N₃(15,000 ppm IBA + 15,000 ppm NAA) followed by (5.85 mm) in I₃N₂(15,000 ppm IBA + 10,000 ppm NAA) While, the minimum callus formation (2.30 mm) were observed under I₀N₀ (Control).

Table: 4.1 Effect of different concentration of IBA, NAA and their combination on callus formation of air-layers

Treatment	Callusing (mm)				Mean
	I ₀	I ₁	I ₂	I ₃	
N₀	2.30	3.80	4.97	5.36	4.11
N₁	3.50	4.19	5.13	5.69	4.62
N₂	5.27	4.36	5.28	5.85	5.19
N₃	5.32	4.50	5.51	6.06	5.35
Mean	4.09	4.21	5.22	5.74	

	I	N	I*N
SE(m)±	0.035	0.035	0.071
CD(5%)	0.101	0.101	0.202

4.1.2. Number of Longest root/air-layer:

Initiation of main roots and their number are important characters of air-layers as they affect the rooting growth, survival percent and growth of air-layers. In the present experiment Initiation of main roots and their number formed were recorded at 65 days after preparation.

The data pertaining to number of Longest roots/ air-layer were recorded and statistically analyzed. The results are presented in Table 4.2, and graphically depicted in Fig.4.2 and Perusal of the analysis of variance (appendix II) clearly shows that different concentrations of IBA, NAA and their combinations had significant effect on the number of primary roots/ air-layer.

Observation data on number of Longest roots/ air-layer had been affected by different concentrations of IBA, which significantly increased the number of Longest roots/ air-layer over the control. I₃ (IBA 15,000 ppm) recorded maximum number of Longest roots/ air-layer (9.84) followed by (8.78) in I₂ (10,000 ppm IBA) and (7.92) in I₁ (5,000 ppm IBA) and was significantly better than all the other treatments as well as control (I₀) with minimum number of Longest roots 7.25.

In case of effect of NAA, it was seen that the maximum number of Longest roots/ air-layer (12.21) was observed in N₃ (15,000 ppm NAA) followed by (12.19)

in N_2 (10,000 ppm NAA) and (11.41) in N_1 (5,000 ppm NAA) and was significantly better than all the other treatments as well as control (N_0) with minimum number of Longest roots 9.78.

The interaction of IBA and NAA indicate that, the maximum number of Longest roots/ air-layer (10.00) were observed in I_3N_3 (15,000 ppm IBA + 15,000 ppm NAA) followed by (10.13) in I_3N_2 (15,000 ppm IBA + 10,000 ppm NAA) While, the minimum number of Longest roots/ air-layer (5.88) were observed under I_0N_0 (Control).

Table: 4.2 Effect of different concentration of IBA, NAA and their combination on number of Longest roots/ air-layer

Treatment	Number of Longest roots/ air-layer				Mean
	I_0	I_1	I_2	I_3	
N_0	5.88	5.75	8.50	9.50	7.41
N_1	7.25	7.68	8.25	9.75	8.23
N_2	7.75	8.75	9.00	10.13	8.91
N_3	8.13	9.50	9.38	10.00	9.25
Mean	7.25	7.92	8.78	9.84	

	I	N	I*N
SE(m)_±	0.112	0.112	0.224
CD(5%)	0.319	0.319	0.639

4.1.3 Length of Longest roots:

The length of Longest roots is an important factor from growth point of view. The observations recorded after 65 days after layering preparation. The data pertaining to length of Longest roots/ air-layer were recorded and statistically analyzed. The results are presented in Table 4.3, and graphically depicted in Fig. 4.3, Perusal of the analysis of variance (appendix III) clearly shows that different concentrations of IBA, NAA and their combinations had significant effect on the length of Longest y roots/ air-layer.

Observation data on length of Longest roots had been affected by different concentrations of IBA, which significantly increased the length of Longest roots over the control. I_3 (IBA 15,000 ppm) shows maximum length of Longest roots (4.92 cm) followed by (4.59 cm) in I_2 (10,000 ppm IBA) and (3.29 cm) in I_1 (5,000 ppm IBA) and was significantly better than all the other treatments as well as control (I_0) with minimum length of Longest roots 2.54 cm.

In case of effect of NAA, it was seen that the maximum length of Longest roots (4.27cm) was observed in N_3 (15,000 ppm NAA) followed by (4.06 cm) in

N_2 (10,000 ppm NAA)and (3.72 cm) in N_1 (5,000 ppm NAA)and was significantly better than all the other treatments as well as control (N_0)with minimum length of Longest roots 3.28 cm.

The interaction of IBA and NAA indicate that, the maximum length of Longest roots (5.34 cm) were observed in I_3N_3 (15,000 ppm IBA + 15,000 ppm NAA) followed by (5.10 cm) in I_3N_2 (15,000 ppm IBA + 10,000 ppm NAA) While, the minimum length of Longest roots (1.86 cm) were observed under I_0N_0 (Control).

Table: 4.3 Effect of different concentration of IBA, NAA and their combination on length of Longest roots

Treatment	Length of Longest roots (cm)				Mean
	I_0	I_1	I_2	I_3	
N_0	1.86	2.74	3.96	4.58	3.28
N_1	2.47	3.21	4.55	4.64	3.72
N_2	2.86	3.40	4.90	5.10	4.06
N_3	2.98	3.82	4.94	5.34	4.27
Mean	2.54	3.29	4.59	4.92	

	I	N	I*N
SE(m)±	0.038	0.038	0.076
CD(5%)	0.108	0.108	0.217

4.1.4 Diameter of Longest roots:

The number of Longest roots and length of Longest roots are also of great importance. The data pertaining to diameter of Longest roots/ air-layer were recorded and statistically analyzed. The results are presented in Table 4.4 and graphically depicted in Fig. 4.4, Perusal of the analysis of variance (appendix IV) clearly shows that different concentrations of IBA, NAA and their combinations had significant effect on the diameter of Longest roots/ air-layer.

