"Effect of IBA and type of cutting on rooting of Golden Dewdrop (*Duranta plumeiri* L.)"

THESIS

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Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya

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In

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(FLORICULTURE AND LANDSCAPE ARCHITECTURE)

by

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Mandsaur (M.P.) – 458001 (2018)

CERTIFICATE - I

This is to certify that the thesis entitled **"Effect of IBA and type of cutting on rooting of Golden Dewdrop (*Duranta plumeiri* L.)"** submitted in partial fulfillment of the requirements for the Degree of **MASTER OF SCIENCE** in **Floriculture and Landscape Architecture** of Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior is a record of the bona-side research work carried out by **Mr.DINESH PATEL,** 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 or has been published. All the assistance and help received during the course of these investigations has been acknowledged by the scholar.

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This is to certify that the thesis entitled **"Effect of IBA and type of cutting on rooting of Golden Dewdrop (*Duranta plumeiri* L.)"** submitted by **Mr. DINESH PATEL,** to the Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior in partial fulfillment of the requirements for the degree of Master of Science in **HORTICULTURE** in the department of **Floriculture and Landscape Architecture** has been accepted after evaluation by the External Examiner and approved by the Student's Advisory Committee after an oral examination on the same.

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Place: Mandsaur

Date:....../......./...... *DINESH PATEL*

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List of Abbreviations/Symbols

Symbol	Abbreviation	Stands for
%		Percentage
&		And
/		Per
@		At the rate of
-	^{0}C	Degree Celsius
-	ANOVA	Analysis of variance
-	B:C	Benefit cost ratio
-	C.D.	Critical difference
-	cm	Centimetre
-	CRD	Completely Randomised Block Design
-	Cv	Cultivar
-	d.f.	Degree of Freedom
-	*et al.*	And others/ associates
-	Etc.	Etcetera
-	Fig.	Figure
	g	Gram
-	ha.	Hectare
-	IAA	Indole acetic acid
-	IBA	Indol Butyric acid
-	i.e.	That is
-	GA_3	Gibbérelline
-	NAA	Naphthalene acetic acid
-	PBZ	Paclobutrazol
-	1,2,4 acid	Potent phenolic compound
-	Kg	Kilogram
-	Kg/ha.	Kilogram per hectare
-	M.P.	Madhya Pradesh
-	M.S.S.	Mean sum of squares
-	Max.	Maximum
-	mg	Milligram
-	Mim.	Minimum
-	Mt	Metric tonnes
-	NHB	National Horticultural Board
-	No.	Number
-	NS	Non significant
-	ppm	Parts per million
-	R.H.	Relative humidity
-	Rs.	Rupees
-	SE(m) ±	Standard Error of Mean
-	Sig.	Significant
-	Viz.	(videlicet) Namely

CHAPTER – I

INTRODUCTION

CHAPTER I

INTRODUCTION

Duranta plumeiri is a shrub of the Verbenaceae family, commonly used as an ornamental plant in tropical and semi-tropical gardens. Originally native to Central and South America and the Caribbean, it is widely naturalized throughout the tropics and has become an invasive species in Australia, China, South Africa and on several Pacific Islands.

It can grow to 18 feet tall and can spread to an equal width. Mature specimens possess axillary thorns. Leaves are light green, elliptic to ovate, opposite, and grow up to 8cm long. Showy light–blue or lavender flowers are in tight clusters located on terminal and axillary stems, blooming almost all the year. The fruits are small yellow berries approximately one1cm in diameter. Duranta can be used in a number of ways. If left to its own devices, the bush forms a sprawling, carefree hedge. Its colourful features also make it an attractive focal point in the landscape.It is a popular ornamental used for accent plants and hedges in tropical and subtropical parts of the world because of its profuse display of flowers and fruits.

Seed propagation is not an option and cutting propagation is most common. Although softwood terminals can be rooted; maturing green wood and matured intermediate wood stem pieces can be used as well. Cutting diameters of 0.1 to 0.2 inch give the best results. Stem piece cutting should have three to five nodes.

It is generally accepted that most of perennial ornamental plants are multiplied and propagated by the use of vegetative propagation; cuttings, layering or grafting (Deng Xiong, 2000).

It is well known that Duranta can either be propagated through seeds or stem cuttings (Robbins and Evans, 2006). However propagation by stem cuttings is the most popular and extensively used method of vegetative propagation. Stem cuttings are classified based on their maturity as softwood, semi-hardwood (Hartmann *et al*., 2002). Using different types of cuttings are effective on some characters such as rooting percentage, number of branches, number of leaves, height growth, stem diameter, fresh, dry weight of shoot and root system. These cuttings are important because of the ease by which plants grow from them although, some are more difficult to root than others

The process of root formation at the base of a cutting may be divided into three stages: initiation elongation of root initials and root growth and development (Hartmann *et al*., 2002). Three groups of chemicals may be applied to regulate the rooting process in some way: (a) hormones, which induce the initial meristematic activity and stimulate the elongation and development of roots formed (b) nutritional elements which promote growth of the new roots(c) protecting agents. such as biocides, which enable the cuttings to resist attack by pathogens during the entire rooting period.

Studies on the physiology of auxin action showed that auxin was involved in such varied plant activities as stem growth, adventitious root formation (Haissig and Davis, 1994), lateral bud inhibition, abscission of leaves and fruits, and activation of cambial cells. Indole-3-acetic acid (IAA) was identified as a naturally occurring compound having considerable auxin activity (Haissig and Davis, 1994). About the same time it was shown that synthetic materials, indole-3-butyric acid (IBA) was more effective than the naturally occurring or synthetic IAA for rooting.

The role of IBA to inducing rooting in many horticultural crops is an established fact. The effectiveness of IBA to induce rooting, improve the rooting percentage and increased in survival of rooted cuttings has been shown. Today, IBA is the most widely used auxins for rooting stem cuttings and for rooting tissue-culture produced micro cuttings. It has been repeatedly confirmed that auxin is required for initiation of adventitious roots on stems, and indeed, it has been shown that divisions of the first root initial cells are dependent upon either applied or endogenous auxins (Gaspar and Hofinger, 1988).

Rooting hormones speed rooting, which can take four to six weeks. IBA concentration of 2000 to 5000ppm are used for most cultivars, but even higher concentration are used for difficult-to-root types. Softwood terminals of easy-to-root cultivars do not require a rooting hormones.

Keeping the above facts in view, an experiment entitled**: "Effect of IBA and type of cutting on rooting of Golden Dewdrop (*Duranta plumeiri* L.)"** was conducted at the net house of the Department of Floriculture &Landscaping at College of Horticulture, Mandsaur (M.P.) with the following objectives:

1. To study the effect of type of cutting on the rooting of Duranta.
2. To study the effect of different IBA concentrations on rooting of Duranta cuttings.
3. To derive the best combination of type of cutting and IBA concentration on rooting of Duranta cuttings.

CHAPTER – II

REVIEW OF LITERATURE

Chapter-II

REVIEW OF LITERATURE

Auxin is used mostly for better rooting in stem cuttings for many flowers which increase survival percentage and better rooting. One of the many approaches has been the application of plant growth regulating chemicals to bring about a change in the growth of roots and shoots of some horticultural crops of ornamental importance. Use of IBA to induce rooting has been in practice since long to ensure success of rooting in cuttings and better establishment of plants.

In this chapter an attempt has been made to present the work done earlier in the aspect of stem cutting with the use of auxin, that enhance rooting and shooting.

2.1 Effect of IBA and type of cutting on rooting of Golden Dewdrop:-

Amaral *et al.* (2012) evaluated the production of seedlings of *D. repens* L. using cutting process with the supply of exogenous IBA in different seasons. The experimental design was completely randomized, with four concentrations of IBA (0, 1000, 3000 and 5000 mg kg^{-1}), three types of cuttings (softwood, semi hardwood and hardwood) and two seasons (wet and dry). They assessed the number of rooted cuttings, survival cuttings, number of shoots per cutting, average length of the longest root and dry mass of shoots and roots. The best dose for propagation of *D. repens* was 3000 mg kg^{-1} IBA. The softwood and semi-hardwood cuttings were the most suitable and the rainy season the more favorable for *D. repens* seedling production.

Okunlola A. L. (2013) evaluated the effects of the types of stem cuttings and stem cutting lengths on the rooting and growth of *Duranta repens* in the nursery. Stem cuttings of the plant were subjected to different treatments; stem cutting types (softwood, semi hardwood and hardwood) and lengths (10 cm and 20 cm). The experiment was conducted under normal nursery conditions to determine the type of stem cutting and stem cutting length best for the rooting of the plant. The experimental design was a 3 x 2 factorial in complete randomized design (CRD) with four replications. The results revealed that the type and stem cutting length had effect on the rooting of *D. repens*. Percentage rooting was higher for hardwood cuttings irrespective of the length of cutting. Hardwood cuttings of 20 cm length however, gave the best rooting followed by the semi hardwood of same length. Softwood cuttings of length 10 cm and 20 cm gave the poorest result.

Singh *et al.* (2014) conducted an investigation in the mist house located at the HNB Garhwal University, Srinagar, Garhwal, Uttarakhand, India. Softwood cuttings of *Duranta erecta* var. Golden were collected from 2 to 4 year old plants and 15 cm long cuttings with apical portion. The cuttings were treated with1, 2, 3, 4 and 5g L^{-1} IBA solutions by quick dip method. Among all the treatments, highest number of roots per cutting (43.00), length of roots per cutting (9.28 cm), diameter of root per cutting (1.67 mm), percentage of rooted cutting (88.00 %), number of sprouts per cuttings (4.34) and the minimum (20.66) days taken to callus formation was noticed in 4g L^{-1}IBA concentration.

2.2 Effect of IBA and type of cutting on rooting of different shrubs and woody perennial ornamentals:-

BOUGAINVILLEA:-

Gupta *et al*. (2002) reported that treatment of Bougainvillea cuttings with 1000ppm IBA gave maximum rooting (100%) with higher number of roots in soaking method but its availability and cost of procuring it by the peasant gardeners made it of utmost importance to study and look for local and accessible alternatives which brought about the usage of coconut water and tetracycline.

Deshmukh and Barad (2006) reported that IBA at 6000 ppm was found significantly superior for increasing sprouting percentage, number of shoots, length of shoot, fresh and dry weight of shoots of *Bougainvillea buttiana* cv. Mahara.

Ramtin *et al.* (2011) conducted a project in the form of factorial test in a randomized complete block design with 12 different treatments and 3 replications. In this experiment 3 forms of cutting were applied; top cutting, middle cutting, lower cutting. After the insertion of IBA (Indole 3- Butyric acid) at four different densities; 0, 1000, 2000, 4000 mg/L in 2.5 centimeters of the lower part of the cuttings for 5 seconds, they were planted in washed sand then the planted cuttings were put under a mist system, so that after 5 weeks they were rooting. The results showed that the plants produced from lower cutting had the maximum level of rooting, evident from the data for; number of bracts, number of leaves, number of buds and size of bract. The highest increases in length of root, number of bracts, number of cyathium, number of leaves and size of bract were recorded with applications of an IBA density of 1000 mg/L. The tests showed that the most rooting was from top cutting and IBA for rooting was not necessary, and that the IBA density of 2500 mg/L was suitable for increasing the speed of rooting and uniformity of root growth, but according to the results of this research, IBA with density of 1000 mg/L caused longer roots and the most rooting was from the lower cutting.

Seyedi *et al*. (2013) observed that the marcotting capability of different treatments differ from each other. The cuttings which were treated by IBA hormone of 4000 mg concentrations per litre showed the most marcotting compared to other treatments. Number and length of the root, wet weight of the root, were affected in a high extent by auxin treatment and type of the cutting. The difference between treatments and the marker was meaningful. The maximum root length, fresh weight of roots, and rooted cuttings were reported to be in treatment of 4000 mg per litre and the different between treatments and the marker was meaningful. The research determined semi-hard wood cutting, the best cutting for rooting of *Bougainvillea glabra.*

Pannerselvam *et al*. (2004) observed the maximum number of shoots per rooted cutting in the cuttings treated with IBA 4000mg/l. The factor responsible for increased shoot length may be due to more quantity of IBA transported to the upper part of the cutting owing to more number of roots which served as an auxin source for shoot development.

Okunlola, A. L. (2017) conducted an experiment in the nursery, the Department of Crop, Soil and Pest management the Federal University of Technology, Akure, on stimulation of rooting of three ornamentals; *Rosa spp., Mussaenda philippica* and *Bougainvillea spp.*, (Rose, Queen of Philippines and Bougainvillea respectively) using some rooting substances; Indole-3-Butyric Acid(IBA), Coconut water and Tetracycline, in different propagating media consisting of Topsoil, Coir fiber and Saw dust fromJuly to September, 2012. Data were collected on number of branches, the number of leaves per cutting, number of roots and length of roots.The results from the study showed that Topsoil had significant ($P < 0.05$) effect on the rooting ability of *Rosa spp.,* and *Bougainvillea spp.,* with cuttings dipped in coconut water having the best performance, while *Mussaenda philippica* cutting shad no roots. Therefore root initiation in cuttings of *Rosa spp.* and *Bougainvillea spp.* could be enhanced when dipped inCoconut water for about five minutes.

Bharmal *et al.* (2005) observed that IBA 2000 ppm as a quick dip method along with 2 sprays of 10 ppm IBA after 30 and 60 days of planting of cuttings was significantly superior treatment over the other (1000, 2000 and 3000 ppm) IBA treatments and control by recording the highest number of primary roots (20.85), survival percentage (96.57%) after 30 days of planting of cuttings in Chrysanthemum cv. Sonali Tara.

ROSE:-

Akhtar *et al*. (2002) carried out studies in the Rose project area, Department of Horticulture, University of Agriculture, Faisalabad, during 2001 to 2002. Rose cuttings taken from two rose species i.e. *Rosa centifolia* and *Rosa damascene* were selected for this experiment. Basal portion of their stem cuttings were treated with 500 ppm and 1000 ppm concentration of two growth hormones, NAA and IBA, by quick dip method in addition to a control. The experiment was laid out according to the randomized complete block design with factorial arrangement. Results expressed significant supremacy of 1000 ppm over rest of the treatments in both the growth hormones. *Rosa centifolia* produced more roots as compared to *Rosa damascena* and IBA giave significantly better roots as compared to NAA.

Abbas *et al*. (2015) studied the effects of hormone Indole Butyric Acid (IBA) and Naphthalene Acetic Acid (NAA) on rooting of hybrid rose cvs. significantly higher sprouting percentage (33.25%) and higher survival percentage (63.25%) was noted in the cuttings treated with IBA @ 3000 ppm as compared to the control (4.75 and 25.5%). More number of leaves (7.5) and length of sprouting (19.16%) were found in the cuttings treated with IBA @ 2000 ppm as compared to rest of treatments. The cuttings treated with IBA @ 3000 ppm (T_3) sprouted in 14.75 days against the control (T_1) (28 days). Maximum number of roots (30.25) were noted in T_2, whereas, the control produced the least number of roots (16.0).

Akhtar *et al*. (2015) designed a study to increase the rooting percentage of cuttings by applying plant growth regulators (PGRs) with different levels. In total 31 treatments with different concentrations (450 ppm, 700 ppm and 950 ppm) of indole butyric acid (IBA), indole acetic acid (IAA), naphthalene acetic acid (NAA) alone, in combination and with same concentrations of 6-benzylamino purine (BAP) were used. Healthy similar sized cutting of *R*. *centifolia* was treated in solution of PGRs by quick dip method and planted in polythene bags. The data for shoot length, shoot dry weight, number of roots, root length and root dry weight were recorded. All three levels (450 ppm, 700 ppm and 950 ppm) of IBA alone produced maximum results in case of all parameters as compared to all other treatments. Among three levels of IBA, 450 ppm concentration produced maximum shoot length (10.67 cm), shoot dry weight (3.02 g), number of roots (14.00), root length (11.90 cm) and root dry weight (0.50 g). Lower concentrations of plant growth regulators produced better results as compared to higher concentrations.

