"STANDARDIZATION OF PORTION OF PLANT PART USED AND IBA CONCENTRATION ON COMMERCIAL PRODUCTION OF ZZ PLANT

(*Zamioculcas zamiifolia*) (Lodd.) Engl."

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MASTER OF SCIENCE IN HORTICULTURE

(FLORICULTURE AND LANDSCAPE ARCHITECTURE)

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COLLEGE OF HORTICULTURE, MOJERLA, WANAPARTHY– 509 382

SRI KONDA LAXMAN TELANGANA STATE HORTICULTURAL UNIVERSITY

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By

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CERTIFICATE

J. ARCHANA has satisfactorily prosecuted the course of research and that the thesis entitled **"STANDARDIZATION OF PORTION OF PLANT PART USED AND IBA CONCENTRATION ON COMMERCIAL PRODUCTION OF ZZ PLANT *(Zamioculcas zamiifolia*) (Lodd.) Engl."** submitted, is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination.

I certify that neither the thesis nor its part thereof has been previously submitted by her for a degree of any University.

Date : **(Dr. N. SEENIVASAN)**

Place: Mojerla, Wanaparthy. **Chairman**

CERTIFICATE

This is to certify that the thesis entitled **"STANDARDIZATION OF PORTION OF PLANT PART USED AND IBA CONCENTRATION ON COMMERCIAL PRODUCTION OF ZZ PLANT (*Zamioculcas zamiifolia)* (Lodd.) Engl."** submitted in partial fulfilment of the requirements for the degree of Master of Science in Horticulture (Floriculture and Landscape Architecture) of Sri Konda Laxman Telangana State Horticultural University, Rajendranagar, is a record of the bonafide research work carried out by **J. ARCHANA** under our guidance and supervision.

No part of the thesis has been submitted by the student for any other degree or diploma. The published part and all assistance received during the course of the investigations have been duly acknowledged by the author of the thesis.

Thesis approved by the Student Advisory Committee.

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Date of final viva – voce:

LIST OF SYMBOLS AND ABBREVIATIONS

FCRD	:	Factorial Completely Randomized Design
et al.	:	(*et albeit*) and elsewhere
etc.	:	and so on; and other people / things
cm	:	Centimeter
C. D	:	Critical difference
°C	:	Degree Celsius
g	:	Gram
i.e.	:	(*Id est.*) that is
viz.,	:	Namely
ppm	:	parts per million
/	:	Per
%	:	Per cent
SKLTSHU	:	Sri Konda Laxman Telangana State Horticultural University
SE (m) ±	:	Standard error of mean
L^{-1}	:	Per litre
mg	:	Milligram
µg	:	Microgram
IBA	:	Indole Butyric Acid
°	:	Degrees

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At the very outset, I submit the commodious and indefinite thanks to my family members, friends and teachers for successful accomplishment of two years in this college and to present this diminutive piece of work.

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Finally, I wish my humble thanks to one and all who have directly and indirectly contributed in the conduct of my research work. Above all, whole hearted prostrations to the almighty for sprinkling his blessings upon me.

Mojerla. **(J. ARCHANA)**

DECLARATION

I, **J. ARCHANA**, hereby declare that the thesis entitled **"STANDARDIZATION OF PORTION OF PLANT PART USED IBA CONCENTRATION COMMERCIAL PRODUCTION OF ZZ PLANT *(Zamioculcas zamiifolia*) (Lodd.) Engl."** submitted To Sri Konda Laxman Telangana State Horticultural University**,** Rajendranagar, for the Degree of Master of Science in Horticulture (Floriculture and Landscape Architecture) is the result of original research work done by me. I declare that no material contained in the thesis has been published earlier in any manner.

Place: Mojerla **Name:** J. ARCHANA
Date: **I.D. No:** MHM/16-02

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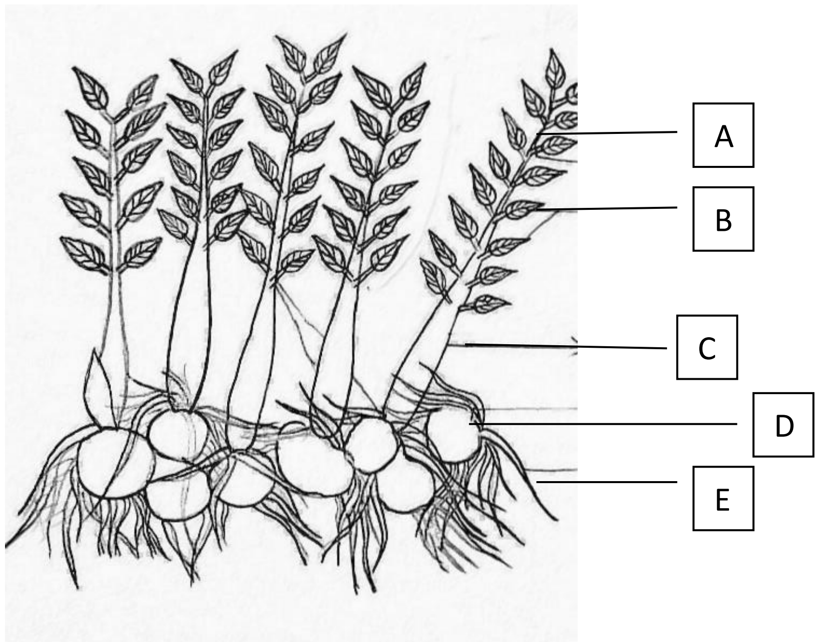

A: Only stalk (no leaflet), **B**: Leaflets, **C**: leafstalk, **D**: Rhizome, **E**: Root

Image of *Zamioculcas zamiifolia* (Lodd.) Engl.

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ABSTRACT

The present investigation entitled "Standardization of portion of plant part used and IBA concentration on commercial production of ZZ plant (*Zamioculcas zamiifolia*) (Lodd.) Engl.'' was conducted at College of Horticulture, Mojerla in the year 2017-18. The experiment consists of four different concentrations of IBA (0, 1000 ppm, 1500 ppm and 2000 ppm) and seven different portion of plant parts (entire pinnate leaf, two leaflets with a node and stalk, only stalk (with no leaflet), leaflet with a node and stalk, leaflet with no node and stalk, apical half of leaflet,

basal half of leaflet) were used. The plant portions were dipped in IBA for one hour. The experiment was laid out in Factorial Completely Randomized Design with two replications.

Portion of plant part were planted in polybags containing two parts of red soil, one part of coco peat and one part of Vermicompost.

Among the plant growth regulators, IBA 1000 ppm recorded minimum (30.5) days to rhizome initiation, maximum number (3.3) of rhizomes, diameter of rhizomes (3.8 cm), fresh weight of rhizomes (32.7 g), moist content of rhizomes (74.0 %), number of roots (12.5), length of roots (13.5cm), number of days taken for leaf stalk emergence (85.1), length of leaf stalk (16.2 cm), number of leafstalks (1.9), number of leaflets on leaf stalk (6.2), length of leaflet (8.1 cm), width of leaflet (3.8 cm), minimum number of days taken for finishing of pot plant (202.2).

Among portion of plant part significantly better results were obtained in entire pinnate leaf (except in number of days to rhizome initiation (48.5)). Maximum number of rhizomes (6.1), diameter of rhizomes (6.1 cm), fresh weight of rhizomes (83.9 g), moist content of rhizomes (87.7 %), number of roots (23.1), length of roots (17.0 cm), number of days taken for leaf stalk emergence (92.0), length of leaf stalk (41.1 cm), number of leaf stalks (2.5), number of leaflets (9.6) on leaf stalk, length of leaflet (10.2 cm), width of leaflet (4.7 cm), minimum number of days taken for finishing of pot plant (220.1). Whereas only stalk (no leaflet) did not form callus and rhizome formation also not observed.