Observation data on diameter of Longest roots had been affected by different concentrations of IBA, which significantly increased the diameter of Longest roots over the control. I_3 (IBA 15,000 ppm) shows maximum diameter of Longest roots (1.98 mm) followed by (1.85 mm) in I_2 (10,000 ppm IBA) and (1.64 mm) in I_1 (5,000 ppm IBA) and was significantly better than all the other treatments as well as control (I_0) with minimum diameter of Longest roots 1.13mm.

In case of effect of NAA, it was seen that the maximum diameter of Longest roots (1.87 mm) was observed in N₃ (15,000 ppm NAA) followed by (1.79 mm) in N₂(10,000 ppm NAA)and (1.62 mm) in N₁(5,000 ppm NAA) and was significantly better than all the other treatments as well as control (N₀) with minimum diameter of Longest roots 1.32mm.

The interaction of IBA and NAA indicate that, the maximum diameter of Longest roots (2.09 mm) were observed in I₃N₃ (15,000 ppm IBA + 15,000 ppm NAA) followed by (2.02 mm) in I₃N₂ (15,000 ppm IBA + 10,000 ppm NAA) While, the minimum diameter of Longest roots (0.38 mm) were observed under I₀N₀ (Control).

Table: 4.4 Effect of different concentration of IBA, NAA and their combination on diameter of Longest roots

Treatment	Diameter of Longest roots (mm)				Mean
	I ₀	I ₁	I ₂	I ₃	
N₀	0.38	1.42	1.66	1.83	1.32
N₁	1.16	1.61	1.71	2.00	1.62
N₂	1.44	1.75	1.96	2.02	1.79
N₃	1.56	1.79	2.07	2.09	1.87
Mean	1.13	1.64	1.85	1.98	

	I	N	I*N
SE(m)±	0.036	0.036	0.072
CD(5%)	0.103	0.103	0.207

4.1.5 Number of secondary roots / layer:

The formation of secondary roots is an important factor for uptake of water and nutrients from the soil and successful establishment of plant. Average number of secondary roots per air-layer was recorded after 65 days i.e. at the time of detachment of layers.

The data pertaining to number of secondary roots/air-layer were recorded and statistically analyzed. The results are presented in Table 4.5and graphically depicted in Fig. 4.5 Perusal of the analysis of variance (appendix V) clearly shows that different concentrations IBA, NAA and their combination had significant effect on the number of secondary roots/ air-layer.

Observation data on number of secondary roots per air-layer had been affected by different concentrations of IBA, which significantly increased the

number of secondary roots per air-layer over the control. IBA₃ (IBA 15,000 ppm) shows maximum number of secondary roots per air-layer (14.56) followed by (12.56) in I₂ (10,000 ppm IBA) and (11.89) in I₁ (5,000 ppm IBA) and was significantly better than all the other treatments as well as control (I₀) with minimum number of secondary roots 12.09.

In case of effect of NAA, it was seen that the maximum number of secondary roots per air-layer (14.25) was observed in N₃ (15,000 ppm NAA) followed by (13.44) in N₂(10,000 ppm NAA) and (12.58) in N₁ (5,000 ppm NAA) andn was significantly better than all the other treatments as well as control (N₀)with minimum number of secondary roots 10.84..

The interaction of IBA and NAA indicate that, the maximum number of secondary roots per air-layer (15.50) were observed in I₃N₃(15,000 ppm IBA + 15,000 ppm NAA) followed by (14.63) in I₃N₂ (15,000 ppm IBA + 10,000 ppm NAA) While, the minimum number of secondary roots per air-layer (8.50) were observed under I₀N₀ (Control).

Table: 4.5 Effect of different concentration of IBA, NAA and their combination on number of secondary roots

Treatment	Number of secondary roots				Mean
	I ₀	I ₁	I ₂	I ₃	
N₀	8.50	8.75	12.25	13.88	10.84
N₁	12.25	11.80	12.00	14.25	12.58
N₂	13.13	13.00	13.00	14.63	13.44
N₃	14.50	14.00	13.00	15.50	14.25
Mean	12.09	11.89	12.56	14.56	

	I	N	I*N
SE(m)±	0.158	0.158	0.316
CD(5%)	0.450	0.450	0.900

4.1.6 Length of secondary roots:

Length of secondary roots is also an important factor from growth point of view. Therefore, observations in this regard were recorded at 65 days after preparation of air layers. The data pertaining length of secondary roots were recorded and statistically analyzed. The results are presented in Table 4.6 and graphically depicted in Fig. 4.6 Perusal of the analysis of variance (appendix VI) clearly shows that different concentrations of IBA, NAA and their combinations had significant effect on the length of secondary roots.

Observation data on length of secondary roots had been affected by different concentrations of IBA, which significantly increased the length of secondary roots over the control. IBA I₃ (IBA 15,000 ppm) shows maximum length of secondary roots (1.64 cm) followed by (1.47 cm) in I₂ (10,000 ppm IBA) and (1.22 cm) in I₁ (5,000 ppm IBA) and was significantly better than all the other treatments as well as control (I₀) with minimum length of secondary roots 0.93.