Nasri *et al*. (2015) investigated the effect of different levels 0, 500 and 1,000 mg l-1 (quick dip method for 20 s) of Indole butyric acid (IBA) on the rooting of 12 wild genotypes (including: Kurdistan 1 to Kurdistan 12) of *R. damascena*. The results show that the rooting ability of *R. damascena* differs significantly among the twelve genotypes. The highest rooting (79.56%) and callus production (69.08%), number of roots (8.33) root fresh and dry weights (361.80 and 244.74 mg, respectively) were recorded in Kurdistan 5 genotype with 1,000 mg l^{-1} IBA. The maximum root length (5.84 cm) was observed in Kurdistan 5 genotype with 500 mg l^{-1} IBA that showed a significant difference compared to the control treatment (0.96 cm). The highest number of leaves per bud (7.33 at 500 mg l^{-1} IBA) and number of buds (5.00 at 1,000 mg l^{-1} IBA) were recorded in Kurdistan 1 genotype. The current study demonstrated that the different genotypes of *R. damascena* were in a difficult-to-root state, which suggests that cutting treatment with 1,000 mg l^{-1} IBA overcame the problem of the difficult-to-root state, and it can also enhance the rooting percentage in the studied genotypes.

Dawa *et al*. (2017) evaluated the effect of two growth regulators IBA and NAA @ 500, 1000, 1500 ppm in comparison to control (without any growth regulator treatment) and growing medium combinations (sand 100%, sand 85% + manure 15%, sand 70% + manure 30%, sand 70% + manure 15% + soil 15%, sand 85% + soil 15%) on the rooting of three rootstocks of rose (*Rosa indica, Rosa banksiae* and *Rosa bourboniana*). Main effect of growth regulators and genotype was significant on majority of rooting characteristics. IBA (1000 ppm) recorded minimum days to root initiation (23.33), maximum rooting (72.22%), root length (6.42 cm) and field survival (82.38%). Among the genotypes, *Rosa indica* performed better, recording maximum rooting (75.24%), primary root number (9.48), root length (6.40 cm), new leaf growth on cuttings (59.05%) and field survival (96.98%) followed by *Rosa banksiae*. Performance of *Rosa bourboniana* was poor recording lowest values for all these parameters. Interaction effects were significant. NAA produced superior results in *Rosa indica* while, IBA gave promising results in *Rosa banksiae* and *Rosa bourboniana*. Growing medium significantly improved various rooting characteristics of cuttings. Superior results were obtained with sand 70%+ manure 30% which, recorded minimum days to root initiation (22.13), maximum rooting (83.33%), primary root number (15.52), root length (8.88 cm), new leaf growth (51.11%) and field survival (85.46%). Among the genotypes, *Rosa indica* consistently gave better results recording minimum days to root initiation (22.70), maximum rooting (90.00%), primary root number (21.21), root length (10.10 cm), new leaf growth (47.33%) and field survival (97.78%).

2.3 Effect of IBA and type of cutting on rooting of ornamental shrubs:-

CAMELLA:-

Zenginbal *et al*. (2014) studied the effect of cutting type, and IBA (Indole-3-butyric acid) on rooting of Turkish tea (*Camellia sinensis* (L.) O. Kuntze) clone ‘Fener-3’cuttings. The highest survival percentage (90%) was observed on full-leaf cuttings treated with 6000 ppm IBA. The rooting percentage varied from 43.3% to 78.3%. The best results were obtained for rooting (78.3%), which is 6000 ppm IBA doses, was gathered with full- leaf cutting. The root lengths varied from 9.83 to 14.77cm. The best result (14.77cm) was taken from 6000 ppm IBA dose based on the full leaf cutting. The root diameters varied from 0.99 mm to 1.30mm. The best result (1.30mm), prepared the full leaf cuttings, 6000ppm IBA doses has been application. The number of root varied from 3.40 to 6.37 units. The best results (6.37 units) were taken 6000ppm IBA doses based on the full-leaf cuttings. The quality of the root varied from 1.93 to 3.50 points. The best result (3.50 points) was taken 6000 ppm IBA doses based on the full-leaf cuttings. Among all parameters the best type of cutting was full-leaf cutting, and 6000 ppm IBA was the most appropriate dose. The lowest rooting and rooting quality were taken from control (0 ppm IBA) treatment.

PINUS:-

Henrique *et al.* (2006) evaluated the rooting of *Pinus caribaea* var. Hondurensis Morelet cuttings under the action of different levels of plant growth regulators. The cuttings consisted of 4-6 cm long shoots of *P. caribaea*var .Hondurensis Morelet with their basal needles removed. The basal part of the cuttings were treated for 2 seconds with the following treatments: 1- NAA 2000mg L^{-1}; 2- NAA 4000mg L^{-1}; 3- NAA 6000mg L^{-1}; 4- NAA 2000mg L^{-1} + PBZ 100mg L^{-1}; 5- NAA 4000mg L^{-1} + PBZ; 6- NAA 6000mg L^{-1} + PBZ; 7- IBA 2000mg L^{-1}; 8- IBA 4000mg L^{-1}; 9- IBA 6000mg L^{-1}; 10-IBA 2000mg L^{-1} + PBZ; 11- IBA 4000mg L^{-1} + PBZ; 12- IBA 6000mg L^{-1} + PBZ; and a control. After receiving the treatment, the cuttings were planted in tubes containing 50% carbonized rice hulls and 50% vermiculite. The evaluations, performed 60 days after planting, showed that *P. caribaea* var. Hondurensis cuttings treated with IBA produced a higher percentage of rooted cuttings than those treated with NAA; the most effective treatment was IBA 4000mg L^{-1} plus 100mg L^{-1}paclobutrazol.

NIGHT JESSAMINE

Rahbin *et al*. (2012) evaluated the effect of cutting location on shoot and Indole butyric acid (IBA) on rooting of 'Night Jessamine' (*Cestrum nocturnum*) stem cuttings, Then was prepared 15 cm long cuttings from each part of shoot and was treated by 0 (distilled water), 1000, 1500, 2000 and 4000 mg/L IBA for 5 seconds and was cultured in pots containing sand and peat-moss. After 75 days was recorded rooting percent; grown cutting percent; root number in each cutting; root length; root fresh and dry weight. Based on results, the cuttings of upper part of shoot significantly were better than the cutting of lower part of shoot especially in relation to rooting percent and grown cuttings percent. IBA 2000 and 4000 mg/L were significantly better than other concentrations.

TECOMA:-

Singh and Negi (2014) observed that the length of sprouts (10.18 cm), diameter of sprout (0.26 cm), number of leaves on new growth (5.59), number of primary roots (18.66%), length of root (10.53 cm), diameter of root (0.11 cm), fresh weight (0.79 gm) and dry weight of root (0.094 gm) were found maximum in 50 cm long cuttings treated with 1500 ppm concentration of IBA in stem cuttings of *Tecoma stans* L.

VITEX:-

Bhagya *et al*. (2014) studied the vegetative propagation of *Vitex negundo* (L.) Single, double and triple node hardwood cuttings were treated with different growth hormone solutions and observations were recorded. The shoot parameters such as days taken to sprout (9 days), number of sprouts(3.23), length of the longest sprout (20.38 cm), fresh weight (3.6 g) and dry weight (0.88 g) of sprouts and the root parameters like time taken to root (30 days), number of roots (19.05), length of the longest root (21.75 cm), fresh weight (2.37 g) and dry weight (0.67 g) of roots were significantly higher in triple node stem cuttings treated with Indole Butyric Acid 3000 ppm. Thus triple node hardwood cuttings treated with 3000 ppm Indole Butyric Acid (IBA) obtained maximum rooting success.

2.4 Effect of IBA and type of cutting on rooting of flowering annuals and herbaceous perennial flowering plants:-

CHRYSANTHEMUM:-

Ganjure *et al*. (2012) conducted an experiment to study the response of IBA and rooting media on rooting of cuttings in chrysanthemum cv. Piwali Rewadi and Found that days to rooting, fresh weight of roots, dry weight of roots, days to sprouting, fresh weight of shoots and dry weight of shoots were found to be higher in treatment application of IBA 1000 ppm. In case of rooting media it is higher in sand + FYM (2:1) and minimum days required to rooting and days to sprouting is in Sand + Silt + FYM (1:1:1).

Markovic *et al*. (2014) studied the effect of application method of indole-3-butyric acid (IBA) (powder dip or immersion in the solution) on rooting of softwood cuttings of Cornelian cherry. Four types of cuttings were taken from elite mother tree in the urban forest in Belgrade area (terminal and single-node cuttings with current season's wood only, and terminal and single-node cuttings with a small section of 2-year-old wood) and rooted under intermittent mist. After 10 weeks, the best results were obtained using terminal cuttings with current season's wood only, treated with 1% IBA (powder dip) (96.7% rooted cuttings; mean number of primary roots per cutting was 12.9).

MARIGOLD:-

Bhatt and Chauhan (2012) conducted an experiment to study effect of auxin on rooting of African marigold (*Tagetes erecta* L.). that maximum average number of roots per cutting after 20 and 30 days was 40.53 and 58.79, respectively under the treatments at IBA + NAA 150 mg/l (T_{10}). The average length of stem per cutting was maximum (6.1 and 15.33 cm) under IBA + NAA 150 mg/l after 20 and 30 days, respectively. The average length of root per cutting was recorded maximum (4.6 cm) under NAA 200 mg/l (T_1) after 20 day sand (5.51 cm) under IBA + NAA 150 mg/l (T_{10}) after 30 days.

CHAPTER – III

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

An experiment entitled **"Effect of IBA and type of cutting on rooting of Golden Dewdrop (*Duranta plumeiri* L.)"** was conducted during 2017-2018 at the net house of the Department of Floriculture & Landscaping at College of Horticulture, Mandsaur (M.P.).

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

3.1 Location:

The experiment was conducted at the College of Horticulture, Department of Floriculture &Landscaping, Mandsaur (M.P.), Rajmata Vijayaraje Scindia Krishi VishwaVidyalaya, Gwalior (M.P.). Mandsaur is situated at 23.45^0 to 24.13^0 N latitude and 74.44^0 to 75.18^0 E longitudes at an altitude of 435 m Mean Sea Level. Geographically, the experimental site is lines at the border of M. P. The location of the experimental farm is situated in the main campus of college.

3.2 Climatic Conditions:

Mandsaur has a subtropical climate with hot summer and cool winter. The temperature rises up to 46^0C during summer and falls to 3.6^0C during winter with an occasional occurrence of frost. The average rainfall is 797.6 mm, most of which occurs during July to September; winter and summer rain are uncommon. The values of weather parameters during the period of investigation were recorded at the Meteorological Observatory at the Bahadari Farm of College of Horticulture Mandsaur. The concerned meteorological data are presented in Table-3.1 and Fig.-3.1

Table-3.1: Daily meteorological data was recorded during the study period (August - October)

Date	Temperature		Relative Humidity (%)	Rainfall (mm)
	Minimum (^0C)	Maximum (^0C)		
23-8-2017	22.5	31.8	70	-
24-8-2017	22.0	30.0	80	07
25-8-2017	21.5	29.5	82	63
26-8-2017	20.7	29.8	82	-
27-8-2017	20.5	29.5	81	10
28-8-2017	20.0	29.0	83	13
29-8-2017	19.5	30.0	78	04
30-8-2017	24.0	29.0	70	02
31-8-2017	24.0	27.0	88	-
01-9-2017	24.0	27.0	88	-
02-9-2017	23.0	27.0	88	15
03-9-2017	23.0	29.0	93	20
04-9-2017	23.0	27.0	93	-
05-9-2017	21.0	29.0	93	02
06-9-2017	22.0	29.0	82	-
07-9-2017	23.0	30.0	80	-
08-9-2017	23.0	30.0	75	-
09-9-2017	24.0	30.0	75	-
10-9-2017	24.0	29.0	70	03
11-9-2017	23.0	29.0	70	-

12-9-2017	23.0	32.0	60	05
13-9-2017	23.0	31.0	71	08
14-9-2017	24.0	28.0	75	-
15-9-2017	24.0	29.0	77	-
16-9-2017	23.0	30.5	80	13
17-9-2017	22.0	31.0	78	45
18-9-2017	24.0	33.0	60	-
19-9-2017	23.0	33.0	57	-
20-9-2017	24.0	31.0	60	-
21-9-2017	23.0	29.0	70	-
22-9-2017	23.0	27.0	79	3.5
23-9-2017	22.0	31.0	72	-
24-9-2017	23.0	32.0	70	-
25-9-2017	22.5	31.0	63	-
26-9-2017	23.0	31.5	57	-
27-9-2017	23.0	33.0	53	-
28-9-2017	23.0	34.0	49	-
29-9-2017	23.0	34.0	47	-
30-9-2017	22.0	35.5	45	-
01-10-2017	22.5	36.0	43	-
02-10-2017	23.0	35.0	40	-
03-10-2017	22.0	34.0	39	-
04-10-2017	21.7	33.1	38	-

05-10-2017	22.0	34.0	41	-
06-10-2017	23.0	33.2	46	-

Source: Meteorological observatory, College of Horticulture, Mandsaur (M.p)