The interaction between portion of plant part and plant growth regulator IBA significantly influenced almost all parameters. Entire pinnate leaf with IBA 1000 ppm registered better results (except in minimum days to rhizome initiation, it was recorded minimum in two leaflets with a node and stalk has taken (29.0) days to rhizome initiation), maximum number of rhizomes (7.5), diameter of rhizomes (9.0 cm), fresh weight of rhizomes (156.3 g), moist content of rhizomes (89.7%), number of roots (30.0), length of roots (19.2 cm), number of days taken for leaf stalk emergence (86.5), length of leaf stalk (52.2 cm), number of leaf stalks (3.5) per plant, number of leaflets (13.0) on leaf stalk, length of leaflet (11.6 cm), width of leaflet (5.4 cm), minimum number of days taken for finishing of pot plant (208.0).

CHAPTER-I

INTRODUCTION

Chapter - I

INTRODUCTION

Zamioculcas common name "Zanzibar gem", "Zuzu plant" or emerald palm, ZZ plant. The name ZZ plant or simply ZZ is appears to be used in the floriculture industry. *Zamioculcas* is a genus of flowering plant in the family Araceae, containing the single species *Zamioculcas zamiifolia* (Lodd.) Engl. It is a tropical perennial plant native to eastern Africa, from Kenya south to northeastern South Africa. Dutch nurseries started wide-scale commercial propagation of the plant around 1996.

The botanical name derives from on the one hand the superficial similarity of its foliage to that of the cycad genus Zamia and on the other hand its kinship to the genus Colocasia under that genus' synonym of 'Culcas'. Botanical synonyms include *Caladium zamiaefolium, Zamioculcas loddigesii* and *Z. lanceolata.*

It was first described as *Caladium zamiifolium* by Loddiges in 1829 (Bot. Cab. 15: t. 1408. 1829), moved to his new genus *Zamioculcas* by Heinrich Wilhelm Schott (Syn. Aroid. 71. 1856) and given its established name *Zamioculcas zamiifolia* by Adolf Engler (Das Pflanzenreich 4, 23B: 305. 1905.).

Zamioculcas zamiifolia (Lodd.) Engl. (Commonly called Zz plant) is a tropical perennial, evergreen plant native to South Africa (Lopez et al., 2009). It is a stem-less herbaceous, monocotyledonous plant in the family Araceae (Feng et al., 2006; Wong, 2009).

Growers in Florida were the first to venture into mass scale production of *Z. zamiifolia* (Lodd.) Engl. as an ornamental in the year 1999 (Harrison, 2009) and since then, it has emerged as an important foliage plant for interiorscaping and a festive decorative plant (Wong, 2009; Brown, 2000; Chen et al., 2002; Chen et al., 2004; Papafotiou and Martini, 2009). Within three years from its first introduction, this plant has become so popular that it was named as the ‘plant of the year' in 2002 by the Florida Nurserymens' and Growers Association (Harrison, 2009).

It is a herbaceous plant growing to 45–60 centimetres (17.7–23.6 in) tall, from a stout underground, succulent rhizome. It is normally evergreen, but becomes deciduous during drought, surviving drought due to the large potato-like rhizome that stores water until rainfall resumes. The leaves are pinnate, 40–60 centimetres (15.7–23.6 in) long, with 6–8 pairs of leaflets 7–15 centimetres (2.8–5.9 in) long; they are smooth, shiny, and dark green. The flowers are produced in a small bright yellow to brown or bronze spadix 5–7 centimetres (2.0–2.8 in) long, partly hidden among the leaf bases; flowering is from mid-summer to early autumn.

Zamioculcas zamiifolia (Lodd.) Engl. contains an unusually high water contents of leaves (91 %) and petioles (95 %) and has an individual leaf longevity is at least six months which may be the reason it can survive extremely well under interior low light levels for four months without water. The species is found to be naturally occurring in both dry grasslands as well as lowland forests, on rocky, lightly shaded terrain, but infrequently under deep shade (Mayo et al., 1998). It grows outdoors as long as the temperature does not fall below 15˚C, but the best growth is between 18˚C and 26˚C and with the relative humidity between 50 % and 95 % (Chen et al., 2004; Reid and Cevallos, 2009).

'ZZ' is more tolerant of low light levels than other foliage plants, such as Snake Plant (*Sansevieria trifasciata*) and Cast-iron Plant (*Aspidistra elatior*). It is easily maintained and adds stalks and new leaves under interior low light environments. Studies have shown that it can grow and produce new leaves under an interior low light level of 25 foot candles for more than one year. In addition, it can survive without being watered for 3 to 4 months. The drought tolerance is probably due to its waxy and shiny leaves and fleshy stems, which have extremely low rates of transpiration, and its thick rhizomes, which store water.

Additionally, few diseases or pests and physiological disorders have been found on this plant in production and interiorscapes. (Chen et al., 2004).

When drought occurs, the leaflets and upper portion of rachis usually fall, leaving only the swollen reserve of the petiole base, just like pseudobulbs in orchids (Orchidaceae) to tide the plant over until the next rain.

ZZ plant is stemless herbaceous perennial. Stout, fleshy petiole bearing alternate pinnate leaflets arise directly from thick horizontal rhizomes. Rhizomes vary in size depending on the age of plant. Basal leaves include pinnate and petiole, and petioles are strongly erect up to 60cm long. Leaflets are up to 15cm long and 7cm wide. Leaves are glossy, dark green and paler beneath, thick and fleshy with viens faintly impressed above. Petioles are thick, markedly swollen at base pale grey green and sometimes faintly mottled green.

The plant has air purifying qualities for the indoor environment. A Study from Department of Plant and Environmental Air purification.

Science at the University of Copenhagen from 2014 shows the plant is able to remove volatile organic compounds in this order of effectiveness, benzene, toluene, ethylbenzene and xylene at a molar flux of around 0.01 mol/(m^2 day). (Dela Cruz et al., 2014).

Zamioculcas zamiifolia (Lodd.) Engl. is part of the Araceae family which is well known for many poisonous genera, such as Philodendron, which contains calcium oxalate. Needle-like calcium oxalate crystals could irritate different sensitive skin parts, mucosa, or conjunctiva. Toxicity Speculations and hysteria during the 2010s led to a belief that *Z. zamiifolia* (Lodd.) Engl. could be extremely poisonous. Extreme versions of this rumor claimed that the plant could cause cancer and was even dangerous to touch, leading people to wear gloves when handling it.

Given the facts that the plant has been used externally in traditional medicine, is a very common office plant and is cultivated on a large scale, it is safe to assume that *Z. zamiifolia* (Lodd.) Engl. is not very toxic.

In fact, an initial toxicological experiment conducted by the University of Bergen in 2015 on extracts from *Z. zamiifolia* (Lodd.) Engl. using brine shrimp as a lethality assay did not indicate lethality to the shrimps even at concentrations of extracts up to 1 mg/mL, providing disproving evidence for the assumption of *Z. zamiifolia's* (Lodd.) Engl. Toxic character. The scientists conducting the experiment found that "On the contrary, it could appear as though the extract contributed to improvements in the vitality of the larvae".

The ZZ plant can be propagated vegetatively either by division or cuttings. Because division requires a grower to begin with several large stock plants, this propagation method is often impractical.

Zamioculcas zamiifolia (Lodd.) Engl. can be propagated vegetatively through rhizome divisions, leaf and petiole cuttings. Propagation through divisions is accomplished by separating individual rhizomes, sorting them based on size and planting the similar sized rhizome in to containers filled with a substrate. Marketable plants to be produced in 8 to 12 months after rhizomes are planted in corresponding pots.

Commercial potting mixes, such as 60 % sphagnum peat, 20 % perlite, and 20 % vermiculite or 55 % sphagnum peat, 25 % pine bark, and 20 % perlite, can be used for ‘ZZ’ plant propagation and production. Mixes should have good physical properties and a pH of 6.0 to 7.0 with an electrical conductivity (EC) of 1.0 to 2.0 dS/m.

The hormone that aids the growth of adventitious roots is called auxin, however synthetic forms of auxins are available commercially in the form of Indole Butyric Acid (IBA) and Naphthalene Acetic Acid (NAA). The use of cuttings from stems, leaves, roots or terminal buds are considered the most commonly applied technique due to its practicability and simplicity.