In case of effect of NAA, it was seen that the maximum length of secondary roots (1.72 cm) was observed in N₃ (15,000 ppm) followed by (1.59 cm) in N₂ (10,000 ppm, NAA) and (1.11 cm) in N₁ (5,000 ppm NAA) and was significantly better than all the other treatments as well as control (N₀) with minimum length of secondary roots 0.83.

The interaction of IBA and NAA indicate that, the maximum length of secondary roots (1.97 cm) were observed in I₃N₃ (15,000 ppm IBA + 15,000 ppm NAA) followed by (1.94 cm) in I₃N₂ (15,000 ppm IBA + 10,000 ppm NAA) While, the minimum length of secondary roots (0.44 cm) were observed under N₀I₀ (Control).

Table: 4.6 Effect of different concentration of IBA, NAA and their combination on length of secondary roots

Treatment	Length of secondary roots (cm)				Mean
	I ₀	I ₁	I ₂	I ₃	
N₀	0.44	0.76	1.04	1.08	0.83
N₁	0.69	0.85	1.33	1.57	1.11
N₂	1.26	1.53	1.65	1.94	1.59
N₃	1.33	1.75	1.84	1.97	1.72
Mean	0.93	1.22	1.47	1.64	

	I	N	I*N
SE(m)±	0.011	0.011	0.022
CD(5%)	0.031	0.031	0.062

4.1.7 Diameter of secondary roots:

The data pertaining diameter of secondary roots were recorded and statistically analyzed. The results are presented in Table 4.7 and graphically depicted in Fig. 4.7. Perusal of the analysis of variance (appendix VII) clearly shows that different concentrations of IBA, NAA and their combinations had significant effect on the diameter of secondary roots.

Observation data on diameter of secondary roots had been affected by different concentrations of IBA, which significantly increased the diameter of secondary roots over the control. IBA₃ (IBA 15,000 ppm) shows maximum diameter of secondary roots (1.61 mm) followed by (1.45 mm) in I₂ (10,000 ppm IBA) and (1.31 mm) in I₁ (5,000 ppm IBA) and was significantly better than all the other treatments as well as control (I₀) with minimum diameter of secondary roots 0.86.

In case of effect of NAA, it was seen that the maximum diameter of secondary roots (1.52 mm) was observed in N₃ (15,000 ppm NAA) followed by (1.43 mm) in N₂ (10,000 ppm NAA) and (1.31 mm) in N₁ (5,000 ppm NAA) and was significantly better than all the other treatments as well as control (N₀) with minimum diameter of secondary roots 0.98.

The interaction of IBA and NAA indicate that, the maximum diameter of secondary roots (1.84 mm) were observed in I₃N₃ (15,000 ppm IBA + 15,000 ppm NAA) observed (1.73 mm) in I₃N₂ (15,000 ppm IBA + 10,000 ppm NAA) While, the minimum diameter of secondary roots (0.50 mm) were observed under I₀N₀ (Control).

Table: 4.7 Effect of different concentration of IBA, NAA and their combination on diameter of secondary roots

Treatment	Diameter of secondary roots(mm)				Mean
	I ₀	I ₁	I ₂	I ₃	
N₀	0.50	1.05	1.11	1.25	0.98
N₁	0.85	1.29	1.45	1.65	1.31
N₂	1.01	1.40	1.56	1.73	1.43
N₃	1.09	1.51	1.67	1.84	1.52
Mean	0.86	1.31	1.45	1.61	

	I	N	I*N
SE(m)±	0.007	0.007	0.014
CD(5%)	0.020	0.020	0.040

4.1.8 Fresh weight of roots/ air-layer:

Fresh weight of roots is an important factor for survival of layers. Survival of layers depends upon the total underground biomass i.e. roots. The data pertaining fresh weight of roots/air-layers were recorded and statistically analyzed. The results are presented in Table 4.8 and graphically depicted in Fig. 4.8 Perusal of the analysis of variance (appendix VIII) clearly shows that different concentration

of IBA, and NAA had significant effect on the fresh weight of roots/air-layers. However, their combinations had non significant effect on the fresh weight of roots/air-layers.

Observation data on fresh weight of roots/air-layers had been affected by different concentrations of IBA, which significantly increased the fresh weight of roots/air-layers over the control. IBA₃ (IBA 15,000 ppm) shows maximum fresh weight of roots/air-layers (1.29 g) followed by (1.24 g) in I₂ (10,000 ppm IBA) and (1.20 g) in I₁ (5,000 ppm IBA) and was significantly better than all the other treatments as well as control (I₀) with minimum fresh weight of roots 1.15 g.

In case of effect of NAA, it was seen that the maximum fresh weight of roots/air-layers (1.29 g) was observed in N₃ (15,000 ppm NAA) followed by (1.25 g) in N₂ (10,000 ppm NAA) and (1.19 g) in N₁ (5,000 ppm NAA) and was significantly better than all the other treatments as well as control (N₀) with minimum fresh weight of roots 1.15 g.

The interaction of IBA and NAA indicate that, the maximum fresh weight of roots/air-layers (1.35 g) were observed in I₃N₃ (15,000 ppm IBA + 15,000 ppm NAA) followed by (1.32 g) in I₃N₂ (15,000 ppm IBA + 15,000 ppm NAA) While, the minimum fresh weight of roots/air-layers (1.06 g) were observed under I₀N₀ (Control).