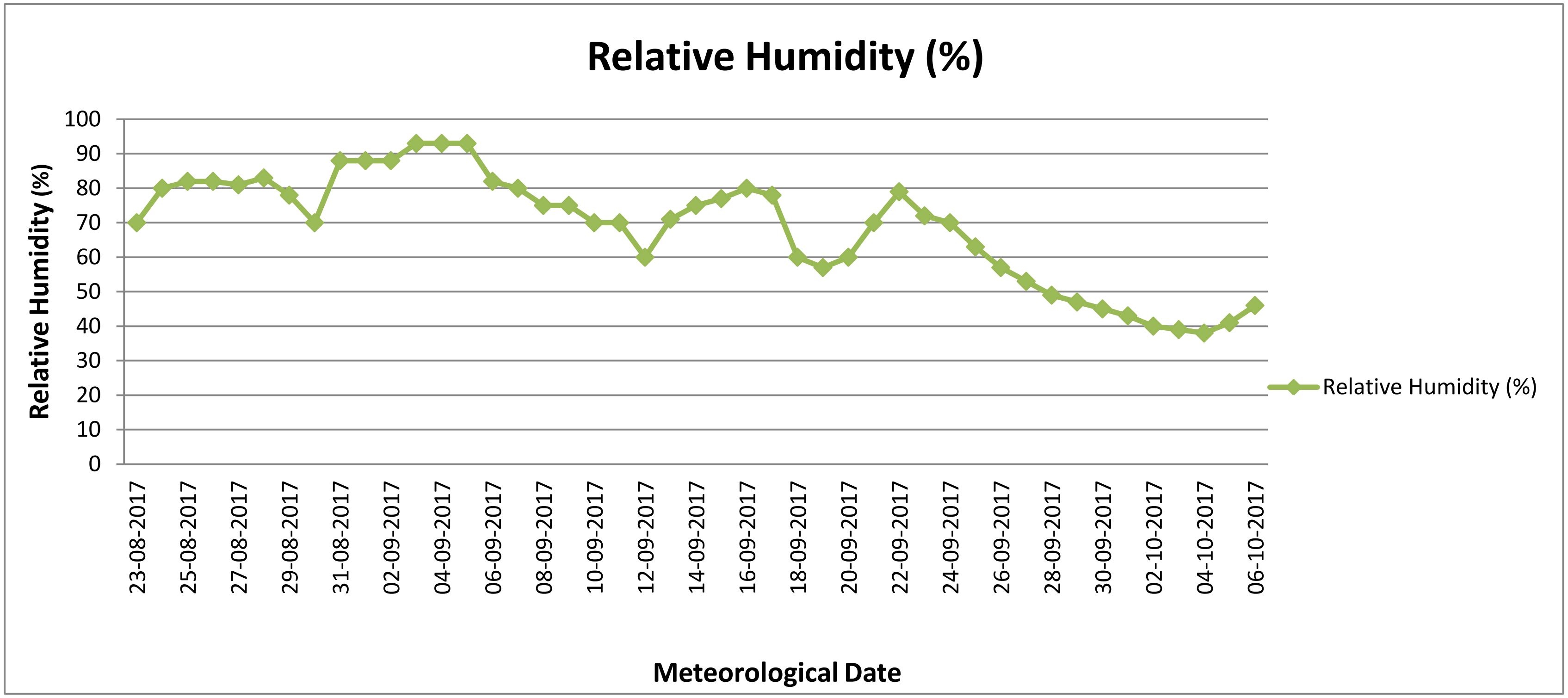
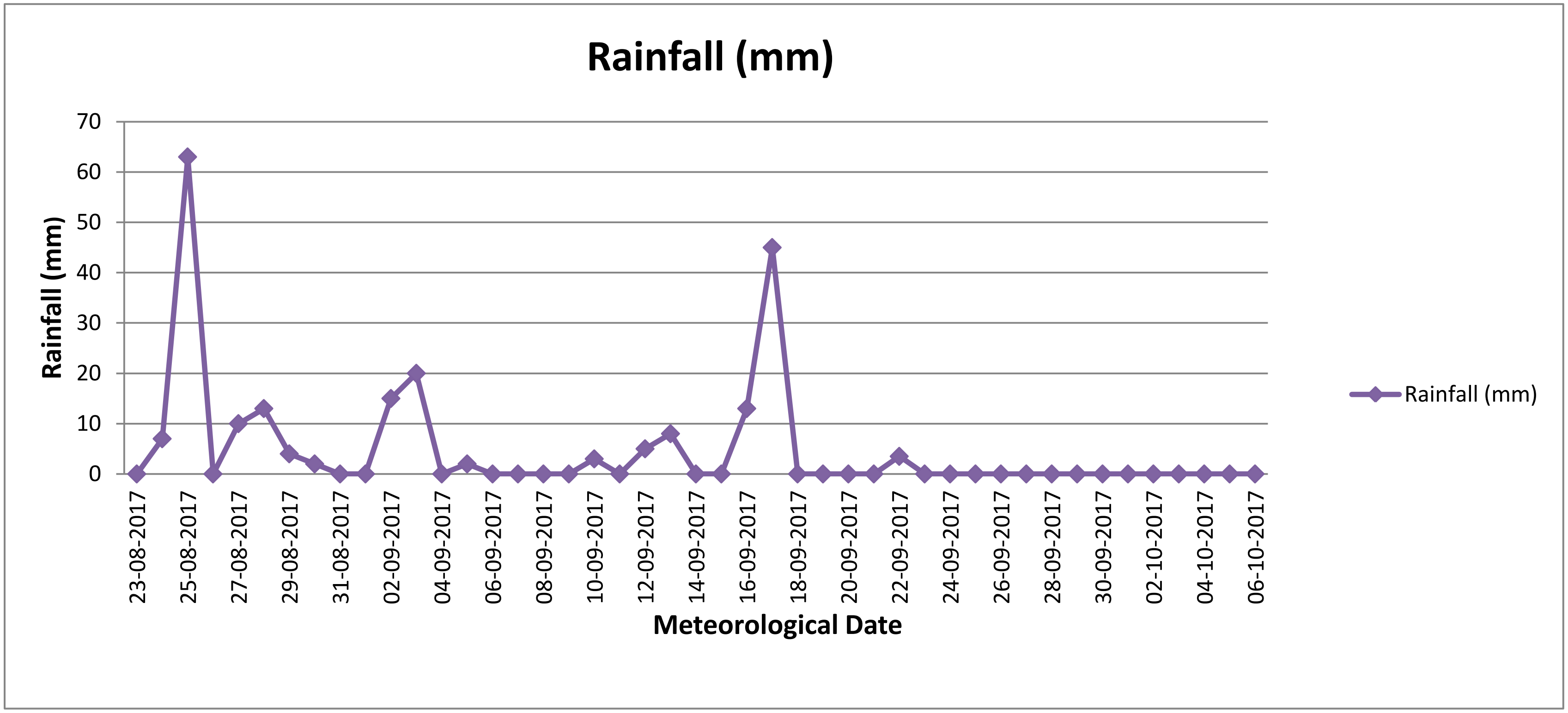
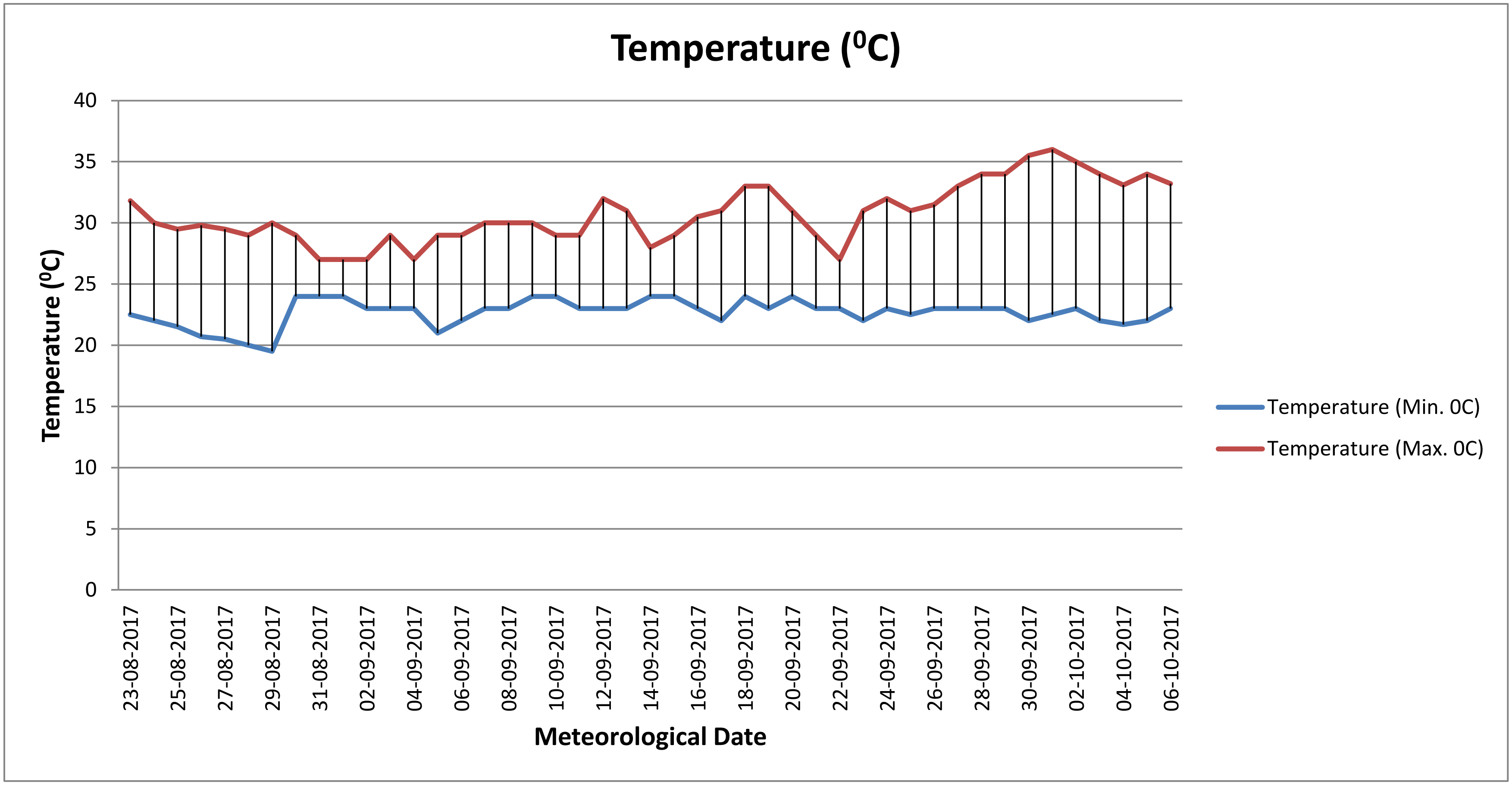

Relative Humidity (%)
100
90
80
70
60
50
40
30
20
10
0
Relative Humidity (%)
23-08-2017
25-08-2017
27-08-2017
29-08-2017
31-08-2017
02-09-2017
04-09-2017
06-09-2017
08-09-2017
10-09-2017
12-09-2017
14-09-2017
16-09-2017
18-09-2017
20-09-2017
22-09-2017
24-09-2017
26-09-2017
28-09-2017
30-09-2017
02-10-2017
04-10-2017
06-10-2017
Relative Humidity (%)
Meteorological Date

Fig. 3.1: Daily meteorological data observed during the study period (August - October 2017)




Temperature (⁰C)
Temperature (⁰C)
40
35
30
25
20
15
10
5
0
23-08-2017
25-08-2017
27-08-2017
29-08-2017
31-08-2017
02-09-2017
04-09-2017
06-09-2017
08-09-2017
10-09-2017
12-09-2017
14-09-2017
16-09-2017
18-09-2017
20-09-2017
22-09-2017
24-09-2017
26-09-2017
28-09-2017
30-09-2017
02-10-2017
04-10-2017
06-10-2017
Meteorological Date
Temperature (Min. 0C)
Temperature (Max. 0C)

3.3 Experimental details and layout:

The experiment was laid out in Completely Randomized Design with eight treatments and three replications under the net house. The detail of technical programme of the experiment is given in Table-3.2, and the treatments were compared among them during the period of experiment are given in Table-3.3.

Table-3.2: Detail of the technical programme:

Name of Crop	Golden dewdrop (*Duranta plumeiri* L.)
Number of treatments	08
Number of cuttings/treatment	15
Number of replications	03
Total number of plants	360
Design	CRD

Plate 1: Stem cuttings of Duranta at 15 days after planting.

Plate 2: Stem cuttings of Duranta at 45 days of planting.

Table-3.3: Details of the treatments:

T.N.	Treatments
T_1	Control (Hardwood cutting)
T_2	Control (Softwood cutting)
T_3	(Hardwood cutting + IBA 3000ppm)
T_4	(Hardwood cutting + IBA 4000ppm)
T_5	(Hardwood cutting + IBA 5000ppm)
T_6	(Softwood cutting + IBA 3000ppm)
T_7	(Softwood cutting + IBA 4000ppm)
T_8	(Softwood cutting + IBA 5000ppm)

3.4 Preparation of cuttings:

Six month old branches for hardwood cutting and one month old branches for softwood cuttings, which are 5 cm long with 3-4 buds were selected for root initiation. The cuttings were treated with 1 per cent captan to prevent the occurrence of fungal diseases.

3.5 Preparation of growth regulator solution:

Indole-3 -butyric acid (IBA)

Desired quantities of IBA were first dissolved in few drops of 1N NaOH and then volume was made up to 250 ml of distilled water to make the proper concentration of IBA.

3.6 Application of plant growth regulators:

The stock solution is dissolved by using distilled water to get required ppm concentration of the solution as per the treatments. Hardwood and softwood cuttings of uniform length and diameter of Duranta were dipped for two minutes as per treatments. The cuttings under control were dipped in distilled water instead of plant growth regulators.

3.7 Planting of cuttings:

Treated cuttings were planted in polybags and the soil around cuttings was pressed firmly. Single cutting was planted in single polybag. Polybag were kept under the net house condition for better rooting.

3.8 After care:

Planted cuttings were sprayed with Carbendazim 0.2% to prevent the occurrence of fungal diseases. Regular irrigation was given to the cuttings with the help of hazara (rose can) at the interval of 2-3 days.

3.9 Observations recorded:

3.9.1 Number of roots per cutting:

The number of roots per cutting was counted for each treatment from randomly selected five rooted cuttings and observations were recorded at 45 days after planting and then average was calculated.

3.9.2 Length of longest root (cm):

The root length of selected cuttings was recorded for each treatment from randomly selected five rooted cuttings from base of cutting to the root tip by centimeter scale at 45 days after planting and then average was calculated.

3.9.3 Number of sprouts per cutting:

The total numbers of sprouts in all five randomly selected cuttings were counted at 25, 35 and 45 days after planting and then average was calculated.

3.9.4 Length of shoot (cm):

The average length of shoot of five randomly selected cuttings was measured from the base of shoot to the shoot tip at 25, 35 and 45 days after planting of cutting with the help of centimetre scale.

3.9.5 Fresh weight of shoots per cutting (g):

All shoots were taken from the five randomly selected cuttings for measuring of fresh weight which was recorded by electronic balance and then average was calculated.

3.9.6 Number of leaves per cutting:

The number of leaves was counted from five randomly selected cuttings and recorded at 25, 35 and 45 days after planting and then average was calculated.

3.9.7 Fresh weight of roots per cutting (g):

The fresh weight of roots per cutting was recorded for each treatment randomly selected five rooted cuttings and roots were detached from the uprooted cuttings and fresh weight was taken with the help of electronic balance.

3.9.8 Dry weight of shoots per cutting (g):

After recording the fresh weight of shoot material was kept in perforated paper bags which were kept in oven and dried at $60^0$for 48 hours.

and then dry weight was taken with the help of electronic balance and average was calculated.

3.9.9 Dry weight of roots per cutting (g):

After recording the fresh weight, roots were kept in perforated paper bags which were kept in oven and dried at 60^0 for 48 hours. and then dry weight was taken with the help of electronic balance and average was calculated.

3.9.10 Diameter of root (cm):

The root diameter of selected cuttings was recorded for each treatment from randomly selected five rooted cuttings with the help of Vernier Callipers at 45 days after planting and then average was calculated.

3.9.11 Rooting percentage:

Rooting percentage of cuttings was calculated for each treatment separately at 45 days after planting by using following formula:

Rooting percentage of cuttings = T-Mp/T x 100

Where,

T = Total number of rooted cuttings

Mp = Mortal plants

3.10 Statistical analysis

The data recorded in the field as well as in laboratory were statistically analyzed to know the degree of variation among the tested treatments. The analysis of variance was carried out for each character separately as per method of Panse and Sukhatme (1985). Significance of differences among treatments was tested using the following skeleton. The calculated 'F' value is compared with table F values at 5% and 10% level of significance. If the calculated 'F' value was greater than the table value the difference was said to be significant and critical difference was calculated for further comparison.

S.V.	D.F.	S.S.	M.S.S.	'F' value (cal.)	'F' value (tab.)
Treatment	(t-1)	TrSS	TrMS=TrMS/df	TrMS/EMS	
Error	t(r-1)	ESS	EMS=ESS/df		
Total	rt-1	TSS			

Where,

r = Number of replications

t = Number of treatments

TrSS = Sum of square for Treatments

TSS = Total Sum of Squares

ErSS = Error sum of squares

TrMSS = Mean sum of square for treatments

ErMSS = Mean sum of square for error

In order to compare the mean value of treatment, standard error and critical values were calculated as follows:

(a)Standard error of mean (S.Em. ±):

$$\text{(a) S.Em.} \pm = \sqrt{\frac{EMS}{r}}$$

Where,

S.EM= Standard error of mean

EMS= Error mean of square

r = Number of replication

(b) Critical difference (CD):

$$CD = S.Ed. \pm x\ t_{5\%\ (edf)}$$

$$\text{(b) } S.Ed = \sqrt{\frac{2\ EMS}{r}}$$

Where,

SEd = Standard error of difference between two treatment means

EMS = Error Mean of square

r = Number of replications

CHAPTER – IV

RESULTS

CHAPTER – IV

RESULTS

The results of the experiment entitled **"Effect of IBA and type of cutting on rooting of Golden Dewdrop (*Duranta plumeiri* L.)"** have been presented in this chapter. The data pertaining to various characters were subjected to statistical analysis by using CRD. In support of the tabular representation of data, graphical representation has also been presented in this chapter to provide better comprehension of the characters.