Ornamental plants hold an important status in the horticulture industry of the world. Plant growth regulators consist of a large group of naturally occurring or synthetically produced organic chemicals. Their exogenous application helps to improve the different economically important and market desirable characteristics of ornamental plants. The use of plant growth regulators is being practiced by the commercial growers of ornamental plants as a part of cultural practice.

Plant growth regulators (PGRs) are chemicals that are designed to affect plant growth or development. They are applied for specific purposes to elicit specific plant responses.

Regeneration of roots in cutting is basically a problem of growth and differentiation at the cellular level and is largely controlled by internal factors including hormonal and nutritional status of the cutting. The root promoting hormones contribute significant role to the process of regeneration of roots in the cuttings and their survival. Indole-3-butyric acid (IBA) plays a key role in both root and shoot development.

IBA is a plant harmone in the auxin family and is an ingredient in many commercial plant rooting products.

IBA is not soluble in water, it is typically dissolved in 75% or pure alcohol for use in plant rooting, making a solution. This alcohol solution is then diluted with distilled water to the desired concentration.

Zamioculcas zamiifolia (Lodd.) Engl. has growing popularity due to its unique appearance, extremely drought tolerant and highly suitable for indoor decoration. However, its commercial multiplication is not systematically documented. Moreover, ZZ plant is a slow growing plant where availability of planting material become scarce for it vegetable multiplication. Hence the present study is conducted to standardize propagation method with the following objectives.

OBJECTIVES

- To study the effect of portion of plant part on rooting and finishing of ZZ plant.
- To study the effect of IBA concentrations on rooting and finishing of ZZ plant.
- To study the interaction effect of portion of plant part and IBA concentrations on rooting and finishing of ZZ plant.

CHAPTER -II

REVIEW OF LITERATURE

Chapter II

REVIEW OF LITERATURE

Ornamental plants hold an important status in the horticulture industry of the world. Plant growth regulators consist of a large group of naturally occurring or synthetically produced organic chemicals. Their exogenous application helps to improve the different economically important and market desirable characteristics of ornamental plants. The use of plant growth regulators is being practiced by the commercial growers of ornamental plants as a part of cultural practice.

Plant growth regulators (PGRs) are chemicals that are designed to affect plant growth or development. They are applied for specific purposes to elicit specific plant responses.

Plant growth regulators (PGRs) consist of organic molecules, produced synthetically and used to alter the growth of plants or plant parts. They have ability to accelerate or retard the plant growth. The hormone which is produced in plants is called phytohormone. Phytohormone is an organic substance produced naturally in higher plants, controlling growth or other physiological functions at a site remote from its place of production, and active in minute amounts (Thimann, 1948).

The growth hormone is the phytohormone and is essential to growth of organs as buds, stems, roots, fruits, and so on by cellular enlargement, both in length and in width, while growth regulator referred to organic compounds other than nutrients, small amounts of which are capable of modifying growth (Leopold, 1955).

Zamioculcas zamiifolia (Lodd.) Engl.

Jaijun Chen and Henny (2003) had reported the ornamental value and propagation and production of *zamioculcas zamiifolia* (Lodd.) Engl.

Matthew Blanchard *et al* (2007) reported that out of Five types of cuttings were harvested from stock plants: two leaves with a node and stem; internode (stem); leaf with a node and stem; leaf without a node; and leaf with a node. Four weeks after sticking, all leaf cuttings with or without stems or a node rooted and produced one large rhizome. Stem cuttings did not callus or root.

Liu Jun-ke (2008) conducted an experiment on studies on the effect of Indole Butyric Acid (IBA) on rooting of leaves of *Zamioculcas zamiifolia* (Lodd.) Engl. The results showed that the concentration of 300 mg / l IBA promote the growth of tuber and root of the money tree. The length and quantity of root, the weight of tuber and survival rates are better than other concentrations. In addition 4-6 leaf petiole root growth effect is the best.

Lopez *et al* (2009) conducted an experiment on *Zamioculcas zamiifolia* (Lodd.) Engl. with single leaflet, apical leaflet sections, basal leaflet sections, or rachis cuttings. Results showed that after 30 days of propagation, rachis cuttings did not form any rhizome or roots, while other cutting types produced rhizomes and roots.

Seneviratne *et al* (2013) the first experiment was designed to determine the best type of vegetative cuttings bearing leaflets at different maturity stages that would initiate roots rapidly during propagation in solid medium. Six types of cuttings were harvested from stock plants growing in a net house with 70 % shade: a basal leaflet without rachis (6.5 cm), two basal leaflets with rachis, a middle leaflet without rachis, two middle leaflets with rachis, a terminal leaflet without rachis, and two terminal leaflets with rachis. Among the vegetative cutting types tested, the basal, middle and terminal leaflets without rachis showed apparently better callus formation in solid medium, compared to the leaflet pairs with rachis.

Poinsettia

Ramtin *et al* (2011) reported that the hormone concentration of 1000 mg / l IBA increased rooting, maximum length of root, number of leaves, number of bracts, number of cyathiums.

Singh and Singh (2005) observed that cuttings of poinsettia treated with IBA 3000 ppm showed maximum roots per cutting, longest root, diameter of root, maximum fresh weight of root per cutting, highest number of leaves per cutting, maximum length and diameter of sprout.

Rose

Tadele Yeshiwas *et al* (2015) conducted an experiment to evaluate the effect of softwood, semi-hard and hard wood cuttings and IBA concentrations of 0, 1000, 1500, 2000, 2500 and 3000 ppm on growth and development of stenting propagated roses. Rose cuttings treated with 1000 ppm of IBA had shown significant positive effects on most of the root and shoot parameters including root length, number of root per cutting, root fresh weight, root dry weight, shoot fresh and dry weight, leaf number and shoot length.

Krishna moorthy *et al* (2017) conducted an experiment with an objective of determine the rose cutting response to auxins *i.e* Indole Butyric Acid (IBA) and Naphthalene Acetic Acid (NAA) at 0, 500, 1000, 1500 and 2000 ppm concentrations in growing media. Maximum bud sprouting (78.8 %), days to sprout (6 days), number of leaves per plant (10), chlorophyll index (39.3 mg/g) in rose cuttings were recorded at IBA 1500 ppm.

Carnation

Purnachandra *et al* (2017) had studied the effect of Indole Butyric Acid (IBA) on rooting of different carnation genotypes. Growth regulator IBA showed significant difference for rooting percent, days to root initiation, root length, number of roots per cutting, fresh weight of roots and dry weight of roots.

Prince *et al* (2018) studied influence of Indole-3-Butyric Acid on rooting efficiency in different carnation genotypes under protected condition. 500 ppm IBA resulted in the maximum rooting percentage as compared to that in 200 ppm concentration.

Bougainvillea

Neerja singh (2012) studied the influence of Indole Butyric Acid (IBA) at 0, 1000, 1500, 2000 ppm concentrations rooting potential in hard wood cuttings of four varieties of bougainvillea. Results indicated that the cuttings treated with 1000 ppm IBA were superior in response with sprouting, rooting, callusing. Establishment was also best in this treatment.

Mehraj *et al* (2013) conducted an experiment on sprouting and rooting of *Bougainvillea spectabilis* stem cuttings treated with $T_{0:}$ control, $T_{1:}$ IBA in dust form, $T_{2:}$ IBA -500 ppm, T_3: IBA- 1000 ppm, T_4: IBA- 2000 ppm. Among which IBA 1000 ppm was performed as the best treatment in days to first rooting (4.0), days to first sprout bud initiation (5.3), number of leaves per cutting (35.2), length of sprout (15.0 cm), number of branches per cutting (4.7), number of root per cutting (64.2), longest root length (33.2 cm), rooting % (100 %),survival % of rooted cuttings (100 %).

Azar Seyedi *et al* (2014) conducted an experiment on bougainvillea cuttings with IBA hormone. Cuttings treated with 4000 ppm IBA showed maximum rooting, root length, root fresh weight.

Ibironke (2016) conducted an experiment on stimulation of rooting of six bougainvillea species using three different rooting hormones like IBA, Tetracycline, coconut water. The results showed that the Indole -3- Butyric Acid and coconut water had significant effect on root emergence and root growth of *Bougainvillea species* compared to the other hormone used.