Table: 4.8 Effect of different concentration of IBA and NAA on fresh weight of roots/air-layers

Treatment	Fresh weight of roots/air-layers (gm)				Mean
	I ₀	I ₁	I ₂	I ₃	
N ₀	1.06	1.14	1.17	1.23	1.15
N ₁	1.11	1.16	1.24	1.25	1.19
N ₂	1.19	1.23	1.27	1.32	1.25
N ₃	1.23	1.26	1.30	1.35	1.29
Mean	1.15	1.20	1.24	1.29	

	I	N	I*N
SE(m) _±	0.016	0.016	0.033
CD(5%)	0.047	0.047	NS

4.1.9 Success in rooting percentage:

Commercial adoption of any propagation practice depends upon the rooting percentage success with the technique used. In the present experiment, the success was recorded in percentage on the basis of air-layers rooted under each treatment up to the time of detachment i.e. 65 days after operation. The data

pertaining rooting percentage were recorded and statistically analyzed. The results are presented in Table 4.9 and graphically depicted in Fig. 4.9. Perusal of the analysis of variance (appendix IX) clearly shows that different concentrations of IBA and NAA had significant effect on the rooting percentage. However, their combinations had non-significant effect on the rooting percentage.

Observation data on rooting percentage had been affected by different concentrations of IBA, which significantly increased the rooting percentage over the control. IBA₃ (IBA 15,000 ppm) shows maximum rooting percentage (52.08%) followed by (43.56%) in I₂ (10,000 ppm IBA) and (40.20%) in I₁ (5,000 ppm IBA) and was significantly better than all the other treatments as well as control (I₀) with minimum success in rooting percentage 38.33%.

In case of effect of NAA, it was seen that the maximum rooting percentage (47.73%) was observed in N₃ (15,000 ppm NAA) followed by (45.21%) in N₂ (10,000 ppm NAA) and (41.87%) in N₁ (5,000 ppm NAA) and was significantly better than all the other treatments as well as control (N₀) with minimum success in rooting percentage 39.37%.

The interaction of IBA and NAA indicate that, the maximum success rooting percentage (57.50%) were observed in I₃N₃ (15,000 ppm IBA + 15,000 ppm NAA) were observed (53.33%) in I₃N₂ (15,000 ppm IBA + 10,000 ppm NAA) While, the minimum rooting percentage (31.66%) were observed under I₀N₀ (Control).

Table: 4.9 Effect of different concentration of IBA, NAA and their on success in rooting percentage

Treatment	Success in rooting percentage (%)				Mean
	I ₀	I ₁	I ₂	I ₃	
N₀	31.66	37.50	41.66	46.66	39.37
N₁	35.83	39.16	41.66	50.83	41.87
N₂	40.83	41.66	45.00	53.33	45.21
N₃	45.00	42.50	45.91	57.50	47.73
Mean	38.33	40.20	43.56	52.08	

	I	N	I*N
SE(m)₊	0.816	0.816	1.632
CD(5%)	2.326	2.326	NS

4.2 Growth Studies:

After detachment and planting of layers, observations on the survival percentage, number of branches, number of leaves per layer were recorded to study the subsequent effect of treatments on the root and shoot development.

4.2.1. Number of leaves per layer:

The data pertaining to number of leaves/air-layers were recorded and statistically analyzed. The results are presented in Table 4.12 and graphically depicted in Fig.4.12. Perusal of the analysis of variance (appendix X) clearly shows that different concentrations of IBA and NAA had significant effect on the number of leaves/air-layers. However, their combinations had non-significant effect on the number of leaves/air-layers.

Observation data on number of leaves per layer had been affected by different concentrations of IBA, which significantly increased the number of leaves per layer over the control. IBA₃ (IBA 15,000 ppm) shows maximum number of leaves per layer (14.00) followed by (12.69) in I₂ (10,000 ppm IBA) and (11.93) in I₁ (5,000 ppm IBA) and was significantly better than all the other treatments as well as control (I₀) with minimum no. of leaves/air layer 10.54.

In case of effect of NAA, it was seen that the maximum number of leaves per layer (13.72) was observed in N₃ (15,000 ppm NAA) followed by (12.90) in N₂ (10,000 ppm NAA) and (11.88) in N₁ (5,000 ppm NAA) and was significantly better than all the other treatments as well as control (N₀) with minimum no. of leaves/air layer 10.66.

The interaction of IBA and NAA indicate that, the maximum number of leaves per layer (15.25) were observed in I₃N₃ (15,000 ppm IBA + 15,000 ppm NAA) were observed (14.53) in I₃N₂ (15,000 ppm IBA + 10,000 ppm NAA) While, the minimum number of leaves per layer (8.35) were observed under I₀N₀ (Control).

Table:4.10. Effect of different concentration of IBA and NAA on number of leaves per layer

Treatment	Number of leaves per layer				Mean
	I ₀	I ₁	I ₂	I ₃	
N₀	8.35	10.59	11.40	12.32	10.66
N₁	10.16	11.29	12.14	13.92	11.88
N₂	11.31	12.35	13.43	14.53	12.90
N₃	12.33	13.49	13.80	15.25	13.72
Mean	10.54	11.93	12.69	14.00	

	I	N	I*N
SE(m)₊	0.156	0.156	0.312
CD(5%)	0.445	0.445	NS

4.2.2 Number of branches per layer:

The data pertaining to number of branches/air-layer were recorded and statistically analyzed. The results are presented in Table 4.11 and graphically depicted in Fig.4.11. Perusal of the analysis of variance (appendix XI) clearly shows that different concentrations of IBA, NAA and their combinations had significant effect on the number of branches/air-layer.

Observation data on number of branches/air-layers had been affected by different concentrations of IBA, which significantly increased the number of branches/air-layers over the control. IBA₃ (IBA 15,000 ppm) shows maximum number of branches/air-layers (5.00) followed by (4.34) in I₂ (10,000 ppm IBA) and (4.05) in I₁ (5,000 ppm IBA) and was significantly better than all the other treatments as well as control (I₀) with minimum no. of branches/air layer 3.06.