4.1. Number of roots per cutting

The data pertaining to number of roots per cutting with different treatments was presented in Table 4.1 and Fig. 4.1 and it can be observed from Table 4.1 and Fig. 4.1 that the effect of IBA and type of cutting on number of roots per cutting was statistically significant.

Data showed that the number of roots per cutting increased in all the treatments among the different IBA concentration. The maximum number of roots per cutting (20.70) was recorded with T_5 (Hardwood cutting + IBA 5000ppm), which was statistically superior to all other treatments, followed by T_4 (Hardwood cutting + IBA 4000ppm), T_3 (Hardwood cutting + IBA 3000ppm), T_8 (Softwood cutting + IBA 5000ppm) and T_7 (Softwood cutting + IBA 4000ppm) which recorded values of 19.76, 19.12,18.55 and 17.24 respectively, while the minimum number of roots per cutting (13.28) was recorded in T_2 (control Softwood cutting). T_1 (control Hardwood cutting) recorded a value of 14.32 in this parameter.

Table- 4.1: Effect of IBA and type of cutting on number of roots per cutting

Treatments	Symbol	Number of roots per cutting
Control (Hardwood cutting)	T_1	14.32
Control (Softwood cutting)	T_2	13.28
(Hardwood cutting + IBA 3000ppm)	T_3	19.12
(Hardwood cutting + IBA 4000ppm)	T_4	19.76
(Hardwood cutting + IBA 5000ppm)	T_5	20.70
(Softwood cutting + IBA 3000ppm)	T_6	16.47
(Softwood cutting + IBA 4000ppm)	T_7	17.24
(Softwood cutting + IBA 5000ppm)	T_8	18.55
S.Em.±		**0.21**
CD at 5%		**0.61**

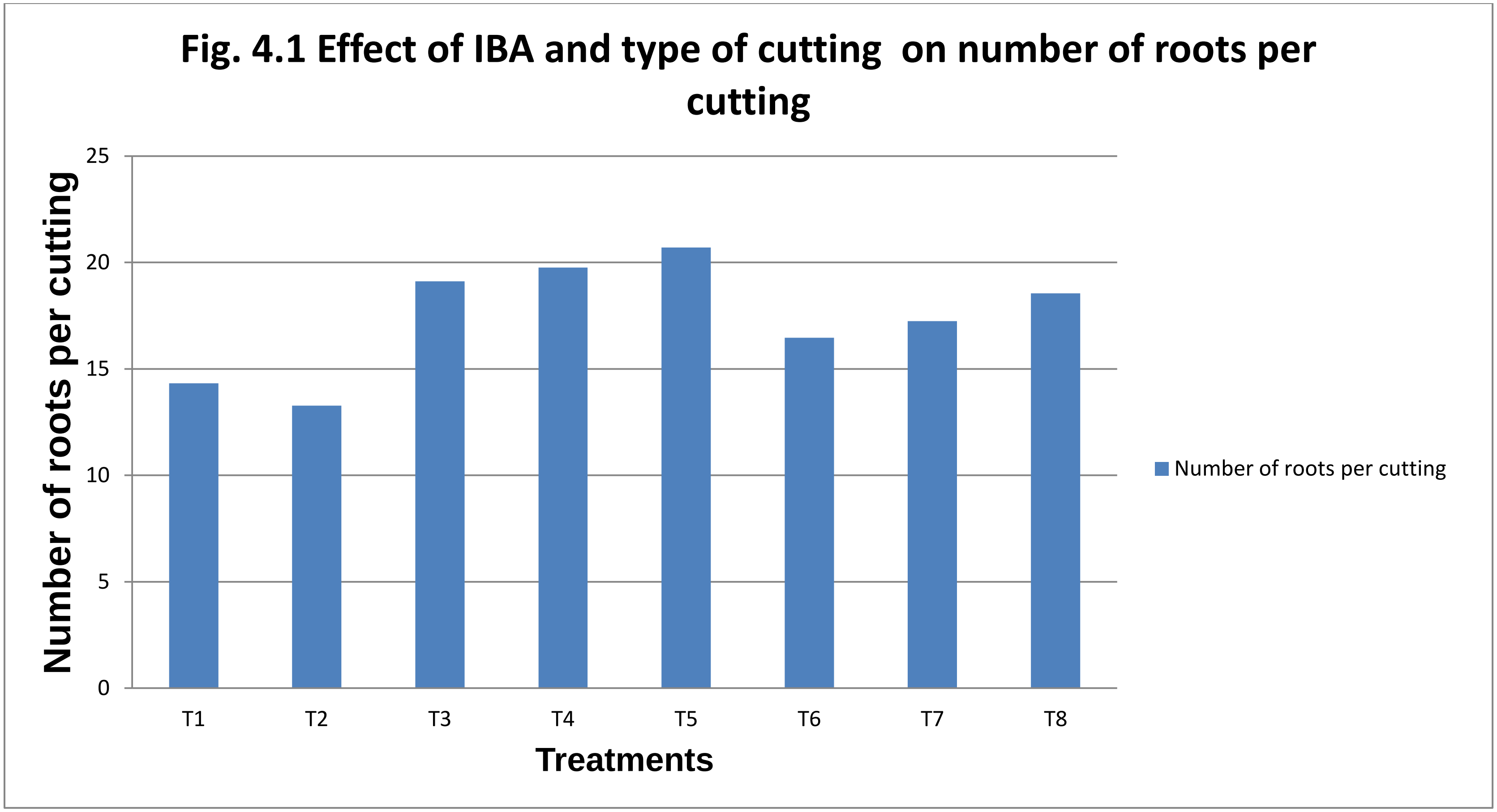


Fig. 4.1 Effect of IBA and type of cutting on number of roots per cutting
Number of roots per cutting
25
20
15
10
5
0
T1
T2
T3
T4
T5
T6
T7
T8
Treatments
Number of roots per cutting

Plate 3:- Effect of IBA & type of cutting on number of roots of Duranta.
T_5- IBA 5000ppm (Hardwood cutting) & T_2- Control (Softwood cutting)

4.2. Length of longest root (cm)

The data on length of longest root is presented in Table 4.2 and Fig. 4.2.

It is apparent from the Table (4.2) that the both IBA and Type of cutting significantly influenced the length of longest root of cuttings. The maximum length of longest root (12.23 cm) was recorded under treatment T_5 (Hardwood cutting + IBA 5000ppm), followed by T_4 (Hardwood cutting + IBA 4000ppm), T_3 (Hardwood cutting + IBA 3000ppm) and T_8 (Softwood cutting + IBA 5000ppm), which recorded 11.74 cm, 11.28 cm, and 10.93 cm respectively. The minimum length of longest root (9.60 cm) was observed in T_2 (control Softwood cutting).

4.3. Diameter of root (cm)

The data on diameter of root recorded at 45 days after planting of cutting is presented in Table 4.2 and Fig. 4.2.

The maximum diameter of root (0.17 cm) was noted in the treatment T_5 (Hardwood cutting + IBA 5000ppm), T_4 (Hardwood cutting + IBA 4000ppm) and T_3 (Hardwood cutting + IBA 3000ppm). The lowest value (0.11cm) for this attribute was observed in T_2 (control - Softwood cutting) and T_1 (control - Hardwood cutting).

Table- 4.2: Effect of IBA and type of cutting on length of longest root (cm) and diameter of root (cm).

Treatments	Symbol	Length of longest root (cm)	Diameter of root (cm)
Control (Hardwood cutting)	T_1	9.77	0.12
Control (Softwood cutting)	T_2	9.60	0.11
(Hardwood cutting + IBA 3000ppm)	T_3	11.28	0.15
(Hardwood cutting + IBA 4000ppm)	T_4	11.74	0.16
(Hardwood cutting + IBA 5000ppm)	T_5	12.23	0.17
(Softwood cutting + IBA 3000ppm)	T_6	10.26	0.13
(Softwood cutting + IBA 4000ppm)	T_7	10.70	0.13
(Softwood cutting + IBA 5000ppm)	T_8	10.93	0.15
S.Em.±		**0.06**	**0.01**
CD at 5%		**0.18**	**0.02**

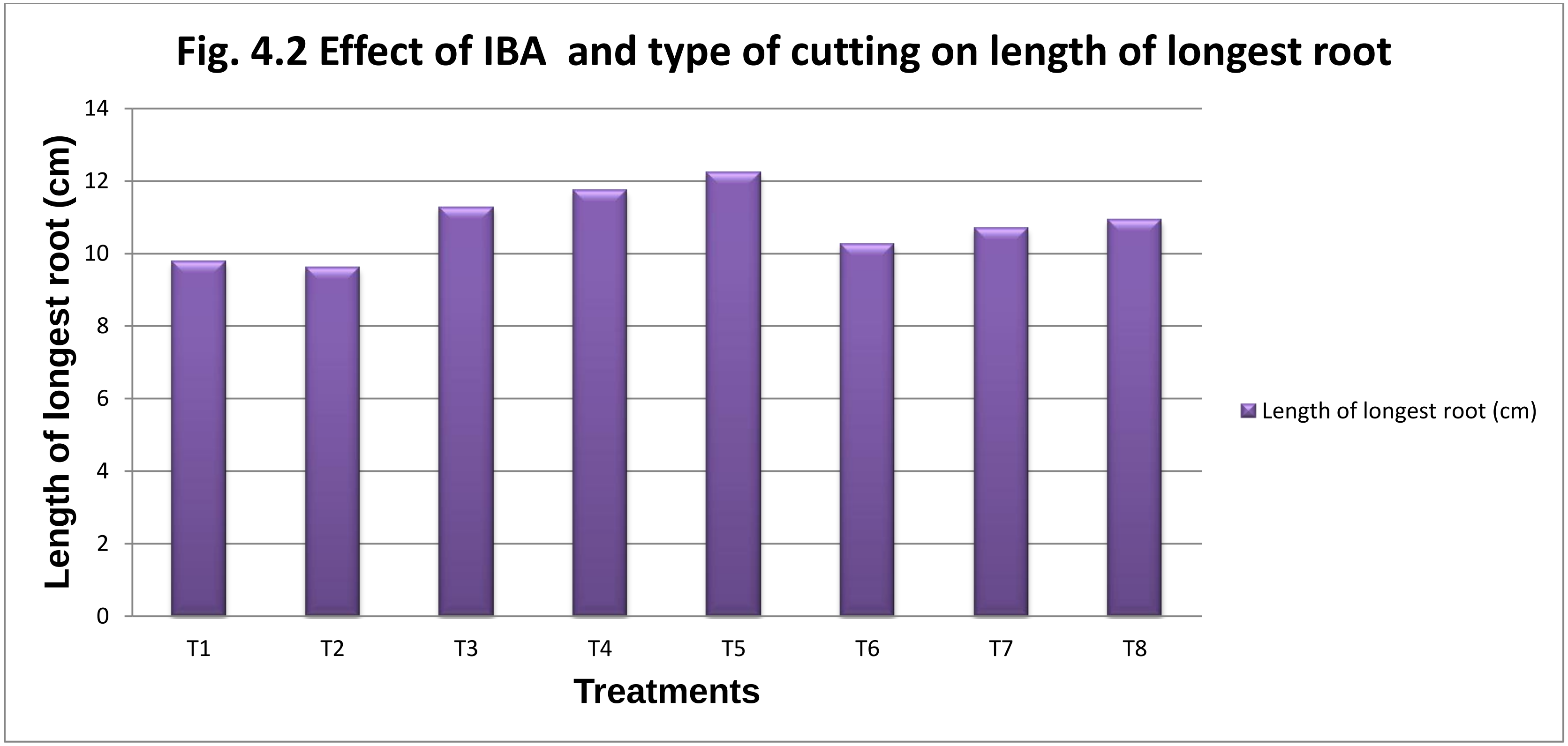


Fig. 4.2 Effect of IBA and type of cutting on length of longest root
Length of longest root (cm)
0
2
4
6
8
10
12
14
T1
T2
T3
T4
T5
T6
T7
T8
Treatments
Length of longest root (cm)

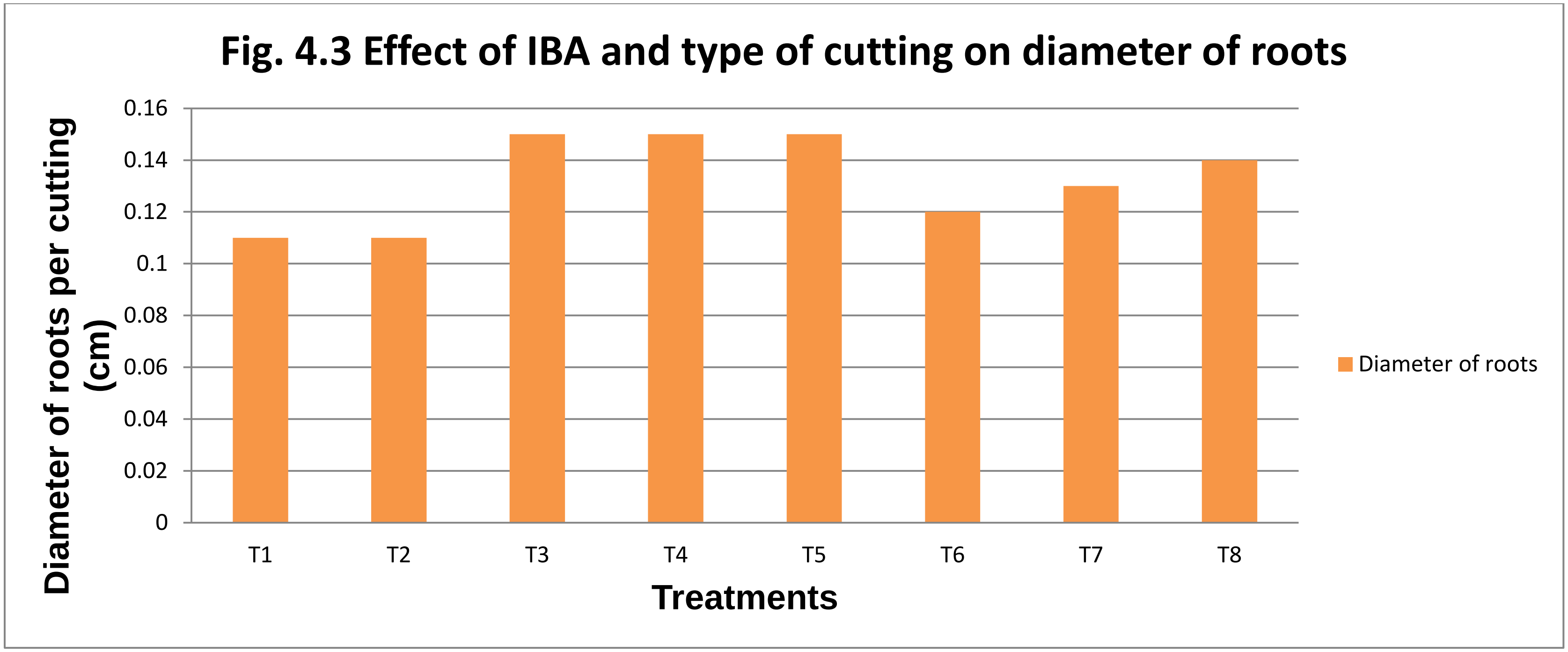


Fig. 4.3 Effect of IBA and type of cutting on diameter of roots
Diameter of roots per cutting (cm)
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
T1
T2
T3
T4
T5
T6
T7
T8
Treatments
Diameter of roots

4.4: Number of sprouts per cutting

The numbers of sprouts per cutting was recorded at 25, 35 and 45 days after planting. The data on the number of sprouts is given in Table 4.3 and Fig. 4.3.