In other plants

Mohammad Nazir Malik *et al* (1983) studied the rooting of soft wood leafy cuttings of sour orange with six concentrations of indole-butyric acid (IBA), *i.e* 250, 500, 1000, 2000, and 4000 ppm and control. Results showed that hundred percent rooting was obtained with 1000 ppm IBA.

Aminah *et al* (1995) observed that the application of auxin (indole butyric acid, IBA) significantly increased the rate of root emergence in single leafy stem cuttings *Shorea leprosula*. A range of IBA doses (0, 20, 40, 60, 80 µg IBA per cutting) were tested and 20 µg per cutting was found to be the best with 70 % of treated cuttings rooted within 12 weeks.

Azamal Husen *et al* (2003) the experiment was conducted on leafy mono-nodal cuttings of 1 –year-old seedlings of teak. The auxin treatments included 1000 and 2000 ppm IBA. However, maximum per cent rooting (88.00 %) was observed in 2000 ppm IBA.

Pulla Reddy. CH (2003) conducted an experiment on Studies on the effect of IBA and NAA on rooting of terminal cuttings of scented geranium (*Pelargonium graveolens* (L) Herit) in different months. Results revealed that Cumulative shoot length and number of fully expanded new leaves were maximum with IBA 2000 ppm during all the months.

Riaz Alam *et al* (2007) studied the effect of different concentration on the rooting of kiwi cuttings (Cv: Hayward and Abbott) was investigated. The callused cuttings of both sexes were treated with 0, 3000, 4000, 5000 and 6000 ppm of IBA. The results revealed that cuttings of both cultivars treated with 4000 ppm, showed good results on percent plant survival, number of roots per plant, root length, root weight, root diameter, number of leaves and shoot diameter.

Casar G. Abdel. 2007. Conducted an experiment on radish cultivar the plants were with indole-3-butyric acid (IBA) at rates of either (0, 20, 30 or 40 $mg.l^{-1}$), to improve growth, yield and yield quality of radishes. Radish marketable yields were linearly increased with the applied IBA rate increases.

Muhammad Ismail Siddiqui *et al* (2007) conducted an experiment on three different types of *Ficus hawaii* cuttings i.e. , softwood, semi hardwood and hardwood cuttings that were treated with different concentrations of Indole Butyric Acid (IBA) i.e. 1000, 2000, 3000, 4000, 5000 ppm and 0 ppm (control). Cuttings treated with 4000 ppm IBA showed maximum sprouting (43.7 %), leaves per plant (63), plant height (37.46 cm), shoots per plant (13), leaf area (19.33 cm^2), shoot thickness (0.57 cm), root length (11.5), and roots per cutting (13).

Jason J. Griffin (2008) studied the *Viburnum rufidulum* Raf. (southern black haw) has potential to be a popular landscape plant as it is attractive large shrub tolerant of many common landscape stresses. Stem cuttings were treated with liquid formulations of the potassium salt of Indole Butyric Acid at 0, 3000, 6000, or 9000 ppm as well as talc formulations of IBA at 1000, 3000 or 8000 ppm were used. Talc formulations failed to stimulate rooting regardless of concentration or growth stage. 6000 ppm concentration showed highest rooting percentage and root number per rooted cuttings. Root length was unaffected by IBA at any growth stage.

Bhagat Ram Kumawat (2009) conducted an experiment on Pomegranate (*Punica granatum* L.) cv. "Mridula" Cuttings. Results revealed that IBA at 1500 ppm concentration increased the leaf length (4.88 cm) and leaf width (1.81 cm) and minimum days for sprouting (9.33), the maximum length of shoot (16.62 cm), the maximum number (2.82) of shoots per cutting, the maximum number (14.07) of leaves per shoot, the maximum length of root (12.92 cm) was recorded with 1500 ppm IBA, the maximum number of roots (10.56) per cutting at 2000 ppm IBA.

Noor Camellia *et al* (2009) investigated the effect of indole-3-butyric acid (IBA) concentrations and type of cutting (soft wood, semi hardwood and hardwood) on root performance of *Jatropha curcas* L. cuttings were investigated. Two experiments were conducted where in first experiment, conducted on july 2007, 10,000 mg/L IBA gave the highest mean value for root length (13.6 cm), number of roots (28), percentage of rooted cuttings (74 %) with root dry weight (0.5 g). In experiment two, conducted on January 2008, 20,000 mg/L gave highest mean value of root length (12.1cm) and root dry weight (0.4 g).

Bani Bhushan Bhatt *et al* (2010) studied the effect of different concentration of Indole buteric acid (IBA) and different growing conditions have been examined for stimulatory effects adventitious root formation in stem cuttings of kagzi-lime. Cuttings were treated with different concentrations of IBA viz., 500, 1000, 1500 ppm. The cuttings treated with IBA 500 ppm, performed the best in all aspects, as root formation, length of root.

Maya Kumari *et al* (2010) conducted an experiment on *Jatropha curcas*. Results revealed that IBA treatment on cuttings increased rooting in Jatropha strain DARL-2 compared to non treated control. IBA application at 200 mg/L gave the best rooting percentage.

Singh. S *et al* (2011) conducted an experiment on *Bambusa nutans* Wall. And *Bambusa tulda* Roxb. Single node culm and culm-branch cuttings. Results indicated that IBA treatment significantly enhanced rooting, root number and root length; registering 14 to 17 times improvement over control in the best rooting season.

Tarit Kumar Baul *et al* (2011) investigated the rooting ability and the growth performance of juvenile single-node leafy stem cuttings of *Litsea monopetala* (Roxb) Pers. The rooting ability of cuttings was studied under 0 %, 0.1 %, 0.2 % and 0.4 % indole-3-butyric acid (IBA) treatments. Significantly better rooting response ($p \leq 0.05$) was observed with 0.1 % IBA compared to control (0 % IBA). The results suggest that application of 0.1 % IBA concentration is recommended for rooting of juvenile leafy stem cuttings.

Bernabe –Antonio.A *et al* (2012) in *Dioscorea remotiflora* (Kunth) leaves or nodal segments were incubated on MS, B5 and WPM culture media with different PGRs in order to obtain an efficient micropropagation protocol. Leaves explants were unable to inducing shoots or callus. However, nodal segments produced axillary shoots and/or callus in all culture media. Results revealed that Shoots were easily rooted with 8.28 1M IBA (96.9 %), displaying the greatest root and shoot biomass, but maximum number of tuberous roots, and root or tuberous root biomass was produced increasing IBA (20.7 lM).

Carmen San Jose *et al* (2012) conducted a study on (*Alnus glutinosa* (L.) Gaertn.). Micro cuttings from shoots cultured in vitro were transferred to a half-strength Woody Plant Medium containing 0 or 0.1 mg l^{-1} indole-3-butyric acid (IBA) for 0 to 7 days. The presence of IBA in the medium increased the rooting percentage, number of roots, percentage of lateral roots, and length of the shoots.

Uma Maheswari *et al* (2012) conducted In vitro Studies of wild yam also known as *Dioscorea oppositifolia* L. is reported. Direct organogenesis and indirect organogenesis of *D. oppositifolia* is achieved in this study. Results revealed that Callus was successfully produced from leaf explants on Murashige and Skoog (MS) medium supplemented with 0.5mg/l indole-3-butyric acid (IBA).

Singh *et al* (2013) conducted an experiment on softwood cuttings of *Thuja compecta.* The cuttings were treated with 1, 2, 3, 4 and 5g L^{-1} IBA solutions by quick dip method. Among all the treatments, highest number of root per cutting (19.67) was recorded under 5g L^{-1} IBA concentration. The maximum length of roots per cutting (9.33 cm) was recorded under 2g L^{-1} IBA concentration. Maximum roots per rooted cutting was observed in 5g L^{-1} concentration. The minimum days taken to callus formation was noticed in 4g L^{-1}.

Hemlata Barathi *et al* (2013) conducted an experiment on (*Codiaeum variegatum*) cuttings. Concluded that in hard wood cuttings of broad leaf variety treated with 400 ppm IBA showed maximum percent cuttings sprouted, length of longest primary roots per cutting, callusing percent, survival percentage as well as lesser days for sprouting. The narrow leaf variety treated with 200 ppm IBA recorded maximum number of sprouts per cutting, length of the longest sprout, and number of leaves per cutting, number of primary roots per cutting.