In case of effect of NAA, it was seen that the maximum number of branches/air-layers (4.64) was observed in N₃ (15,000 ppm NAA) followed by (4.36) in N₂ (10,000 ppm NAA) and (4.06) in N₁ (5,000 ppm NAA) and was significantly better than all the other treatments as well as control (N₀) with minimum no. of branches/air layer 3.39.

The interaction of IBA and NAA indicate that, the maximum number of branches/air-layers (5.50) were observed in I₃N₃ (15,000 ppm IBA + 15,000 ppm NAA) followed by (5.08) in I₃N₂ (15,000 ppm IBA + 10,000 ppm NAA) While, the minimum number of branches/air-layers (2.03) were observed under I₀N₀ (Control).

Table: 4.11. Effect of different concentration of IBA and NAA on number of branches/air-layers

Treatment	Number of branches/air-layers				Mean
	I ₀	I ₁	I ₂	I ₃	
N ₀	2.03	3.27	3.74	4.54	3.39
N ₁	3.11	3.97	4.27	4.87	4.06
N ₂	3.58	4.31	4.48	5.08	4.36
N ₃	3.53	4.65	4.89	5.50	4.64
Mean	3.06	4.05	4.34	5.00	

	I	N	I*N
SE(m) _±	0.053	0.053	0.107
CD(5%)	0.152	0.152	0.304

4.2.3 Survival percentage after planting:

The data pertaining to survival percentage were recorded and statistically analyzed. The results are presented in Table 4.10 and graphically depicted in Fig.4.10. Perusal of the analysis of variance (appendix XII) clearly shows that different concentrations of IBA, NAA and their combinations had significant effect on the survival percentage of air-layers of guava.

Observation data on survival percentage had been affected by different concentrations of IBA, which significantly increased the survival percentage over the control. IBA₃ (IBA 15,000 ppm) shows maximum survival percentage (47.50%) followed by (39.16%) in I₂ (10,000 ppm IBA) and (36.04%) in I₁ (5,000 ppm IBA) and was significantly better than all the other treatments as well as control (I₀) with minimum survival percentage of 34.16%.

In case of effect of NAA, it was seen that the maximum survival percentage (43.12%) was observed in N₃ (15,000 ppm NAA) followed by (40.83%) in N₂ (10,000 ppm NAA) and (37.71%) in N₁ (5,000 ppm NAA) and was significantly better than all the other treatments as well as control (N₀) with minimum survival percentage of 35.21%.

The interaction of IBA and NAA indicate that, the maximum survival percentage (51.66%) were observed in I₃N₃ (15,000 ppm IBA + 15,000 ppm NAA) followed by (48.33%) in I₃N₂ (15,000 ppm IBA + 10,000 ppm NAA) While, the minimum survival percentage (28.33%) were observed under I₀N₀ (Control).

Table: 4.12. Effect of different concentration of IBA and NAA on survival percentage

Treatment	Survival percentage (%)				Mean
	I ₀	I ₁	I ₂	I ₃	
N ₀	28.33	34.17	35.83	42.50	35.21
N ₁	30.83	34.16	38.33	47.50	37.71
N ₂	36.66	37.50	40.83	48.33	40.83
N ₃	40.83	38.33	41.67	51.66	43.12
Mean	34.16	36.04	39.16	47.50	

	I	N	I*N
SE(m)_±	0.948	0.948	1.896
CD(5%)	2.701	2.701	5.402

Table 4.3.1. Net profit and benefit cost ratio:

The economics of different treatment is usually a deciding factor for its adoption by the farmers for commercial crop production. It is therefore, of wide interest to calculate the economic effect of various treatments on rooting and survival of guava air layers.

Treatment I₃N₃ secured that highest gross profit, net return along with BCR (Rs 25830, Rs 20368.70 and BCR 1:4.72 treatment respectably) followed by I₃N₂ (Rs 24165, Rs 18705.20 and BCR 1:4.42 treatment respectably) and I₃N₁ (Rs 23750, Rs 18291.70 and BCR 1:4.35 treatment respectably).

Table:4.13. Calculation of economics: Net return Rs. Per 1000 air layers

S.NO.	Treatment	Survival of air layers	Gross income (Rs.)	Total cost (Rs.)	Net return (Rs.)	B:C Ratio
1	I ₀ N ₀	283.3	14165	5450	8715	1:2.59
2	I ₀ N ₁	308.3	15415	5451.50	9963.5	1:2.82
3	I ₀ N ₂	366.6	18330	5453.00	12877	1:3.36
4	I ₀ N ₃	408.3	20415	5454.50	14960.50	1:3.74
5	I ₁ N ₀	341.7	17085	5454.31	11630.69	1:3.13
6	I ₁ N ₁	341.6	17080	5455.81	11624.19	1:3.13
7	I ₁ N ₂	375	18750	5457.31	13292.69	1:3.43
8	I ₁ N ₃	383.3	19165	5458.81	13706.19	1:3.51
9	I ₂ N ₀	358.3	17915	5455.22	12459.78	1:3.28
10	I ₂ N ₁	383.3	19165	5456.72	13708.28	1:3.51
11	I ₂ N ₂	408.3	20415	5458.22	14956.78	1:3.74
12	I ₂ N ₃	416.7	20835	5459.72	15375.28	1:3.81
13	I ₃ N ₀	425	21250	5456.80	15793.20	1:3.89
14	I ₃ N ₁	475	23750	5458.30	18291.70	1:4.35
15	I ₃ N ₂	483.3	24165	5459.80	18705.20	1:4.42
16	I ₃ N ₃	516.6	25830	5461.30	20368.70	1:4.72

Chapter- V

DISCUSSION

In this chapter, an attempt has been made to elucidate the possible reasons of the variability obtained due to treatment differences in the present investigation entitled “**Effects of different concentration of IBA and NAA on rooting and growth of air layering in guava (*Psidium guajava*L.)**” On the basis of findings described in the preceding chapter, the results have been discussed here critically in the following lines in the light of literature pertaining to the findings of other workers for different characters.