It is apparent from the data that different concentrations of IBA and type of cutting significantly influenced the number of sprouts per cutting at 25, 35 and 45 days after planting of cuttings. The treatment T_5 (Hardwood cutting + IBA 5000ppm) recorded the highest number of sprouts per cutting (3.53) at 25 DAP, which was followed by T_4 (Hardwood cutting + IBA 4000ppm) which recorded a value of 3.03 and T_3 (Hardwood cutting + IBA 3000ppm) (2.80) whereas, the lowest number of sprouts per cutting (1.90) was observed in T_2 (control - Softwood cutting).

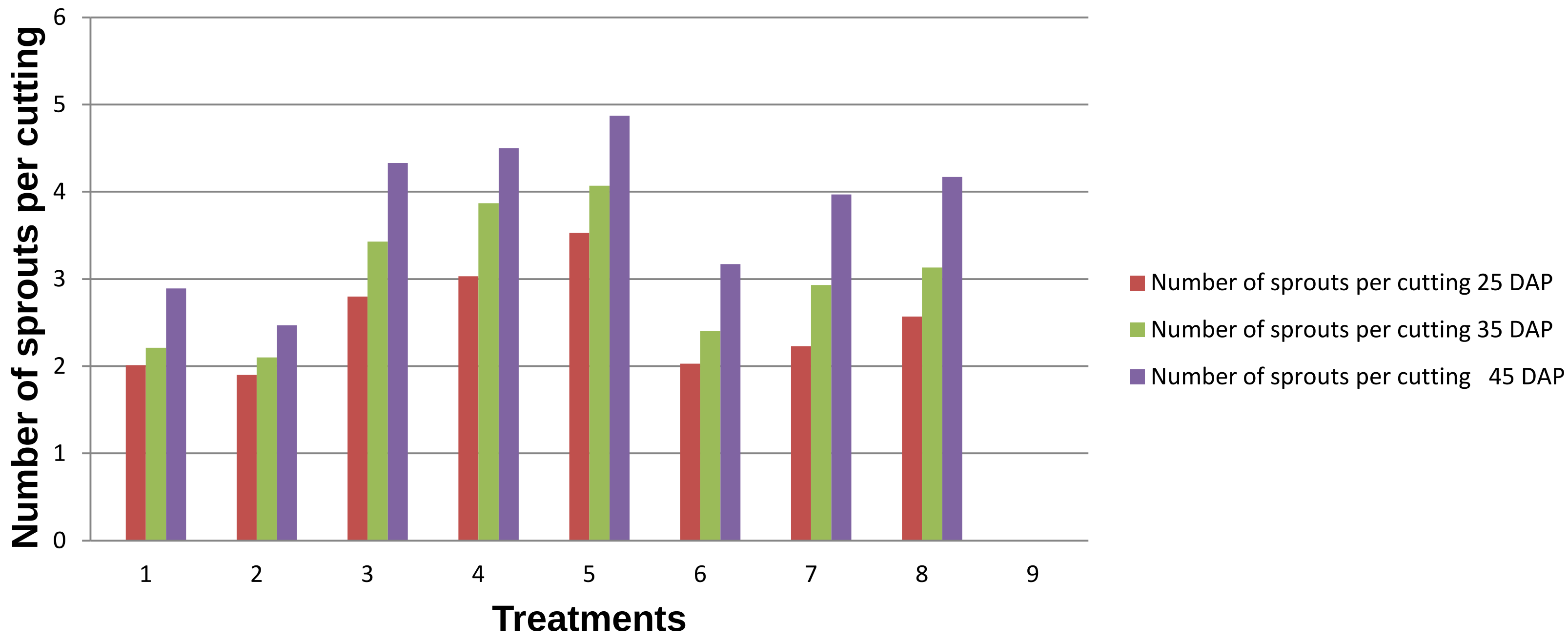
Number of sprouts per cutting ranged from 2.10 to 4.07 at 35 days after planting of cuttings. The highest number of sprouts (4.07) per cutting was noted under treatment T_5 (Hardwood cutting + IBA 5000ppm) and it was followed by T_4 (Hardwood cutting + IBA 4000ppm) (3.87) and T_3 (Hardwood cutting + IBA 3000ppm) (3.43). The lowest number of sprouts (2.10) was recorded in T_2 (control - Softwood cutting).

Similarly, at 45 days after planting, the maximum number of sprouts per cutting (4.87) was recorded under treatment T_5 (Hardwood cutting + IBA 5000ppm) followed by T_4 (Hardwood cutting + IBA 4000ppm) (4.50) and T_3 (Hardwood cutting + IBA 3000ppm) (4.33) which was significantly highest than all the treatments. The lowest number of sprouts (2.47) per cutting was recorded under T_2 (control - Softwood cutting).

Table- 4.3: Effect of IBA and type of cutting on number of sprouts per cutting at 25, 35 and 45 days after planting.

	Treatment	**Number of sprouts per cutting**		
		25 DAP	**35 DAP**	**45 DAP**
T_1	Control (Hardwood cutting)	2.01	2.21	2.89
T_2	Control (Softwood cutting)	1.90	2.10	2.47
T_3	(Hardwood cutting + IBA 3000ppm)	2.80	3.43	4.33
T_4	(Hardwood cutting + IBA 4000ppm)	3.03	3.87	4.50
T_5	(Hardwood cutting + IBA 5000ppm)	3.53	4.07	4.87
T_6	(Softwood cutting + IBA 3000ppm)	2.03	2.40	3.17
T_7	(Softwood cutting + IBA 4000ppm)	2.23	2.93	3.97
T_8	(Softwood cutting + IBA 5000ppm)	2.57	3.13	4.17
S.Em.±		**0.08**	**0.06**	**0.07**
CD at 5%		**0.25**	**0.17**	**0.21**

Fig. 4.4 Effect of IBA and type of cutting on number of sprouts per cutting



4.5: Length of shoot (cm)

Shoot length is one of the main characters representing vegetative growth of plant. The observations of shoot length were recorded at 25, 35 and 45 days after planting of cuttings. The data on length of shoot is given in Table 4.4 and Fig. 4.4.

It is apparent from the data that IBA and type of cutting significantly influenced the length of Duranta at 25, 35 and 45 days after planting. At 25 days after planting the maximum shoot length of (2.53 cm) was recorded with treatment T_5 (Hardwood cutting + IBA 5000ppm) which was followed by T_4 (Hardwood cutting + IBA 4000ppm) (2.40) whereas, the minimum average length of shoot (1.11 cm) was observed in T_2 control - softwood cutting).

At 35 days after planting the maximum shoot length of (4.55 cm) was recorded with the treatment T_5 (Hardwood cutting + IBA 5000ppm), which was followed by T_4 (Hardwood cutting + IBA 4000ppm) (4.29). The minimum shoot length (2.30 cm) was observed in T_2 (control - Softwood cutting).

Similarly, at 45 days after planting, the maximum length (5.51 cm) of shoot was recorded under treatment T_5 (Hardwood cutting + IBA 5000ppm), which was at per with treatment T_4 (Hardwood cutting + IBA 4000ppm) (5.36). The minimum length (3.62 cm) of shoot was recorded under control (T_2).

Table- 4.4: Effect of IBA and type of cutting on length of shoot per cutting at 25, 35 and 45 days after planting.

	Treatment	**Length of shoot per cutting**		
		25 DAP	**35 DAP**	**45 DAP**
T_1	Control (Hardwood cutting)	1.20	2.67	3.84
T_2	Control (Softwood cutting)	1.11	2.30	3.62
T_3	(Hardwood cutting + IBA 3000ppm)	2.27	4.09	5.01
T_4	(Hardwood cutting + IBA 4000ppm)	2.40	4.29	5.36
T_5	(Hardwood cutting + IBA 5000ppm)	2.53	4.55	5.51
T_6	(Softwood cutting + IBA 3000ppm)	1.52	3.38	4.48
T_7	(Softwood cutting + IBA 4000ppm)	1.92	3.43	4.53
T_8	(Softwood cutting + IBA 5000ppm)	2.11	3.69	4.67
S.Em.±		**0.04**	**0.05**	**0.05**
CD at 5%		**0.12**	**0.15**	**0.16**

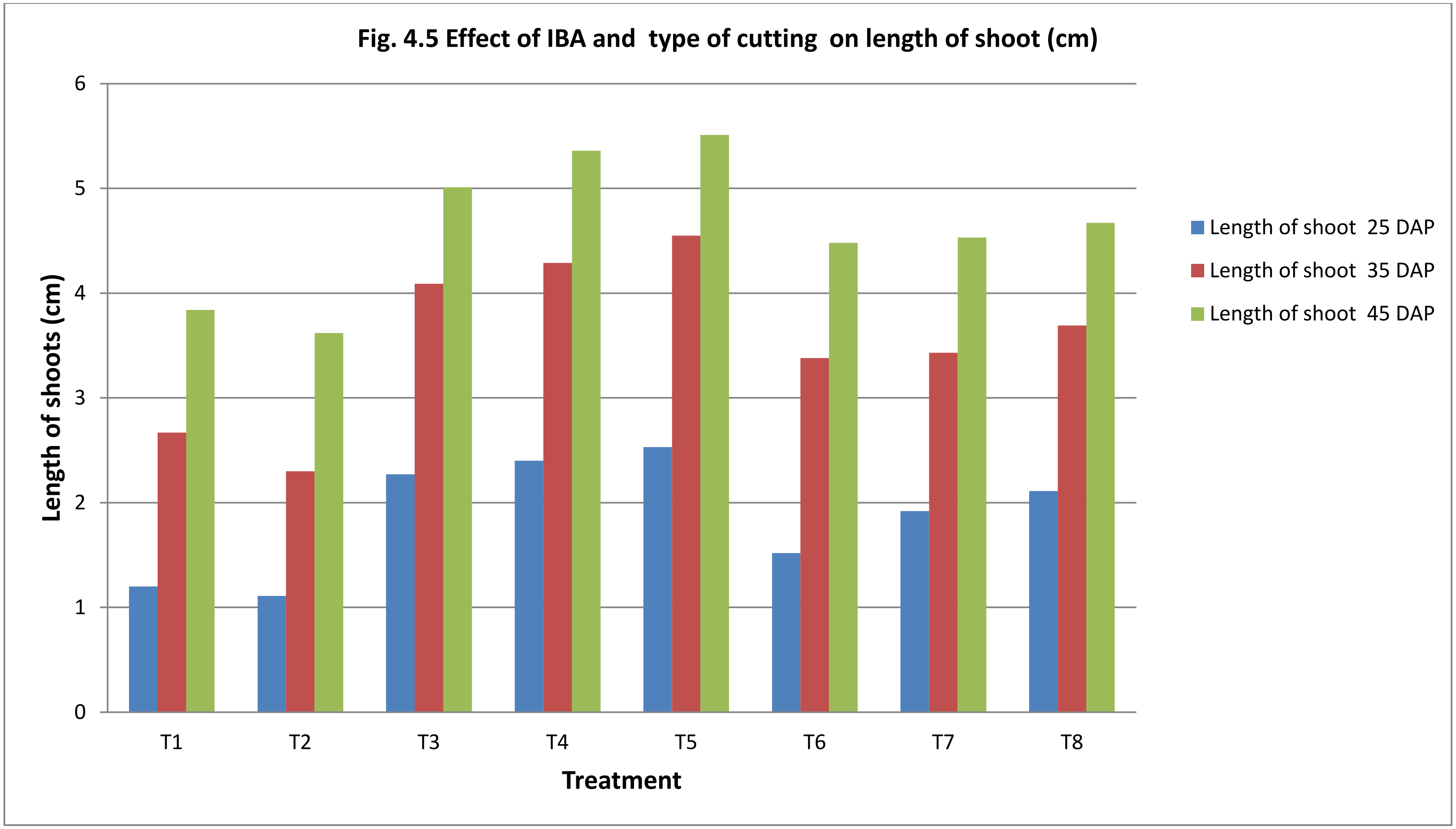


Fig. 4.5 Effect of IBA and type of cutting on length of shoot (cm)
Length of shoots (cm)
0
1
2
3
4
5
6
T1
T2
T3
T4
T5
T6
T7
T8
Treatment
Length of shoot 25 DAP
Length of shoot 35 DAP
Length of shoot 45 DAP

4.6: Number of leaves per cutting

Leaf is one of the main characters representing vegetative growth of plant. The number of leaves per cutting was recorded at the interval of 25, 35 and 45 days after planting of cuttings. The effect of different treatments on number of leaves per cutting is presented in Table 4.5 and Fig. 4.5.

Number of leaves per cutting at 25 days after planting ranged from 4.23 to 10.03. The maximum number of leaves (10.03) per cutting was recorded with treatment T_5 (Hardwood cutting + IBA 5000ppm) which was followed by T_4 (Hardwood cutting + IBA 4000ppm) (9.40). The minimum number of leaves (4.23) per cutting was recorded in T_2 (control - Softwood cutting).

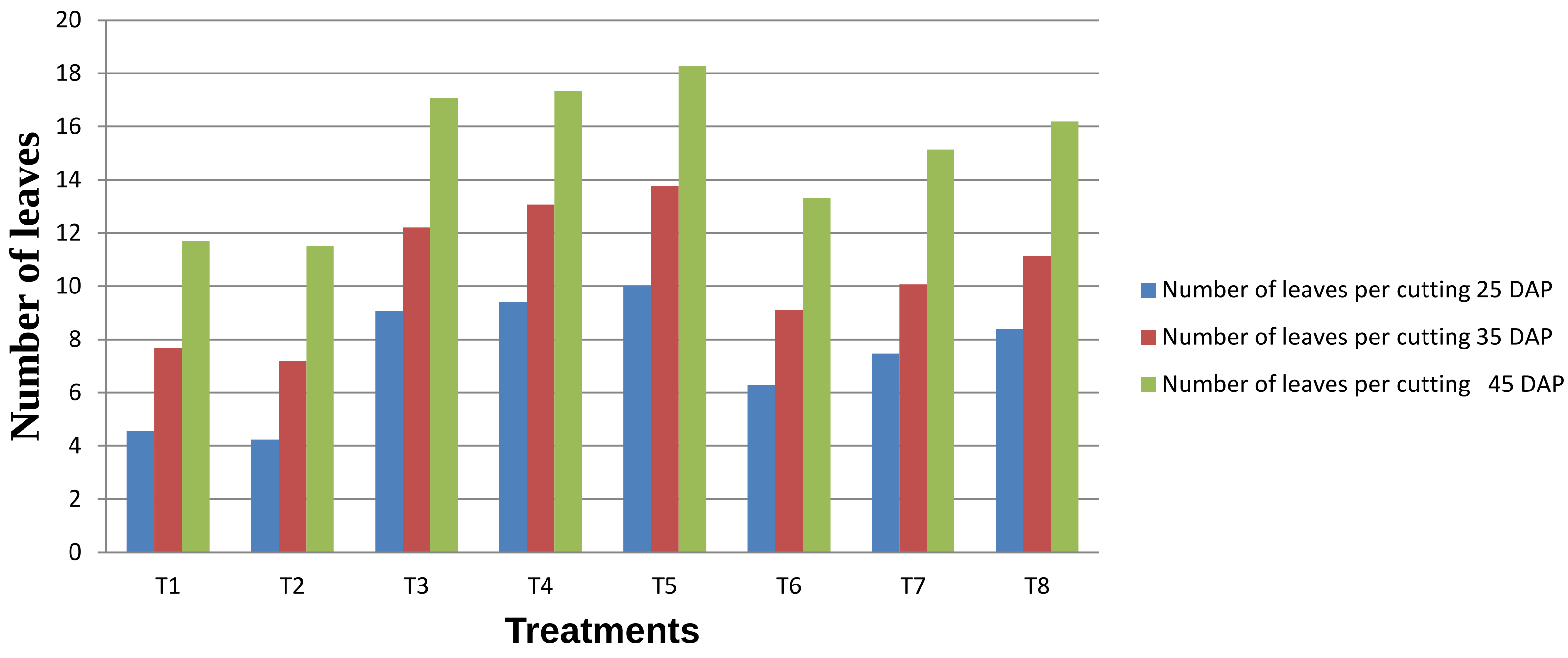
At 35 days after planting of cuttings, the maximum (13.77) value for this attribute was noted with the treatment T_5 (Hardwood cutting + IBA 5000ppm), followed by T_4 (Hardwood cutting + IBA 4000ppm) (13.07) and T_3 (Hardwood cutting + IBA 3000ppm) (12.20). The lowest number (7.20) of leaves per cutting was observed in T_2 (control - Softwood cutting).