Mohammad Galavi *et al* (2013) in Grape Cuttings (*Vitis vinifera*) studied the effects of four concentrations of Indole -3- Butyric Acid (IBA) (0, 2000, 4000, and 6000 mg/l), and out of which the maximum number of roots, root length and root fresh and dry weight was obtained by using 4000 mg/l IBA.

R. Kumar *et al* (2013) conducted an experiment on rooting of geranium stem cuttings. Results revealed that Among IBA concentrations, maximum rooting percentage and length of root system were recorded with IBA 1000 ppm (80.56 % and 8.28 cm) and minimum in control.

Singh *et al* (2014) conducted an experiment on stem cuttings of *Morus alba* treated with 1000, 1500, 2000 mg.L^{-1} IBA and NAA solutions by quick dip method. Among all the treatments, number of sprouted cuttings, length of the roots per cuttings, percentage of rooted cutting, length of longest sprouts of root were higher in IBA 2000 mg.L^{-1}.

Singh *et al* (2014) conducted an experiment on softwood cuttings *Duranta erecta* var golden. Cuttings were treated with 1, 2, 3, 4, 5g.L^{-1} IBA solution by quick dip method. Among all the treatments, highest number of roots per cutting (43.00), length of roots per cuttings (9.28 cm), diameter of root per cutting (1.67 mm), percentage of rooted cutting (88.00 %), number of sprouts per cutting (4.34), and minimum days to callus formation was noticed in 4g L^{-1} IBA concentration.

Hamed Babaie *et al* (2014) studied the effect of different concentrations of IBA and time of taking cutting on rooting, growth and survival of *F. binnendijikii* cuttings. Treatments were consisted of four levels hormones: 0, 2000, 4000 and 6000 mg/l. Results showed that highest root percentage, root number and fresh weight of root were for IBA concentration of 4000 and 6000 mg/l. The maximum of mean length of root and longest root were achieved in concentration of 6000 mg/l IBA. Highest survival percentage of plants was recorded in concentration of 4000 and 6000 mg/l IBA. The greatest length of new shoots was obtained in concentration of 4000 mg/l IBA, while the maximum number of new leaf was in IBA concentration of 2000 and 4000 mg/l IBA.

Singh *et al* (2014) conducted an experiment on tem cuttings of *Morus alba* were treated with 1000, 1500 and 2000 mg.L^{-1} IBA and NAA solutions by quick dip method. Results revealed that among all the treatments, number of sprouted cuttings, length of the roots/cutting, percentage of rooted cutting, lengths of longest sprouts of root were higher in IBA 2000 mg.L^{-1}.

Petterson Baptista LUZ *et al* (2015) conducted an experiment on ornamental plant *Cheliocostus speciosus* cuttings were treated with IBA concentrations. 720 mg L^{-1} increased the rooting percentage, and the 685 mg L^{-1} increased root number.

Ferdous *et al* (2015) conducted an experiment on BAP and IBA pulsing for in vitro multiplication of banana cultivars through shoot-tip culture. Maximum number of roots (3.83 and 2.50) and longest root (3.60 cm and 3.10 cm) was found from 0.3 mg/l IBA in Amrita Sagar and Sabri respectively.

Parmar (2015) conducted an experiment on Efficacy of Indole butyric acid (IBA) on rooting of stem cuttings of star gooseberry (*Phyllanthus acidus*). Results revealed that hardwood cuttings of star gooseberry treated with 2000 mg l^{-1} gave maximum sprouting, root and shoot growth parameters: number of leaves and shoots, leaf area, length of longest shoot and root, fresh and dry biomass of root and shoot, root : shoot ratio and survival percentage.

Thayamini H. Seran *et al* (2015) conducted an experiment on stem cuttings of dragon fruit (*Hylocereus undatus*). To determine the most suitable concentration of IBA for better establishment. Results revealed that at 60 days after planting of cuttings, shoot length (9.5 cm), shoot fresh (10.25 g) and dry (0.59 g) weights were recorded higher in cuttings dipped in 6000 ppm concentration of IBA.

Mohammed Sadisu Waziri *et al* (2015) studied the effect of 4 various concentrations of Indole butyric acid (IBA) on the rooting and growth of *Delonix regia* stem cuttings. The treatments consisted of combinations IBA (1000, 2000, 3000, 4000 ppm) and control. The results showed that application of IBA at 2000-3000ppm compared to 1000-4000 ppm gave significantly higher results in all measured parameters. Cuttings treated with IBA in respective of concentrations gave higher results than those without IBA (control) in all parameters except root number were treated cuttings were at par with control.

Muhammad Irfan Ashraf *et al* (2016) conducted an experiment on onion with IBA and Dichloro phenoxy acetic acid (2, 4-D) among two IBA results in a maximum Leaf width, leaf length, bulb moisture content, bulb diameter.

Patel Kavan Jayantkumar (2016) studied the Effect of different IBA concentration and rooting media on cutting of *Hibiscus rosa-sinensis* L. Results revealed that Among the various levels of IBA, 4000 ppm IBA (C_3) was most effective for obtaining early sprouting, (10.23 days), number of sprouts per cutting (2.66), length of longest shoot per cutting at 30 and 60 days (7.14 cm and 10.71 cm), fresh weight of shoot per cutting (3.43 g), dry weight of shoot per cutting (1.60 g), number of roots per cutting at 30 and 60 days (7.61 and 12.01), length of longest root per cutting at 30 and 60 days (3.32 cm and 8.95 cm), fresh weight of root per cutting (3.18 g), dry weight of root (1.47 g), number of leaves per cutting at 30 and 60 days (2.88 and 12.50), rooting percentage (78.75 %) and survival percentage (74.19 %) of rooted cuttings.

El-Sayed H.A. Hamad *et al* (2017) conducted an experiment on *Pachira aquatica* Aubl. For Rooting (%), root number/cutting, root length (cm), fresh and dry weights of roots/cutting (g), No. of shoots/cutting, fresh and dry weights of shoots/ cutting (g), No. of leaves/cutting, leaf area/cutting (cm^2) as well as fresh and dry weights of leaves/cutting (g) as growth parameters were recorded. Results showed that in most cases the maximum values were obtained by treating cuttings with IBA at 4000 ppm.

Vikas Kumar Khatik *et al* (2017) conducted an experiment on rose using IBA. Among all the concentration of IBA and different media, rooting of rose cuttings treated with 200 ppm IBA under soil + sand + Vermicompost (2:1:1) gave good results. The growing media and IBA results in early sprouting (14.00 days), highest number of leaves per cutting (3.25), leaflet length (2.25 cm), leaflet width (1.30 cm), roots per cutting (4.00 roots), length of root (2.93 cm) and field survival percentage (38.25 %).

Akshay. KR *et al* (2018) conducted an experiment on black pepper (*Piper nigrum*) cuttings. Results revealed that IBA 1000 ppm increased the different shoot parameters of cuttings such as, days to sprout, number of leaves per cutting, length of shoot, percentage of sprouting, fresh and dry weight and root parameters such as, minimum days to rooting, higher percentage of rooting, higher number of primary roots, maximum fresh and dry weight of roots.

Netam *et al* (2018) conducted an experiment with four different concentrations of IBA (500, 1000, 1500, 2000 ppm) each along with control were treated for root initiation in cuttings of jasmine. Results revealed that maximum survival percentage (88.33 %) of rooted cuttings, less days to sprouting per cutting (8.25), number of leaves per rooted cutting, maximum number of leaves per rooted cutting (10.58), length of shoot per rooted cutting (3.30 cm), length of root per rooted cutting (5.10) were recorded maximum at 1500 ppm.

Deepak Mewar *et al* (2018) studied the response of various IBA concentrations to wild fig cuttings with concentrations of IBA (3000, 6000, 9000 ppm and control). The results showed that 6000 ppm IBA treated performed best among all the other remaining treatment of the experiment.