In the present trial, different concentration of IBA viz. $I_0 = 0$ ppm IBA (Only talcum Powder), $I_1 = 5,000$ ppm IBA, $I_2 = 10,000$ ppm IBA, $I_3 = 15,000$ ppm IBA and NAA viz. $N_0 = 0$ ppm NAA (Only talcum powder), $N_1 = 5,000$ ppm NAA, $N_2 = 10,000$ ppm NAA, $N_3 = 15,000$ ppm NAA were tried to study their individual and combined effect on the rooting growth of air layers in guava.

5.1 Effect of IBA:

Since the discovery of IBA various workers have used them to initiate roots in air layers or cuttings of different fruit trees with varying degree of success. In this trial, IBA had significantly affected the various root characters viz. callus formation, number of primary roots/ air-layer, length of primary roots, diameter of primary roots, fresh weight of roots/air layer, number of secondary roots / layer, length of secondary roots, diameter of secondary roots, and success in rooting percentage. Various growth characters viz., , number of leaves per layer, number of branches per layer, survival percentage after planting.

In case of IBA treated layers, all these root and growth characters increased with increase in concentration and attained the highest magnitude at IBA 15000ppm (I_3). As a result, the maximum values of these characters, i.e., callus formation (5.74 mm), number of primary roots/ air-layer (14.94), length of primary roots (4.98 cm), diameter of primary roots (2.03 mm), number of secondary roots / layer (12.02), length of secondary roots (1.64 cm), diameter of secondary roots (1.61 mm), fresh weight of roots/ air-layer (1.29 gm) and rooting percentage (52.08%). Various growth characters viz. survival percentage after planting (47.50%), number of branches per layer (5.00) and number of leaves per layer (14.00) were annexed with IBA 15000 ppm. Response of other concentration

of IBA was also increased. A number of workers had also reported that application of IBA at different concentrations was best for rooting.

During the process of rooting, callusing occurs first and root primordial forms afterwards. For prompt callusing, proper concentration of carbohydrates in the branches used for air layering is essential. Layering is usually done during rainy season because synthesized food material including carbohydrates gets accumulated in the plants and it encourages quick healing and better callusing. Further during the process of rooting application of exogenous auxin also helps to a greater extent. IBA at higher concentration (15000 ppm) gave better result than at lower concentrations or under control and there appeared to be an increasing tendency of rooting with an increasing concentration, this might be at higher concentration of IBA the quantity of auxin reaching the cambial activity may be adequate for initiating root primordia, so the highest performance was seen at higher concentrations of IBA. Indicating the possibility of better success with employing higher concentrations of IBA (Bhagat *et al.*, 1999). The maximum number of longest and secondary roots might be due to hormonal effect leading to accumulation of internal substances and their downward movement. Regarding the number of secondary roots might be due to more cell division. The maximum mean length of longest roots, suggesting that higher concentration of IBA stimulated faster growth of roots resulting in maximum length as reported by Tyagi and Patel, 2004. The highest roots weight may be attributed to the fact that external application of auxin generally stimulates the movement of natural auxin and other materials in downward direction from the leaves and shoot tips, which accumulate at the incision made on the shoot resulting in the formation of roots with higher root fresh and dry weight.

5.2 Effect of NAA:

In case of NAA treated layers, all the root and growth characters increased with different treatments as compared to control. NAA attained the highest magnitude at N₃(15,000 ppm NAA) followed by N₂(10,000 ppm NAA). As a result, the maximum values of these characters, i.e., callus formation (5.35 mm), number of primary roots/ air-layer (12.21), length of primary roots (4.35 cm), diameter of primary roots (2.02 mm), number of secondary roots / layer (11.90), length of secondary roots (1.72 cm), diameter of secondary roots (1.52 mm), fresh weight of roots/ air-layer (1.29 gm) and rooting percentage (47.73%). Various growth characters viz. survival percentage after planting (43.12%), number of branches

per layer (4.64) and number of leaves per layer (13.72) were annexed with N₃(15,000 ppm NAA).The present investigations are in conformity with the results of Nisaret *al.* (1990), Shrivastava *et al.*(1998), Nair (2001), Shrivastava and Bhel (2002), Rajput and Senjaliya (2015) and Sinishet *al.* (2005) in citrus, , and Singh *et al.* (2007), Maurya *et al.* (2012) and Rymbai *et al.* (2012) in guava.

During the process of root development callusing is subsequently followed by appearance of root primordial and formation of primary roots and their branching. It seems when there was greater number of primary roots and higher rooting percentage. It ultimate resulted in higher number of secondary roots, diameter of secondary roots and finally more fresh weight of roots. On the other hand growth attributing parameters viz. number of branches, survival etc. was completely governed by the volume of root of the plants. Thus when the growth of the air layers after detachment and planting in the nursery was also better.

It might have been due to good drainage and high porosity that helped in the development of excellent root system. Such media enhances apical meristematic activities and also triggers cambial cell division. It also reflects that these combinations might have provided favorable physical conditions for sufficient nutrients access which are needed for activating enzymatic and biochemical processes.