At 45 days after planting, the number of leaves per cutting ranged from 11.50 to 18.27. The maximum number (18.27) of leaves per cutting was observed under treatment T_5 (Hardwood cutting + IBA 5000ppm) which was found significantly superior to all other treatments of this study. The lowest number (11.50) of leaves per cutting was recorded in control (T_2).

Table- 4.5: Effect of IBA and type of cutting on number of leaves per cutting at 25, 35 and 45 days after planting.

	Treatment	Number of leaves per cutting		
		25 DAP	**35 DAP**	**45 DAP**
T_1	Control (Hardwood cutting)	4.57	7.67	11.71
T_2	Control (Softwood cutting)	4.23	7.20	11.50
T_3	(Hardwood cutting + IBA 3000ppm)	9.07	12.20	17.07
T_4	(Hardwood cutting + IBA 4000ppm)	9.40	13.07	17.33
T_5	(Hardwood cutting + IBA 5000ppm)	10.03	13.77	18.27
T_6	(Softwood cutting + IBA 3000ppm)	6.30	9.10	13.30
T_7	(Softwood cutting + IBA 4000ppm)	7.47	10.07	15.13
T_8	(Softwood cutting + IBA 5000ppm)	8.40	11.13	16.20
S.Em.±		**0.14**	**0.20**	**0.30**
CD at 5%		**0.42**	**0.58**	**0.91**

Fig. 4.6 Effect IBA on type of cutting on number of leaves per cutting



4.7: Fresh weight of shoots per cutting (g)

The data pertaining to fresh weight of shoots per cutting with different treatments are presented in Table 4.6 and Fig. 4.6 and it can be observed from that the effect of IBA and type of cutting on fresh weight of shoots per cutting was statistically significant.

The maximum fresh weight of shoots per cutting (3.42 g) was recorded with T_5 (Hardwood cutting + IBA 5000ppm) which was at par with treatment T_4 (Hardwood cutting + IBA 4000ppm) (3.34 g) and followed by T_3 (Hardwood cutting + IBA 3000ppm), T_8 (Softwood cutting + IBA 5000ppm) and T_7 (Softwood cutting + IBA 4000ppm) which recorded 3.15 g, 2.88 g and 2.69 g respectively, while the minimum fresh weight of shoots per cutting (1.46 g) was recorded in T_2 (control - Softwood cutting).

4.8: Dry weight of shoots per cutting (g)

The data pertaining to dry weight of shoots per cutting with different treatments were presented in Table 4.6 and Fig. 4.6.

The maximum dry weight of shoots per cutting (1.27 g) was recorded with T_5 (Hardwood cutting + IBA 5000ppm) which was followed by T_4 (Hardwood cutting + IBA 4000ppm) (1.21 g) and T_3 (Hardwood cutting + IBA 3000ppm) (1.12 g) respectively, while the minimum dry weight of shoots per cutting (0.62) was recorded in T_2 (control - Softwood cutting).

Table- 4.6: Effect of IBA and type of cutting on fresh weight of shoot (g) and dry weight of shoot (g) per cutting.

Treatments	Symbol	Fresh weight of shoot (g)	Dry weight of shoot (g)
Control (Hardwood cutting)	T_1	1.79	0.65
Control (Softwood cutting)	T_2	1.46	0.62
(Hardwood cutting + IBA 3000ppm)	T_3	3.15	1.12
(Hardwood cutting + IBA 4000ppm)	T_4	3.34	1.21
(Hardwood cutting + IBA 5000ppm)	T_5	3.42	1.27
(Softwood cutting + IBA 3000ppm)	T_6	2.28	0.87
(Softwood cutting + IBA 4000ppm)	T_7	2.69	0.94
(Softwood cutting + IBA 5000ppm)	T_8	2.88	0.96
S.Em.±		**0.04**	**0.01**
CD at 5%		**0.11**	**0.04**

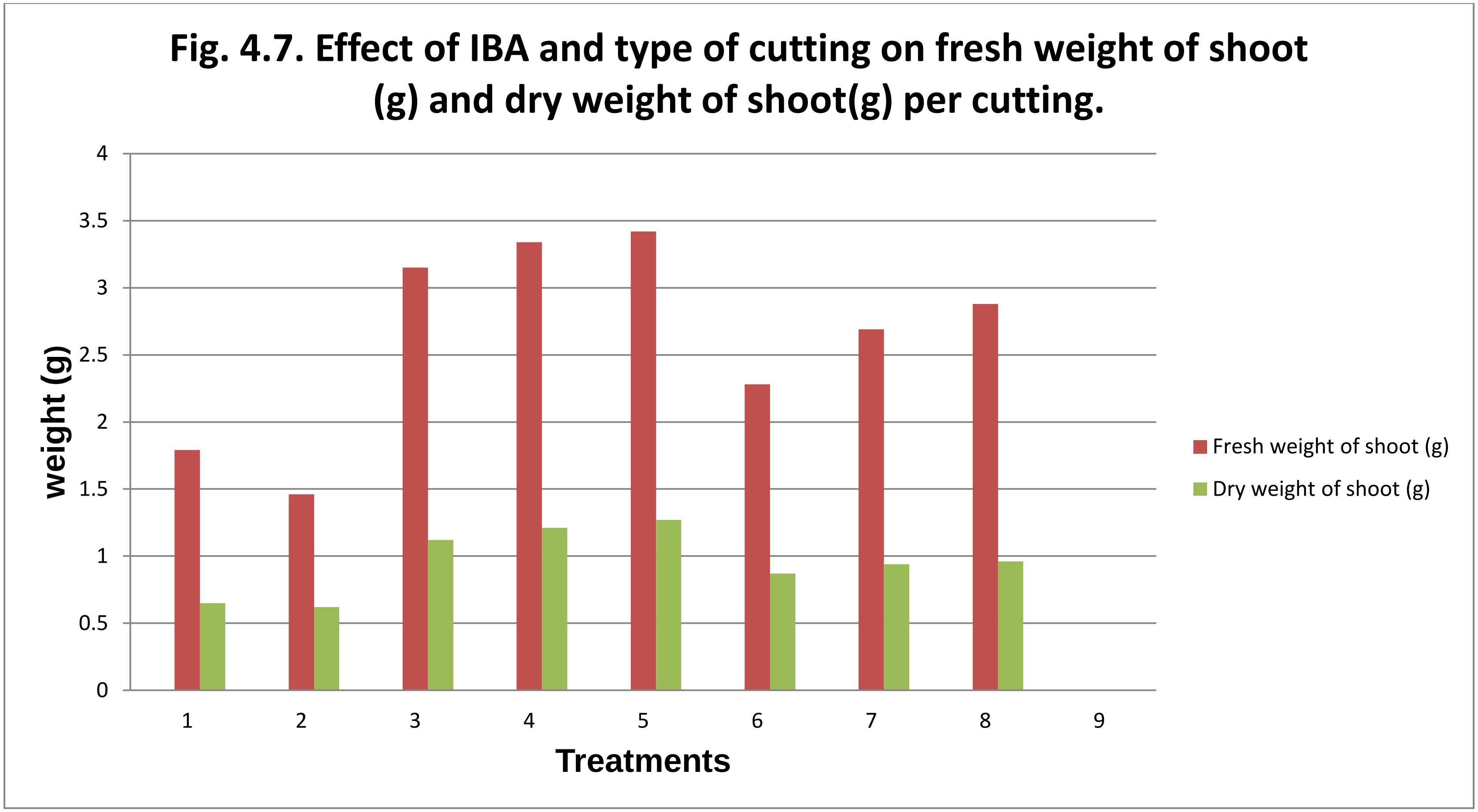


Fig. 4.7. Effect of IBA and type of cutting on fresh weight of shoot (g) and dry weight of shoot(g) per cutting.
weight (g)
4
3.5
3
2.5
2
1.5
1
0.5
0
1
2
3
4
5
6
7
8
9
Treatments
Fresh weight of shoot (g)
Dry weight of shoot (g)

4.9: Fresh weight of roots per cutting (g)

The data pertaining to fresh weight of roots per cutting with different treatments are presented in Table 4.7 and Fig. 4.7 and it can be observed that the effect of IBA and type of cutting on fresh weight of shoots per cutting was statistically significant.

The maximum fresh weight of roots per cutting (0.66 g) was recorded with T_5 (Hardwood cutting + IBA 5000ppm) which was followed by treatment T_4 (Hardwood cutting + IBA 4000ppm), T_3 (Hardwood cutting + IBA 3000ppm), T_8 (Softwood cutting + IBA 5000ppm) and T_7 (Softwood cutting + IBA 4000ppm) which recorded 0.62 g, 0.56 g, 0.49 g and 0.44 g respectively, while the minimum fresh weight of roots per cutting (0.28 g) was recorded in T_2 (control - Softwood cutting).

4.10: Dry weight of roots per cutting (g)

The data pertaining to dry weight of roots per cutting with different treatments are presented in Table 4.7 and Fig. 4.7.

The maximum dry weight of roots per cutting (0.28 g) was recorded with T_5 (Hardwood cutting + IBA 5000ppm) which was followed by T_4 (Hardwood cutting + IBA 4000ppm) (0.26 g) and T_3 (Hardwood cutting + IBA 3000ppm) (0.23 g) respectively, while the minimum dry weight of roots per cutting (0.11g) was recorded in T_2 (control - Softwood cutting).

Table- 4.7: Effect of IBA and type of cutting on fresh weight of root (g) and dry weight of root (g) per cutting.

Treatments	Symbol	Fresh weight of root (g)	Dry weight of root (g)
Control (Hardwood cutting)	T_1	0.31	0.12
Control (Softwood cutting)	T_2	0.28	0.11
(Hardwood cutting + IBA 3000ppm)	T_3	0.56	0.23
(Hardwood cutting + IBA 4000ppm)	T_4	0.62	0.26
(Hardwood cutting + IBA 5000ppm)	T_5	0.66	0.28
(Softwood cutting + IBA 3000ppm)	T_6	0.40	0.15
(Softwood cutting + IBA 4000ppm)	T_7	0.44	0.17
(Softwood cutting + IBA 5000ppm)	T_8	0.49	0.21
S.Em.±		**0.01**	**0.01**
CD at 5%		**0.03**	**0.01**

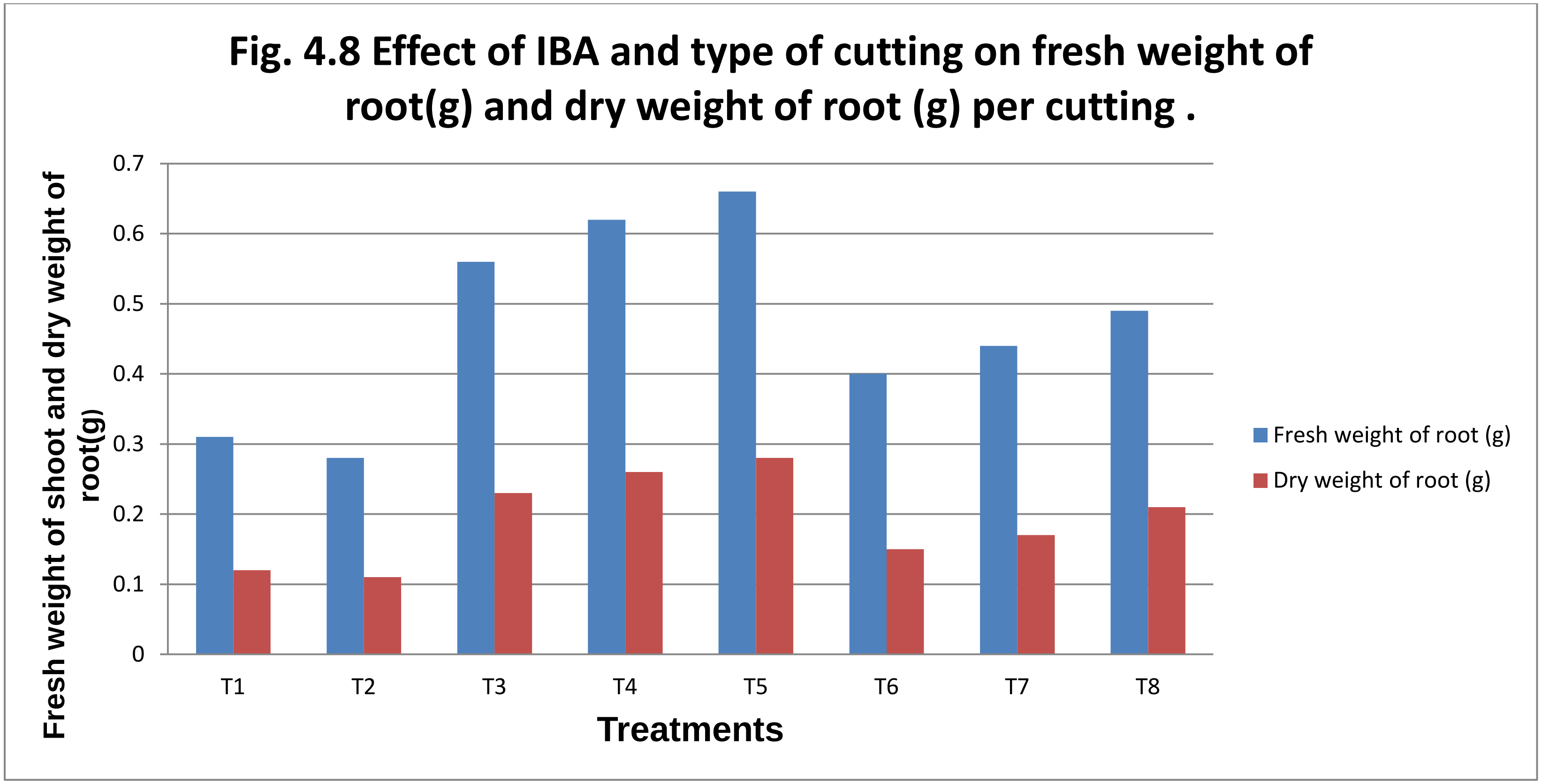


Fig. 4.8 Effect of IBA and type of cutting on fresh weight of root(g) and dry weight of root (g) per cutting .
Fresh weight of shoot and dry weight of root(g)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
T1
T2
T3
T4
T5
T6
T7
T8
Treatments
Fresh weight of root (g)
Dry weight of root (g)