Shamsudheen *et al* (2018) conducted an experiment on shoot multiplication of *Alpinia galangal* (L.) wild. Using rhizome buds. Study revealed that 1.0 mg/l IBA gave the highest number of roots (15.66 ± 1.2) and greatest root length (11.66 ± 0.88 cm) after four weeks.

CHAPTER-III

MATERIALS AND METHODS

Chapter - III

MATERIALS AND METHODS

The present study entitled, **"Standardization of portion of plant part used and IBA concentration on commercial production of ZZ plant (*Zamioculcas zamiifolia*) (Lodd.) Engl.''** was conducted during 2017-2018.

The materials used, techniques adopted, methodology and statistical analysis for conducting the experiment and observations recorded during the course of the investigation are described in this chapter.

3.1 LOCATION AND CLIMATE OF EXPERIMENTAL SITE

The present investigation on **"Standardization of portion of plant part used and IBA concentration on commercial production of ZZ plant (*Zamioculcas zamiifolia*) (Lodd.) Engl.''** was carried out at College of Horticulture, Mojerla, at Floriculture Research Block under Polyhouse condition (plate 1) during the year 2017-2018.

The experimental site, Mojerla is situated at an altitude of 347.3 m above mean sea level on 78˚29˚East longitude and 17˚19˚North latitude. The climate of Mojerla is semi-arid. The data on weather parameters during the period of investigation were recorded at the meteorological research station located at Krishi Vignana Kendra, Madanapuram, Kothakota Mandal. (Appendix I)

3.2 PROPERTIES OF MEDIA

Coco peat is a natural fibre extracted from the husk of coconut. In agriculture and horticulture, coir is a substitute for sphagnum (peat moss). It can hold large quantities of water, coco peat is used as a soil conditioner. Due to low levels of nutrients in its composition, coco peat is usually not the sole component in the medium used to grow plants. Vermicompost is the end product of the breakdown of organic matter by earthworms. Vermicompost rich in many nutrients and having neutral pH. It improves soil aeration, improves water holding capacity. Enhances plant growth and root growth. Red soil is porous and friable structure and low water holding capacity.

3.2.1 PREPARATION OF MEDIA

The media was prepared in the ratio of 2: 1: 1 of red soil, coco peat, and vermi compost respectively. And the media was filled in poly bag size of 9 inch and 23 inch.

3.2.2 EXPERIMENTAL DETAILS

1. Name of crop	: Zee Zee plant
2. Botanical name	: *Zamioculcas zamiifolia* (Lodd.) Engl.
3. Family	: Araceae
4. Experimental design	: Factorial Completely Randomized Design
5. Number of factors	: Two
6. Number of replications	: Two
7. Number of treatments	: 28
8. Method of Planting	: poly bag
9. Date of planting	: 11/11/2017

Treatment details

Treatments: 28

Factor A: Portion of plant part (P)

- P_1- Entire pinnate leaf
- P_2- Two leaflets with node and stalk

- P_3- Only stalk (no leaflet)
- P_4- Leaflet with a node
- P_5- Leaflet with no node
- P_6- Apical half of leaflet
- P_7- Basal half of leaflet

Factor B: IBA concentrations (C)

- C_1-IBA1000ppm
- C_2-IBA1500ppm
- C_3-IBA2000ppm
- C_4-Control (without treatment).

Treatment combinations

T_1	P_1 C_1	**T_{11}**	P_3 C_3	**T_{21}**	P_6 C_1
T_2	P_1 C_2	**T_{12}**	P_3 C_4	**T_{22}**	P_6 C_2
T_3	P_1 C_3	**T_{13}**	P_4 C_1	**T_{23}**	P_6 C_3
T_4	P_1 C_4	**T_{14}**	P_4 C_2	**T_{24}**	P_6 C_4
T_5	P_2 C_1	**T_{15}**	P_4 C_3	**T_{25}**	P_7 C_1
T_6	P_2 C_2	**T_{16}**	P_4 C_4	**T_{26}**	P_7 C_2
T_7	P_2 C_3	**T_{17}**	P_5 C_1	**T_{27}**	P_7 C_3
T_8	P_2 C4	**T_{18}**	P_5 C_2	**T_{28}**	P_7 C_4
T_9	P_3 C_1	**T_{19}**	P_5 C_3		
T_{10}	P_3 C_2	**T_{20}**	P_5 C_4		

3.2.3 PREPARATION OF PLANT GROWTH SUBSTANCE SOLUTION

A 2000 ppm IBA solution was prepared by dissolving 2g of IBA in little quantity of ethyl alcohol, then diluted in one liter of distilled water to make 2000 ppm. Similarly 1500, 1000 ppm were prepared by dissolving the required quantity of IBA.

3.2.4 PREPARATION OF CUTTINGS

Leaf sections like entire pinnate leaf, two leaflets with node and stalk, only stalk (no leaflet), leaflet with a node, leaflet with no node, apical half of leaflet, basal half of leaf let are taken from a healthy plant. (plate 2).

3.2.5 TREATMENT OF CUTTINGS

Cuttings were dipped in different concentrations of IBA like 1000 ppm, 1500 ppm, 2000 ppm, and control without any treatment and cuttings were dipped up to one hour in IBA solution. (Plate 3).

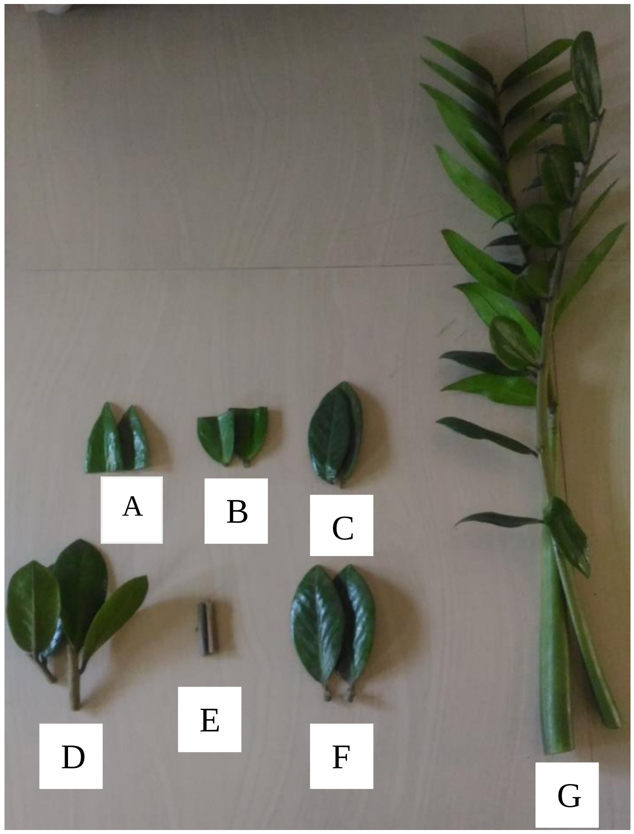
3.3 DETAILS OF OBSERVATIONS RECORDED

Data on following characters were recorded during the course of investigation for the experiments conducted. Uniformly growing three plants were randomly selected and tagged in each treatment and replication for the purpose of recording observations.

RHIZOME GROWTH PARAMETERS

3.3.1 Number of days taken for rhizome initiation

The number of days taken for rhizome initiation was calculated from the date of planting of cuttings to the date of appearance of rhizome was counted and recorded as days to rhizome initiation.



A: Apical half of leaflet, **B**: Basal half of leaflet, **C**: Leaflet with no node, **D**: Two leaflets with node and stalk, **E**: Only stalk (no leaflet), **F**: Leaflet with node, **G**: Entire pinnate leaf.

Plate 2: Preparation of the cuttings for imposing treatments

IBA 1000 ppm **IBA 1500 ppm** **IBA 2000 ppm**

Plate 3: Dipping the cuttings in treatment solution

IBA 1000 ppm	IBA 1500 ppm	IBA 2000 ppm

Plate 3: Dipping the cuttings in treatment solution

3.3.2 Number of rhizomes

The number of rhizomes per each plant was counted by uprooting the plants from soil and by separating the rhizomes then average values were computed.