5.3 Combined effect of IBA and NAA:

In the present investigation most of the root and shoot parameters were appreciably increased under I₃N₃(15,000 ppm IBA + 15,000 ppm NAA) followed by I₃N₂ (15,000 ppm IBA + 15,000 ppm NAA). This can be attributed due to increased level of IBA promoting substance, better rooting surrounding and other nutrients with the application of NAA. However fresh weight of roots/layers, success in rooting percentage and number of leaves was found non- significant.

Chapter- VI

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

6.1 Summary

The present investigation entitled “**Effects of different concentration of IBA and NAA on rooting and growth of air layers in guava (*Psidium guajava L.*)**”. The experiment was conducted at the Nursery, Department of Horticulture, College of Agriculture, Gwalior, Rajmata Vijaya raje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.) during the session 2016 - 2017.

The experiment was laid out in Randomized Block Design with 16 treatment combinations consisting of three level of IBA $I_0 = 0$ ppm (Control), $I_1 = 5,000$ ppm IBA, $I_2 = 10,000$ ppm IBA, $I_3 = 15,000$ ppm IBA and NAA $N_0 = 0$ ppm (Control), $N_1 = 5,000$ ppm NAA, $N_2 = 10,000$ ppm NAA, $N_3 = 15,000$ ppm NAA.

The observations were recorded on different aspects of rooting, growth and survival *viz.* callus formation, number of primary roots/ air-layer, length of primary roots, diameter of primary roots, number of secondary roots / layer, length of secondary roots, diameter of secondary roots, fresh weight of roots/ air-layer, success in rooting percentage, survival percentage after planting, number of branches per layer and number of leaves per layer.

All parameters were found significantly superior under I_3 (15,000 ppm IBA) followed by I_2 comprising of I_1 including control.

NAA treatment $N_3 = 15,000$ ppm NAA was observed superior followed by $N_2 = 10,000$ ppm NAA in all the parameters *viz.* callus formation, number of primary roots/ air-layer, length of primary roots, diameter of primary roots, number of secondary roots / layer, length of secondary roots, diameter of secondary roots, fresh weight of roots/ air-layer, success in rooting percentage, survival percentage after planting, number of branches per layer and number of leaves per layer.

The interaction of different treatment combinations showed significant effect except fresh weight of roots and, number of leaves per layer and success in rooting percentage. The maximum value for all the parameters *viz.* callus formation, number of primary roots/ air-layer, length of primary roots, diameter of primary roots, number of secondary roots / layer, length of secondary roots,

diameter of secondary roots, fresh weight of roots/ air-layer, success in rooting percentage, survival percentage after planting, number of branches per layer and number of leaves per layer was recorded under the treatment combination of I₃N₃ (15,000 ppm IBA + 15,000 ppm NAA) followed by I₃N₂ (15,000 ppm IBA + 10,000 ppm NAA) while the minimum value was recorded under I₀N₀ (Control).

6.2 Conclusion

The experiment was conducted at the Nursery area, College of Agriculture, Gwalior (M.P.), to study the effects of different concentration of IBA and NAA on rooting and growth of air layers in guava (*Psidiumguajava L.*).

In general, it was concluded that the growing media I₃ IBA comprising of (15,000 ppm IBA) followed by I₂ comprising of (10,000 ppm IBA) was superior over rest of the IBA under study, which significantly influenced the rooting, growth and survival of air layers of guava.

As regards NAA treatment N₃ = 15,000ppm NAA was observed superior followed by N₂= 10,000 ppm NAA showed significant effect on rooting, growth and survival of air layers of guava.

The interaction effect of IBA and NAA showed significant effect except fresh weight of roots per layer, success in rooting percentage and number of leaves. It is concluded that I₃N₃ (15,000 ppm IBA + 15,000 ppm NAA) followed by I₃N₂ (15,000 ppm IBA + 10,000 ppm NAA) is the best combination and showed superiority over rest of the combinations with respect to growth and survival of air layers of guava.

6.3 Suggestions for further work

- I. The present investigation entitled “**Effects of different concentration of IBA and NAA on rooting and growth of air layers in guava (*Psidiumguajava L.*)**” should be repeated to confirm the findings.
- II. This experiment should be tried with sphagnum moss as a rooting media.
- III. Study of bio fertilizers to be included.
- IV. Use colour polythene rapper for maximum rooting percent.
- V. This experiment should be tried in other agroclimatic conditions.

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Appendice

Appendix.I: Analysis of variances for rooting parameters

Callus formation

ANOVA

		SS	MS	Fcal	Ftab 5%	Ftab 1%	
REP	3	0.081792	0.027264	1.36	2.815	4.25	
I	3	30.36449	10.1215	504.01	2.815	4.25	**
N	3	15.34303	5.114343	254.68	2.815	4.25	**
I*N	9	13.26919	1.474354	73.42	2.095	2.83	**
ERROR	45	0.903683	0.020082				
TOTAL	63	59.96219					

** significant

II. No. of primary roots

ANOVA

SV	DF	SS	MS	Fcal	Ftab 5%	Ftab 1%	
REP	3	1.679219	0.55974	2.79	2.815	4.25	
I	3	60.39172	20.13057	100.23	2.815	4.25	**
N	3	31.76672	10.58891	52.72	2.815	4.25	**
I*N	9	15.64391	1.738212	8.65	2.095	2.83	**
ERROR	45	9.038281	0.200851				
TOTAL	63	118.5198					