4.11: Rooting percentage

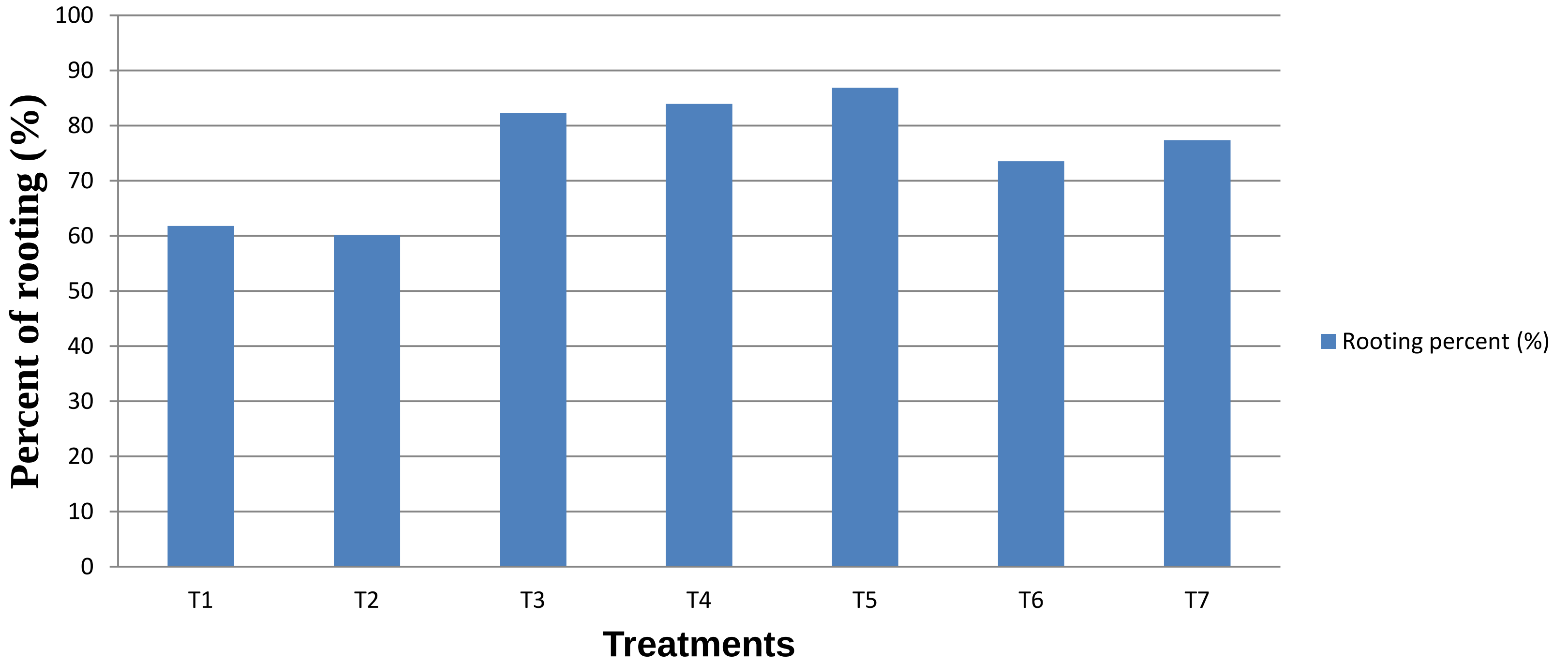
The data on rooting percentage is presented in Table 4.8 and Fig. 4.8.

The rooting percentages were significantly affected by the treatments. Results revealed that the rooting percentage of rooted cutting ranged from 60.12 to 86.90 %. The maximum rooting percentage (86.90 %) was recorded with T_5 (Hardwood cutting + IBA 5000ppm) which was followed by T_4 (Hardwood cutting + IBA 4000ppm) (83.97 %) and T_3 (Hardwood cutting + IBA 3000ppm) (82.26 %) respectively. The lowest rooting percentage (60.12 %) was recorded in T_2 (control -Softwood cutting).

Table- 4.8: Effect of IBA and type of cutting on rooting percent of cuttings

Treatments	Symbol	Rooting percent (%)
Control (Hardwood cutting)	T_1	61.85
Control (Softwood cutting)	T_2	60.12
(Hardwood cutting + IBA 3000ppm)	T_3	82.26
(Hardwood cutting + IBA 4000ppm)	T_4	83.97
(Hardwood cutting + IBA 5000ppm)	T_5	86.90
(Softwood cutting + IBA 3000ppm)	T_6	73.55
(Softwood cutting + IBA 4000ppm)	T_7	77.36
(Softwood cutting + IBA 5000ppm)	T_8	81.08
S.Em.±		**0.48**
CD at 5%		**1.42**

Fig. 4.9 **Effect of IBA and type of cutting on rooting percent of cutting**



CHAPTER – V

DISCUSSION

CHAPTER – V

DISCUSSION

In this chapter an attempt has been made to evaluate the possible reasons of the variability obtained due to treatment differences in the present investigation entitled **"Effect of IBA and type of cutting on rooting of Golden Dewdrop (*Duranta plumeiri* L.)"** The findings described in the preceding chapter have been critically discussed here in detail.

4.1. Number of roots per cutting

The present investigation revealed a significant influence of IBA and type of cuttings on the number of roots per cutting.

The maximum number of roots per cutting was recorded by treatment T_5 (Hardwood cutting + IBA 5000ppm) followed by T_4 (Hardwood cutting + IBA 4000ppm) and T_3 (Hardwood cutting + IBA 3000ppm).

The above finding indicated that the treatment of cutting by auxin with appropriate concentration induces early and better root initiation. Thus, the maximum number of roots was produced in those cuttings which received appropriate concentration of auxin. This might be because auxin application initiates early and more roots per cuttings. The best rooting promoter is IBA due to its fast auxin activity and an enzymatic system of fairly slow destruction. The increase in number of roots by the application of auxin is a common feature in many herbaceous perennial crops (Hartmann *et al*., 2002).

The influence of auxins in promoting adventitious root formation through their ability to promote the initiation of lateral roots and enhancing the transport of carbohydrates to the cutting base is well documented in several studies. Zeinab and

Hossein (2014) also reported that IBA treatments significantly increased rooting percentage compared with the control in *Hibiscus rosa-sinensis*.

Similar findings have been reported by Ullah *et al.* (2013) in Marigold, and Singh *et al.* (2013) in Night Queen.

4.2. Length of longest root (cm)

The length of longest root increased in all the treatments. The maximum length of longest root was recorded with T_5 (Hardwood cutting + IBA 5000ppm), which was statistically superior to all the treatments, while the minimum number of roots per cutting was recorded in control.

The appropriate concentration of IBA and type of cutting of Duranta showed better length of roots and it may be due to early differentiation of cells and enhanced cell elongation caused by auxin. Auxins initiate synthesis of structural enzyme protein in the formation of adventitious root thus increasing the root length (Audus, 1963).

Similar findings were observed by Sharma (2014) in Marigold, Swamy *et al.* (2002) in *Grewia optiva* and *Robinia pseudoacacia*, Grewal *et al.* (2005) in *Dendranthema grandiflora* cv. Snowball and Singh *et al.* (2013) in Night Jasmine.

4.3. Diameter of root (cm)

The present investigation revealed a significant influence of IBA and type of cuttings on diameter of roots per cutting. The maximum diameter of root was noted in the treatment T_5 (Hardwood cutting + IBA 5000ppm), T_4 (Hardwood cutting + IBA 4000ppm) and T_3 (Hardwood cutting + IBA 3000ppm). The lowest value for this attribute was observed in T_2 control.

The increase in the length and thickness of root over control may be due to the enhanced hydrolysis of carbohydrates, auxin induced accumulation of metabolites and cell division caused by treatment with auxin .The present finding is in close agreement with of Shenoy (1992) in *Rosa damascena*

4.4: Number of sprouts per cutting

The number of sprouts per cutting increased in all the treatments among the different IBA concentration and type of cutting. The maximum number of sprouts per cutting was recorded with T_5 (Hardwood cutting + IBA 5000ppm), which was statistically superior to all the treatments, while the minimum number of sprouts per cutting was recorded in control.

The number of sprouts per cuttings was observed to be more IBA treated cuttings and it may be due to auxin and its appropriate concentration which enhance the formation of callus and tissue and differentiation of vascular tissue (Mitra and Bose, 1954).

This support the finding that the less mature a plant, generally the easier it is to root a cutting from it, also the less mature the growth stage of a plant for example the softwood the more easily it can lose water, dry out and die. In addition, Day and Loveys, (1998) and Dole and Wilkins, (2005) also stated that the success of rooting of woody stem cuttings in the majority of ornamental plants depends on the physiological stage of the mother plant. Also rooting varies with the type of cutting, the species rooted and the environmental conditions.

These finding agree with the finding of Singh *et. al* (2013) in night queen (*Cestrum nocturnum* L).

4.5: Length of shoot (cm)

The maximum shoot length was recorded in T_5 (Hardwood cutting + IBA 5000ppm) and it may be due to early sprouting of vegetative buds which was noted with this treatment. Auxin enhanced cell division , cell enlargement and promotion of protein synthesis which might have resulted in enhanced vegetative growth.

Similar findings were observed by Ullah *et al.* (2013) in Marigold and Girisha *et al.* (2012) in Daisy.

4.6: Number of leaves per cutting

There were significant differences for number of leaves per cutting among different treatments. The maximum number of leaves per cutting was recorded by treatment T_5 (Hardwood cutting + IBA 5000ppm).

Increase in number of leaves may be due to vigorous growth and early initiation of roots induced by the growth regulator which absorbs more nutrients and thereby producing more leaves as reported by Stancato *et al.* (2003).

The experiment was conducted during the rainy season which supports high humidity thereby reducing the heat load on the cuttings hence permitting the utilization of high light conditions to increase photosynthesis (Hartmann *et. al*, 1990; Acquaah, 2005). Leaves are the primary photosynthetic organ which captures sunlight for the process of photosynthesis towards the growth and subsequent development of the plant (Stancato *et al.* 2003).

4.7: Fresh weight of shoots per cutting (g)

The fresh weight of shoots per cutting was recorded maximum in T_5 (Hardwood cutting + IBA 5000ppm), This might be due to early and fast cell division and cell enlargement with early and easy initiation of roots caused by auxin. Fresh matter accumulation of plant depends upon the vegetative growth parameter *viz.* plant height, spread or average number of branches and it is directly influenced by auxin. Thus it enhanced the fresh matter accumulation, resulted from photosynthesis or the hydrolysis of starch resulting in increase in concentration of sugar (Thimman, 1972).

4.8: Dry weight of shoots per cutting (g)

The dry weight of shoots was recorded the highest in T_5 (Hardwood cutting + IBA 5000ppm) treated cuttings and it may be due to contribution of early sprouting and good length of shoot. The increase in dry weight may be ascribed to effects of plant growth regulators, higher rate of supply of photosynthates from source to sink which subsequently might have resulted in higher fresh matter and dry matter accumulation (Singh, 2004).

4.9: Fresh weight of roots per cutting (g)

The fresh weight of the root is related to number of roots, length of roots and thickness of the roots, which were found to be maximum in T_5 (Hardwood cutting + IBA 5000ppm).

It was observed that fresh weight of roots is directly associated to the number and size of root. Increase in number and length of roots, enhanced the fresh weight of roots. The reason for this may be the more rapid translocation of hormone along the way of cell division and elongation and enhanced enzymatic activity (Debnath and Maiti, 1990). Similar effect has also been observed by Farooqi *et al.* (1994) in *Rosa damascena*.

Sharma (2014) also reported that IBA is responsible to increase the fresh weight of roots in Marigold.

4.10: Dry weight of roots per cutting (g)

The dry weight of roots is related to number of roots, length of roots and thickness of the roots, which were found to be maximum in T_5 (Hardwood cutting + IBA 5000ppm).

Auxin treatment induced higher number of roots, cell elongation of roots with cell division and consequently accounting for higher fresh weight and thus dry weight of roots.

Rana and Sood (2012) also found that IBA is better than IAA and NAA for producing maximum number of lateral roots.

4.11: Rooting percentage

Among all treatments, the highest rooting percentage was observed in T_5 (Hardwood cutting + IBA 5000ppm) and combinations of Hardwood cutting + IBA 4000ppm (T_4), which may be due to the better rooting and other root parameters in these treatments, the treatments which recorded highest fresh and dry weights of roots were able to survive better under field condition. Similar results were observed by Pooja (2010) in Japanese honey suckle and Shenoy (1992) in *Rosa damascena.*

CHAPTER – VI

SUMMARY, CONCLUSIONS AND SUGGESTIONS FOR FUTURE WORK

Chapter – VI

SUMMARY, CONCLUSIONS AND SUGGESTIONS FOR FURTHER WORK

6.1: Summary:

The present investigation entitled: **"Effect of Indole butyric acid and type of cutting on rooting of Golden Dewdrop (*Duranta plumeiri* L.)"** was conducted during 2017-18 at the Department of Floriculture and Landscape Architecture, K.N.K. College of Horticulture, Mandsaur, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.).

The experiment was laid out in Completely Randomized Design with three replications. Two types of Duranta cutting (softwood and hardwood) and three concentrations of IBA (3000 ppm, 4000 ppm and 5000 ppm) were used for this experiment. The observations on different rooting and shooting parameters were recorded and the results obtained are summarized below.

Number of roots per cutting was found maximum under T_5 (hardwood cutting + IBA 5000ppm) which was followed by T_4 (hardwood cutting +IBA 4000ppm) The lowest number of roots per cutting was observed in untreated softwood cutting at 45 days after planting.

Length of longest root (cm) was found to be maximum under T_5 (hardwood cutting +IBA 5000ppm) which was followed by T_4 (hardwood cutting +IBA 4000ppm). The minimum length of longest root per cutting was observed in untreated softwwood cutting at 45 days after planting.

Diameter of root (cm) was found to be maximum under T_5 (hardwood cutting + IBA 5000ppm) which was followed by T_4 (hardwood cutting +IBA 4000ppm). The minimum diameter of roots was observed in untreated softwood cutting at 45 days after planting.

Number of sprouts per cutting was found to be maximum under T_5 (hardwood cutting + IBA 5000ppm) which was followed by T_4 (hardwood cutting +IBA 4000ppm).

The minimum number of sprouts per cutting was observed in untreated softwood cutting at 10 days after planting.

Length of shoot (cm) was found to be maximum under T_5 (hardwood cutting + IBA 5000ppm) which was followed by T_4 (hardwood cutting + IBA 4000ppm). The minimum length of shoot was observed in untreated softwood cutting) at 10 days after planting.

Fresh weight of shoots per cutting (g) was found to be the maximum under T5 (hardwood cutting + IBA 5000ppm) which was followed by T_4 (hardwood cutting + IBA 4000ppm), The minimum fresh weignt of shoots per cutting was observed in untreated softwood cutting at 45 days after planting.

Number of leaves per cutting was found to be maximum with the application of T_5 (hardwood cutting + IBA 5000ppm) which was followed by T_4 (hardwood cutting + IBA 4000ppm) The lowest number of leaves per cutting was observed in untreated softwood cutting.

Fresh weight of roots per cutting (g) was found to be maximum under T_5 (hardwood cutting + IBA 5000ppm) which was followed by T_4 (hardwood cutting +IBA 4000ppm). The minimum fresh weight of roots per cutting was observed in untreated softwood cutting at 45 days after planting.

Dry weight of shoot per cutting (g), was found to be maximum under T_5 (hardwood cutting + IBA 5000ppm) which was followed by T_4 (hardwood cutting +IBA 4000ppm). The lowest dry weight of shoots per cutting was observed in untreated softwood cutting at 45 days after planting.