3.3.3 Diameter of rhizome (cm)

Rhizome diameter was measured by using vernier calipers and the mean figure was expressed in centimeters (cm).

3.3.4 Fresh weight of rhizome (g)

Rhizomes were collected from plants and fresh weight was recorded. The average weight of individual rhizome from each treatment was computed and expressed in grams.

3.3.5 Moisture content of rhizome (%)

After recording the fresh weight, the rhizomes were oven dried and the dry weight was recorded. The difference between the fresh weight and dry weight was calculated and recorded as the moisture content in rhizome and was expressed in percentage.

$$\text{Moisture content formulae} = \frac{\text{Fresh Weight} - \text{Dry Weight}}{\text{Fresh Weight}} \times 100$$

ROOT GROWTH PARAMETERS

3.3.6 Number of roots

Number of roots per cutting was counted by uprooting the plant from the soil and washed thoroughly to remove sand and recorded the total number of roots per plant and average was calculated.

3.3.7 Length of root (cm)

Length of root per cutting was recorded with the help of measuring scale and mean length was calculated.

Shoot growth parameters

3.3.8 Number of days taken for leaf stalk emergence

Number of days taken for leaf stalk emergence was calculated from time of planting to the day when the first sprout appears from soil and calculated and it is expressed in days.

3.3.9 Length of leaf stalk (cm)

The length of leafstalk was measured with the help of measuring scale and value was expressed in centimeters (cm).

3.3.10 Number of leaf stalks

Number of leaf stalks was counted and the mean values are expressed in numbers.

3.3.11 Number of leaf lets on leaf stalk

Number of leafs per leafstalk was counted and the mean value was expressed in number.

3.3.12 Length of leaflet (cm)

The length of leaflet was measured with the help of measuring scale and mean value was expressed in centimeters.

3.3.13 Width of leaflet (cm)

The width of leaflet was measured with the help of measuring scale and mean value was expressed in centimeters.

3.3.14 Number of days taken for finishing of pot plant

The number of days counted from the date of planting to the plant ready for marketing when it is having three leaflets was counted and recorded as days taken for finishing of pot plant.

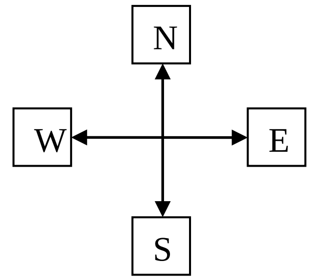


Figure 1 Layout of the experimental field

R_1			R_2	
T_1	T_9		T_{16}	T_5
T_3	T_2		T_4	T_{20}
T_{12}	T_{10}		T_7	T_{26}
T_8	T_{14}		T_{24}	T_{18}
T_{15}	T_4	P	T_9	T_{21}
T_{11}	T_{23}		T_{27}	T_3
T_5	T_{17}	A	T_{25}	T_1
T_{20}	T_7	T	T_{14}	T_{12}
T_{26}	T_{13}	H	T_6	T_{28}
T_{19}	T_{16}		T_{10}	T_8
T_{22}	T_{25}		T_2	T_{15}
T_{18}	T_{27}		T_{17}	T_{11}
T_{28}	T_{24}		T_{23}	T_{22}
T_{21}	T_6		T_{13}	T_{19}

Design: FCRD

Treatments

Factor- A: Portion of plant part (P)

P_1-Entire pinnate leaf

P_2-Twoleaflets with node & stalk

P_3-Only stalk (no leaflet)

P_4-Leaflet with node

P_5- Leaflet with no node

P_6-Apical half of leaflet

P_7-Basal half of leaflet

Factor-B: IBA concentration (C)

C_1-IBA 1000

C_2-IBA 1500

C_3-IBA 2000

C_4-Control (Without treatment)

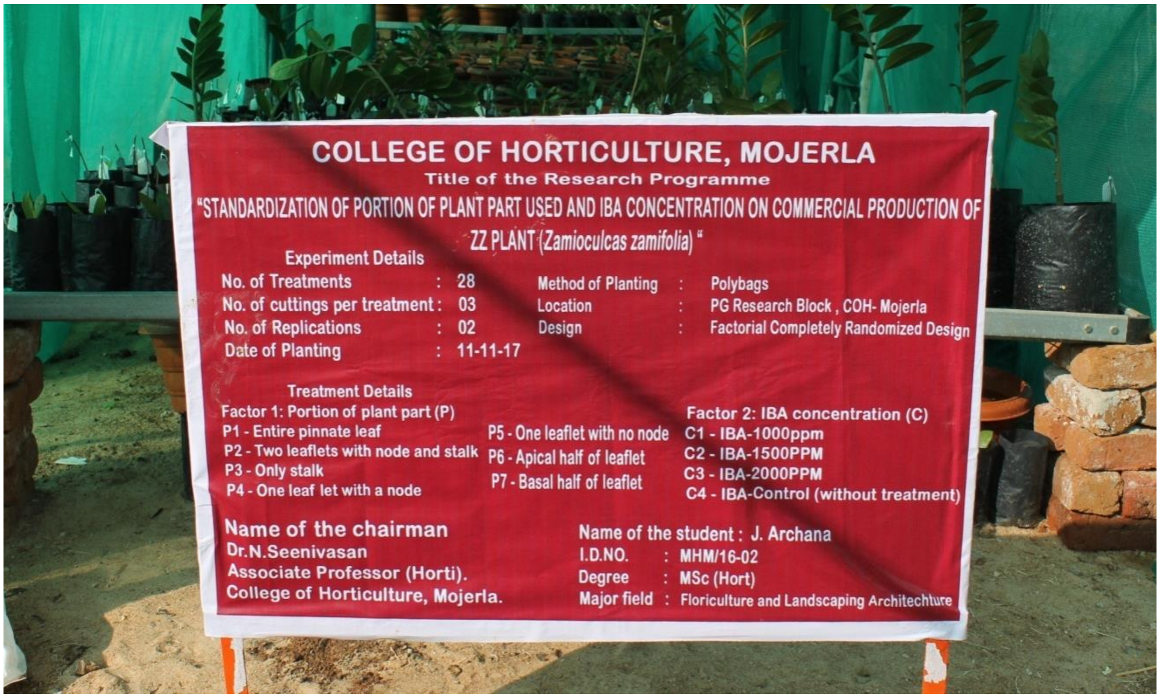


Plate 1: View of the experimental field

CHAPTER-IV

RESULTS AND DISCUSSION

Chapter IV

RESULTS AND DISCUSSION

The results of the present investigation entitled "Standardization of portion of plant part used and IBA concentration on commercial production of ZZ plant (*Zamioculcas zamiifolia*) (Lodd.) Engl.'' was carried out at Floriculture Research Block under Polyhouse condition, College of Horticulture, Mojerla during 2017 – 2018 are presented in this chapter.

The data of various parameters like days to rhizome initiation, number of rhizomes, diameter of rhizomes (cm), fresh weight of rhizomes (g), moisture content of rhizomes (%), number of roots, length of roots (cm), number of days taken for leaf stalk emergence, length of leaf stalk (cm), number of leaf stalks, number of leaflets on leaf stalk, length of leaflet (cm), width of leaflet (cm), number of days taken for finishing of pot plant.

Rhizome growth parameters

4.1 Number of days taken to rhizome initiation

Data regarding the number of days to rhizome initiation are presented in table 4.1 and graphically depicted in fig. 2.

Among different portion of plant part, two leaflets with node and stalk recorded significantly minimum number of days (31.6 days) for rhizome initiation, while Entire pinnate leaf had recorded significantly maximum number of days (48.5 days) for rhizome initiation. In only stalk (no leaflet) no formation of rhizome was recorded.

Among the different IBA concentrations, IBA 1000 ppm recorded significantly minimum number of days (30.5 days) for rhizome initiation, while control (without IBA treatment) has recorded significantly maximum number of days (34.6 days) for rhizome initiation.

Table 4.1 Effect of portion of plant part and IBA concentration on number of days taken to rhizome initiation in *Zamioculcas zamiifolia* (Lodd.) Engl.