** significant

III. Length of primary roots

ANOVA

SV	DF	SS	MS	Fcal	Ftab 5%	Ftab 1%	
REP	3	0.361442	0.120481	5.22	2.815	4.25	
I	3	59.21429	19.7381	854.89	2.815	4.25	**
N	3	8.94178	2.980593	129.09	2.815	4.25	**
I*N	9	0.606639	0.067404	2.92	2.095	2.83	**
ERROR	45	1.038983	0.023089				
TOTAL	63	70.16314					

** significant

IV. Diameter of primary roots

ANOVA							
SV	DF	SS	MS	Fcal	Ftab 5%	Ftab 1%	
REP	3	0.106613	0.035538	1.69	2.815	4.25	
I	3	6.683637	2.227879	106.03	2.815	4.25	**
N	3	2.853087	0.951029	45.26	2.815	4.25	**
I*N	9	1.462025	0.162447	7.73	2.095	2.83	**
ERROR	45	0.945537	0.021012				
TOTAL	63	12.0509					

**** significant**

V. No. of secondary roots

ANOVA							
SV	DF	SS	MS	Fcal	Ftab 5%	Ftab 1%	
REP	3	4.104219	1.368073	3.43	2.815	4.25	
I	3	71.87297	23.95766	60.10	2.815	4.25	**
N	3	102.148	34.04932	85.42	2.815	4.25	**
I*N	9	48.23141	5.359045	13.44	2.095	2.83	**
ERROR	45	17.93828	0.398628				
TOTAL	63	244.2948					

**** significant**

VI. Length of secondary roots

ANOVA							
SV	DF	SS	MS	Fcal	Ftab 5%	Ftab 1%	
REP	3	0.046917	0.015639	8.33	2.815	4.25	
I	3	4.567555	1.522518	811.21	2.815	4.25	**
N	3	8.281105	2.760368	1470.75	2.815	4.25	**
I*N	9	0.384902	0.042767	22.79	2.095	2.83	**
ERROR	45	0.084458	0.001877				
TOTAL	63	13.36494					

**** significant**

VII. Diameter of secondary

ANOVA							
SV	DF	SS	MS	Fcal	Ftab 5%	Ftab 1%	
REP	3	0.059356	0.019785	25.55	2.815	4.25	
I	3	5.007319	1.669106	2155.62	2.815	4.25	**
N	3	2.733756	0.911252	1176.86	2.815	4.25	**
I*N	9	0.041619	0.004624	5.97	2.095	2.83	**
ERROR	45	0.034844	0.000774				
TOTAL	63	7.876894					

**** significant**

IX. Success in rooting percentage

ANOVA

SV	DF	SS	MS	Fcal	Ftab 5%	Ftab 1%	
REP	3	518.7178	172.9059	16.22	2.815		
I	3	1779.238	593.0795	55.64	2.815	4.25	**
N	3	647.2775	215.7592	20.24	2.815	4.25	**
I*N	9	128.0112	14.22346	1.33	2.095	2.83	
ERROR	45	479.6644	10.65921				
TOTAL	63	3552.909					

****significant**

VIII. Fresh weight of roots

ANOVA

SV	DF	SS	MS	Fcal	Ftab 5%	Ftab 1%	
REP	3	0.055681	0.01856	4.31	2.815	4.25	
I	3	0.175969	0.058656	13.61	2.815	4.25	**
N	3	0.180731	0.060244	13.98	2.815	4.25	**
I*N	9	0.008344	0.000927	0.22	2.095	2.83	
ERROR	45	0.193919	0.004309				
TOTAL	63	0.614644					

**** significant**

Appendix.II: Analysis of variances for growth parameters

X. No. of leaves per layers

ANOVA

SV	DF	SS	MS	Fcal	Ftab 5%	Ftab 1%	
REP	3	2.281625	0.760542	1.95	2.815	4.25	
I	3	100.6726	33.55754	85.98	2.815	4.25	**
N	3	83.62012	27.87337	71.41	2.815	4.25	**
I*N	9	4.291825	0.476869	1.22	2.095	2.83	
ERRO R	45	17.56417	0.390315				
TOTA	63	208.4304					

**** significant**

XI. No. of branches per layers

ANOVA

REP	3	0.207619	0.069206	1.50	2.815	4.25	
I	3	31.06357	10.35452	224.98	2.815	4.25	**
N	3	13.77332	4.591106	99.75	2.815	4.25	**
I*N	9	1.280906	0.142323	3.09	2.095	2.83	**
ERROR	45	2.071081	0.046024				
TOTAL	63	48.39649					

** significant

XII. Survival percentage

ANOVA

SV	DF	SS	MS	Fcal	Ftab 5%	Ftab 1%	
REP	3	605.9705	201.9902	14.05	2.815	4.25	
I	3	1667.005	555.6684	38.66	2.815	4.25	**
N	3	579.6469	193.2156	13.44	2.815	4.25	**
I*N	9	116.8296	12.98106	0.90	2.095	2.83	
ERROR	45	646.7354	14.3719				
TOTAL	63	3616.188					

** significant

VITA

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Year	Degree	University	Major field of study	Percentage/ Division
2017	M.Sc.(Horticulture)	RVSKVV GWALIOR(M.P.)	Fruit science	73.6%
2015	B.Sc.(Ag)	RVSKVV, GWALIOR(M.P.)	Agriculture	69.50%
2011	HSSC	MP BOARD BHOPAL	Agriculture	65.60%
2009	HSC Kharai	MP BOARD BHOPAL	All Subject	45.10%

I have submitted my thesis in 2016-2017 during his course work in partial fulfillment of the requirement for the degree of M.Sc.(Horti.) in fruit science

Date.....

Place.....

Bhuriyaverma