Dry weight of roots per cutting (g), was found to be the maximum under T_5 (hardwood cutting + IBA 5000ppm) which was followed by T_4 (hardwood cutting + IBA 4000ppm). The minimum dry weight of roots per cutting was observed in untreated softwood cutting at 45 days after planting.

Rooting percentage was found to be maximum under T_5 (hardwood cutting + IBA 5000ppm) which was followed by T_4 (hardwood cutting +IBA 4000ppm). The lowest rooting percentage was observed in untreated softwood cutting at 45 days after planting.

6.2 Conclusions

On the basis of the results obtained by the investigation entitiled **"Effect of Indole butyric acid and type of cutting on rooting of Golden Dewdrop (*Duranta plumeiri* L.)"** it may be concluded that T_5 (hardwood cutting +IBA 5000 ppm) proved better than all other treatments recording the maximum value of various attributes related to the growth of shoot and root parameters like number of roots per cutting, length of longest root, number of sporuts per cutting, number of leaves per cutting, length of shoot, fresh weight of shoots per cutting, fresh weight of roots per cutting, dry weight of shoots per cutting, dry weight of roots per cutting, diameter of root and rooting percentage of duranta cuttings.

6.3 Suggestions for future work

Following future line of work is suggested for obtaining improved propagations for benefit to growers.

1. Since it was the first year of trial it is suggested that, finding of the present study must be tested over year and locations for confirmation.
2. More concentrations of IBA may be tested on Duranta cuttings.
3. Other auxins in different concentrations can be tested on Duranta cuttings.
4. Similar studies may be conducted during different seasons.
5. Such studies may be conducted on different woody ornamentals suitable for the Malwa region of M.P.

REFERENCES

Bibliography

Abbas, M.H.; Baksh, M.A.; Ahmad, S.; Javeid M.A. and Rehman, A. (2015). Effect of individual and combined concentrations of IBA and NAA for root development of Rose cultivar, Bajazzo. *J. Agric. Res*., **53**(2).

Acquaah, G. (2005). Horticulture: Principles and Practices, Third Edition, Upper Saddle River, Pearson Education Incorporated Hall New Jersey. 367pp.

Akhtar, M.S.; Khan, M.A.; Atif R. and Adnan Y. (2002). Response of different rose species to different root promoting hormones. *Pak. J. Agri. Sci.,* **39**(4): 297-299.

Akhtar, G.; Akram, A.; Sajjad, Y.; Balal, R.M.; Shahid, M.A.; Sardar, H.; Naseem, K. and Shah, S.M. (2015). Potential of plant growth regulators on modulating rooting of *Rosa centifolia. American Journal of Plant Sciences*, **6**: 659-665.

Amaral, G.C.; Brito, L.D.S.; Avelino, R.C.; Silva, J. and Beckmann-Cavalcante, M.Z. (2012). Seedling production of *Duranta repens* L. using cuttings process. *Revista deCiencias Agrarnas* (Portugal), **35**(1): 134-142.

Audus, L.J. (1963). Plant growth substances, Leonard Hill Books Ltd., London.

Bharmal, V.S.; Ranpise, S.A. and Darwade, R.T. (2005). Effect of different levels of indole butyric acid (IBA) on rooting, growth and flower yield of Chrysanthemum cv. Sonali Tara. *Orissa J. Horti,,* **33**(2): 36- 41.

Bhagya, H.P.; Lalithya, K.A. and Bharathi, K. (2014). Influence of growth hormones and nodal cutting on rooting of *Vitex negundo* L. *Indian J. Agric. Res.,* **48** (2) 81-88.

Bhatt, S.T. and Chauhan, N.M. (2012). Effect of auxin on rooting of African marigold (*Tagetes erecta* L.) *Advanced Res. J. of crop Improvement,* **3**(1) : 69-70.

Dawa, S.; Rather, Z.A.; Tundup, P. and Tamchos, T. (2017). Effect of growth regulators and growth media on rooting of semi hardwood cuttings of rose root stocks. *Int. J. Curr. Microbiol. App. Sci.,* **6**(4): 1042-1051.

Day, J. S. and Loves, B. R. (1998). Propagation from cutting of two woody ornamental Australian shrub *Boronia megastigma* and *Hypocalymna angustifolium* Endl. (White myrtle). *Australian J. Exp. Agric,.* **38**: 201-206.

Debnath, G.C. and Maiti, S.C. (1990). Effect of the growth regulators on rooting of softwood cuttings of Guava under mist. *Haryana J. Hort. Sci*., **19**: 79- 85.

Deng Xiong, Bagping C.C.; Jian Wen D. and MuLin C. (2000). Cutting propagation techniques for *Quisqualis indica. Journal of Zhejiang Forestry College* **17**: 384-388.

Deshmukh, K.K. and Barad, A.V. (2006). Effect of growth regulators on rooting of stem cutting in *Bougainvillea buttiana* var. Mahara. *Crop Research*, Hisar, **32**(3): 391-393.

Dole, J.M. and Wilkins, H.F. 2005. Floriculture: principles and species. 2nd ed. Prentice Hall, Upper Saddle River, N.J. 558pp.

Farooqi, A.A.; Shenoy, R. And Sreeramu, B.S. (1994). Influence of planting material and growth regulators on the rooting of cutting in *Rosa damascena* Mill. *Indian Perf.*, **38**(4): 133-143.

Ganjure, S.L.; Gawande, M.G. and Golliwar, V.J. (2014). Response of IBA and rooting media on rooting of cutting in Chrysanthemum. *International Journal of Science and Research,* **3***(7*): 1306-1309.

Gaspar, T. and Hofinger, M. (1988). Auxin metabolism during adventitious rooting. In: Davis, T. D.; Haissig, B. E. and Sankhla, N. (Eds.). *Adventitious root ormation in cuttings*. Portland: Dioscoride Press. pp. 61-69.

Girisha, R.; Shirol, A.M.; Reddy, B.S., Patil, V.K. and Krishnamurthy, G.H. (2012). Growth, quality and yield characteristics of Daisy (*Aster amellus* L.) cultivar Dwarf Pink as influenced by different plant growth regulators. *Karnataka J. Agric. Sci*., **25**(1): 163-165.

Grewal, H.S.; Kumar, R. and Chauhan, R. (2005). Effect of IBA and NAA on rooting in chrysanthemum (*Dendranthema grandiflora* Tzevlev) terminal cuttings. *J. of Ornamental Hort*., **8**(3): 230-232.

Gupta, V.N.; Banerj, B.K. and Datta, S.K. (2002). Effect of auxin on rooting and sprouting behavior of stem cuttings of bougainvillea under mist. *Haryana J.Horti. Sci,***31**: 42-44.

Haissig, B.E. and Davis, T.D. (1994). An historical evaluation of adventitious rooting research to 1993. In: Davis, T.D.; Haissig, B. E. (Eds.). *Biology of adventitious root formation*. New York: Plenum Publishing Corporation. pp. 275-331.

Hartmann, H. T.; Kester, D. E. and Davies, F. T. (1990). Plant Propagation: Principles and Practices 5th Edition. Prentice-Hall, Incorporated 647pp.

Hartmann, H.T.; Kester, D.E.; Davies, F.T. and Geneve, R.L. (2002). Plant Propagation, Principles and Practices, 7th Edition, Prentice Hall, Upper Saddle River, New Jersey 880pp.

Henrique, A.; Campinhos, E.N.; Ono, E.O. and Pinho, S.Z.D. (2006). Effect of plant growth regulators in the rooting of Pinus cuttings. *Brazilian Arch. Bio.and Tech*, **49**(2): 189-196

Markovic, M.; Grbic, M. and Djukic, M. (2014). Effect of cutting type and a method of IBA application on rooting of softwood cuttings from elite tree of Cornelian cherry (*Cornus Mas* L.) from Belgrade area. *Silva Balcanica*, **15**(1):30-3.

Mitra G.C,Bose N (1994). Rooting and histological responses of detacbed leaves to B-indolebutyric acid with special reference to *Boerbavia diffusa* Linn. Phytomorphology **7**:3.

Nasri, F.; Fadakar, A.; Saba, M. K. and Yousefi, B. (2015). Study of Indole butyric acid (IBA) effects on cutting rooting improving some of wild genotypes of damask Roses (*Rosa damascena* mill.). *J.Agric. Scis*. **60** (3): 263-275.

Okunlola, A. L. (2013). The effects of cutting types and length on rooting of *duranta repens* L. in the nursery. *Global Journal of Human Social Science Geography, Geo-sciences, Environmental and Disaster Management,* **13**(3).

Okunlola A. L. (2017). Response of selected ornamentals to rooting hormone in Different Propagating Media. *Ibironke Scientific Pages Bot*. **1**(1): 22-28.

Panse, V.G. and Sukhatme, P.V. (1967). Statistical methods for agricultural workers, ICAR, New Delhi.pp. 381.

Pannerselvam, K.; Bhavanisankar, K.; Jayapragasam, M.; Kumar, A.; Radhakrishan, P.; Vijayrughavan, A. and Adalarasan, R. (2004). Effect of growth regulators and planting media on rooting of cutting in *Nothopodytes nimmoniana* Mabberity. *Indian J. Plant Physiol*., **9**(3): 308-312.

Pooja, H.M. (2010). Standardization of vegetative propagation of Japanese honeysuckle (*Lonicera japonica* Thunb.) using growth regulators, *M.Sc. (Hort.) Thesis*, University of Agricultural Sciences, Bangalore.

Rahbin, A.; Aboutalebi, A. and Hasanzadeh, H. (2012). Study on the effect of cutting location on shoot and IBA on rooting of 'Night Jessamine' (*Cestrum nocturnum*) stem cuttings. *Inter. Res.J.Applied and Basic Scis*. **3** (11): 2345-2348.

Ramtin A.; Khalighi A.; Hadavi E. and Hekmati J. (2011). Effect of different IBA concentrations and types of cuttings on rooting and flowering of *Poinsettia pulcherrima* L. *International Journal of Agri Science,* **1**(5): *303-310.*

Rana, R.S. and Sood, K.K. (2012). Effect of cutting diameter and hormonal application on the Propagation of *Ficus roxburghii* Wall. through Branch Cuttings. *Annals of Forest Research*, 55, 69-84.

Robbins, J.A. and Evans, M.R. (2006b). Growing Media for container production in a greenhouse or nursery (Part II: Physical and Chemical Properties) [online]. University of Arkansas Cooperative Extension Service Printing Services FSA-6098. Available from: http://www.uaex.edu/Other_Areas/ publications/PDF/FSA-6098.pdf.

Sharma, R. (2014). Study on the effect of Auxins on rooting, growth and flowering of african marigold (*Tagetes erecta* L.) propagated through stem cuttings. M. Sc. (Hort.) thesis. I.G.K.V., Raipur.

Shenoy, R. (1992). Influence of planting material and growth regulators on the rooting of stem cuttings in *Rosa damascena* Mill. M Sc (Hort.) Thesis submitted to the University of Agricultural Sciences, Bangalore.

Singh, K. K.; Rawat, J.M.S.; Tomar, Y.K. and Kumar, P.b (2013). Effect of IBA concentration on inducing rooting in stem cuttings of *Thuja compacta* under mist house condition. *Hort. Flora Res. Spectrum,* **2**(1): 30-34.

Singh, K.K. and Negi, B. (2014). Effect of various concentrations of IBA and length of cutting on the rooting in stem cutting of *Tecoma stans* L. under mist chamber. *Inter.J.Cur. Res.* **6** (12):10946-10949.

Singh, K.K.; Choudhary, T.; Kumar, P. and Rawat, J.M.S. (2014). Effect of IBA for inducing rooting in stem cuttings of Duranta Golden. *Hort Flora Research Spectrum*, **3**(1): 77-80.

Stancato, G.C.; Aguiar, F.F. A.; Kanashiro, S. and Tavares, A.R. (2003). *Rhipsalis grandiflora* Haw propagation by stem cuttings. *Scientia Agricola*. 56: 185 – 90.

Swamy, S.L.; Puri, S. and Singh, A.K. (2002). Effect of auxins (IBA and NAA) and season on rooting of juvenile and mature hardwood cuttings of *Robinia pseudoacacia* and *Grewia optiva*. New Forests, 23:143–157.

Seyedi. A.; Esmaeili, A. and Mostafavi, M. (2013). Study of stem type and different levels of IBA on rooting of *Bougainvillea glabra. International Journal of Agriculture and Crop Sciences*. **5**(12): 1276-1279

Thimman, K.V (1992). The natural plant hormones. In: steward,. F.C. (Ed); :Plant physiogy, Academic Press. New York. **3**-332.

Zeinab I. and Hossein Z. (2014) Evaluation of propagation of Chinese Hibiscus (*Hibiscus rosa-sinensis*) through stenting method in response to different IBA concentrations and rootstocks. *American J.Plant Scie,* 5: 1836-1841.

Zenginbal, H.; Haznedar, A. and Dolgun, O. (2014). Effect of Indole-3-Butyric Acid (IBA) and cutting type on rooting of *Camellia sinensis* (L.) O. Kuntze. *American J. Exp.Agri,*. **4**(12): 1935-1943.

APPENDICES

Appendix- I: Analysis of variance for number of roots and length of longest root

Source of variation	D.F.	Mean sum of squares	
		Number of roots	Length of longest root
Treatment	7	20.643	2.559
Error	17	0.349	0.028
Total	24		

Appendix- II: Analysis of variance for diameter of root and number of sprouts

Source of variation	D.F.	Mean sum of squares			
		Diameter of root	Number of sprouts		
			25 DAP	35 DAP	45 DAP
Treatment	7	0.0013	1.0003	1.6673	2.1802
Error	17	0.0003	0.0560	0.0271	0.0387
Total	24				

Appendix- III: Analysis of variance for length of shoot and number of leaves

Source of variation	D.F.	Mean sum of squares					
		Length of shoot			Number of leaves		
		25 DAP	35 DAP	45 DAP	25 DAP	35 DAP	45 DAP
Treatment	7	0.8988	1.8183	1.3394	14.5600	17.8331	20.4850
Error	17	0.0214	0.0216	0.0235	0.1596	0.3055	0.7410
Total	24						

Appendix- IV: Analysis of variance for fresh weight of shoots and dry weight of shoots

Source of variation	D.F.	Mean sum of squares	
		Fresh weight of shoots per cutting (g)	Dry weight of shoots per cutting (g)
Treatment	7	1.5675	0.1725
Error	17	0.0104	0.0018
Total	24		

Appendix- V: Analysis of variance for fresh weight of roots, dry weight of roots and rooting percent

Source of variation	D.F.	Mean sum of squares		
		Fresh weight of roots per cutting (g)	Dry weight of roots per cutting (g)	Rooting percent
Treatment	7	0.0580	0.0120	303.232
Error	17	0.0010	0.0001	1.818
Total	24			

VITA

The author of the thesis Dinesh Patel, S/O Shri Mrityunjay Patel was born on December 11, 1991 at Mahasunmdra District (c.g.). He passed his Higher Secondary examination in the year 2008 from the C.G. Board Raipur with first division (66 %).

He joined College of Agricuture, Rajnandgaon in 2010 and completed his B.Sc. (Ag.) in the year 2014 with 2nd division securing an OGPA of 6.92 on 10 point scale.

After graduation he joined M.sc (Horticulture) K.N.K. College of Horticulture, Mandsaur, R.V.S.K.V.V., Gwalior (M.P.) for specialization in Floriculture and Landscape Architecture. He had completed the entire course requirement for the above said Master degree in the year 2017-18 with an OGPA of 7.00 on a 10 point scale.

He was allotted an interesting research problem entitled of **"Effect of IBA and type of cutting on rooting of Golden Dewdrop (*Duranta plumeiri* L.)"** his choice for thesis work, which has been duly completed by him and presented in the form of this thesis.