Portion of plant part (P)	**IBA** 1000 ppm (C_1)	**IBA** 1500 ppm (C_2)	**IBA** 2000 ppm (C_3)	**Control** Without IBA (C_4)	**Mean**
Entire pinnate leaf (P_1)	44.5	47.5	48.5	53.5	48.5
Two leaflets with node and stalk (P_2)	29.0	31.0	32.0	34.5	31.6
Only stalk (no leaflet) (P_3)	0.0	0.0	0.0	0.0	0.0
Leaflet with node (P_4)	32.5	34.5	34.5	36.5	34.5
Leaflet with no node (P_5)	34.5	35.5	36.5	38.0	36.1
Apical half of leaflet (P_6)	35.5	36.5	37.0	39.5	37.1
Basal half of leaflet (P_7)	37.5	38.5	38.5	40.5	38.7
Mean	30.5	31.9	32.4	34.6	
	CD at 5 %		**SE(m) ±**		
P	0.81		0.28		
C	0.61		0.21		
PXC	1.62		0.55		

P = portion of plant part,

C = IBA concentration

PXC = Interaction of portion of plant part and IBA concentration.

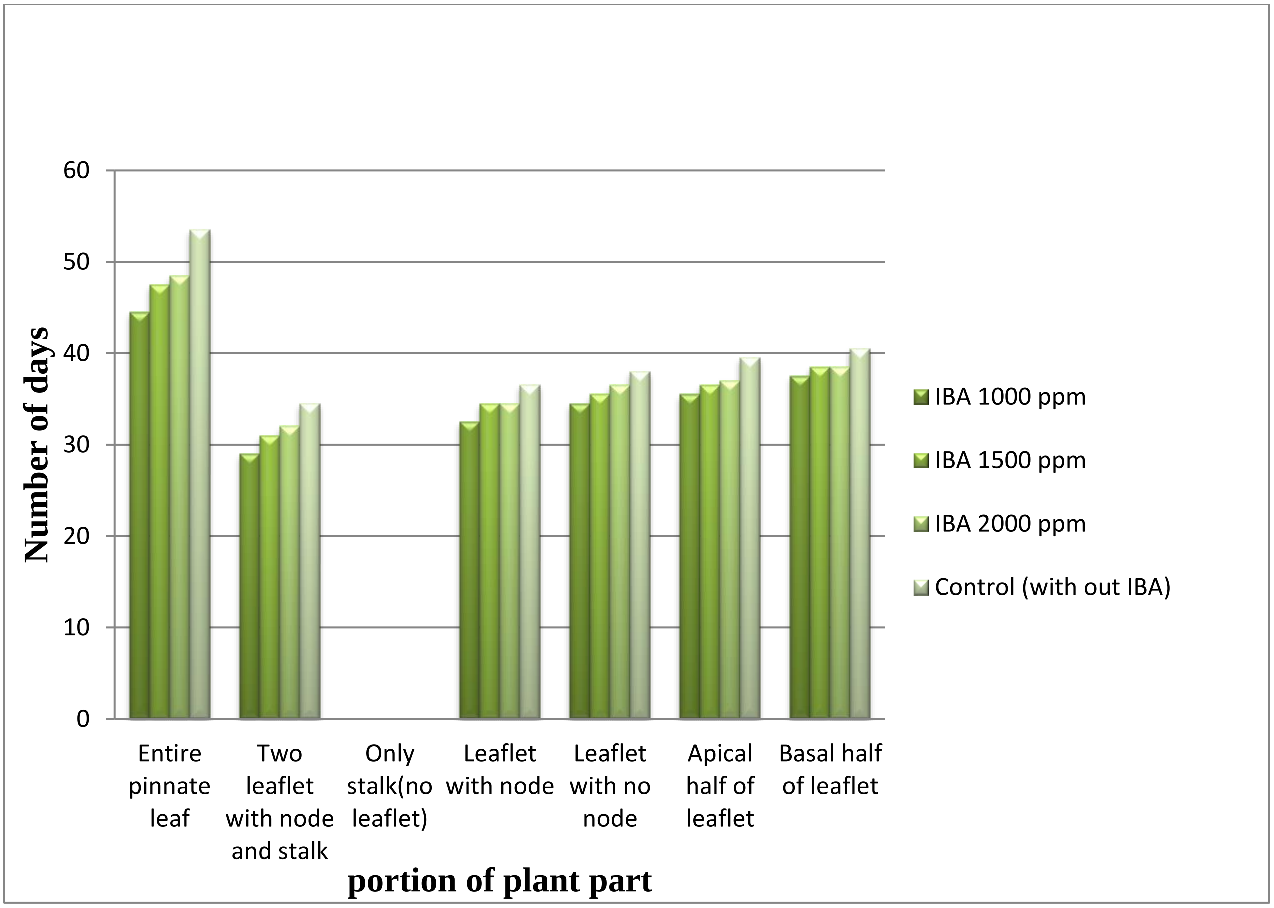


Fig. 2 Effect of portion of plant part and IBA concentration on number of days taken to rhizome initiation in *Zamioculcas zamiifolia* (Lodd.) Engl.

Plate 4: Early rhizome initiation in basal half of leaflet with 1000 ppm IBA

Plate 4: Early rhizome initiation in leaflet with no node with 1000 ppm IBA

Plate 4: Early rhizome initiation in two leaflets with node and stalk with 1000 ppm IBA

Plate 4: Early rhizome initiation in leaflet with a node with 1000 ppm IBA

Interaction effect of portion of plant part and plant growth regulator IBA was found to be significant. Among the treatment combinations, minimum number of days (29 days) recorded in two leaflets with node and stalk when they were treated with IBA 1000 ppm. While, the maximum number of days (53.5 days) was recorded in control (without IBA).

In only stalk (no leaflets) no rhizome formation was recorded at any concentration. Even if it forms callus by externally applying auxin. It may not be able to produce a rhizome because there is no photosynthetic organs (leaflets) for synthesis of food. And for further growth it require auxin buds and young leaves are the main sources of synthesis of auxin.

Entire pinnate leaf recorded maximum number of days to rhizome formation. This is because rhizomes will be produced only after the entire cutting surface of pinnate leaf has been covered by callus tissue, which takes more than a month depending on the diameter of pinnate leaf.

Auxin application has been found to enhance the histological features like formation of callus and tissue and differentiation of vascular tissue (Mitra and Bose, 1954).

The above findings are in agreement with the previous work of Singh. K. K. The minimum days (23.6 days) taken to callus formation in softwood cuttings of *Thuja compacta* was noticed under IBA concentration at 4g L^{-1} and maximum days (69.34 days) taken was found with control set of cuttings after insertion in to the rooting medium.

4.2 Number of rhizomes

Data regarding the number of rhizomes were presented in the table 4.2 and graphically depicted in fig. 3.

Among the plant portions used entire pinnate leaf has significantly more number of rhizomes (6.1) per plant. While, Basal half of leaflet recorded

Table 4.2 Effect of portion of plant part and IBA concentration on number of rhizomes per plant in *Zamioculcas zamiifolia* (Lodd.) Engl.

Portion of plant part (P)	**IBA** 1000 ppm (C_1)	**IBA** 1500 ppm (C_2)	**IBA** 2000 ppm (C_3)	**Control** Without IBA (C_4)	**Mean**
Entire pinnate leaf (P_1)	7.5	6.5	6.0	4.5	6.1
Two leaflets with node and stalk (P_2)	4.0	2.5	2.0	1.0	2.3
Only stalk (no leaflets) (P_3)	0.0	0.0	0.0	0.0	0.0
Leaflet with a node (P_4)	3.5	3.0	2.5	2.0	2.7
Leaflet with no node (P_5)	3.0	2.5	2.0	2.0	2.3
Apical half of leaflet (P_6)	3.0	3.0	2.5	1.5	2.5
Basal half of leaflet (P_7)	2.5	1.5	1.5	1.0	1.6
Mean	3.3	2.7	2.3	1.7	
	CD at 5 %		**SE(m) ±**		
P	0.47		0.16		
C	0.36		0.12		
PXC	0.95		0.32		

P = portion of plant part,

C = IBA concentration

PXC = Interaction of portion of plant part and IBA concentration.

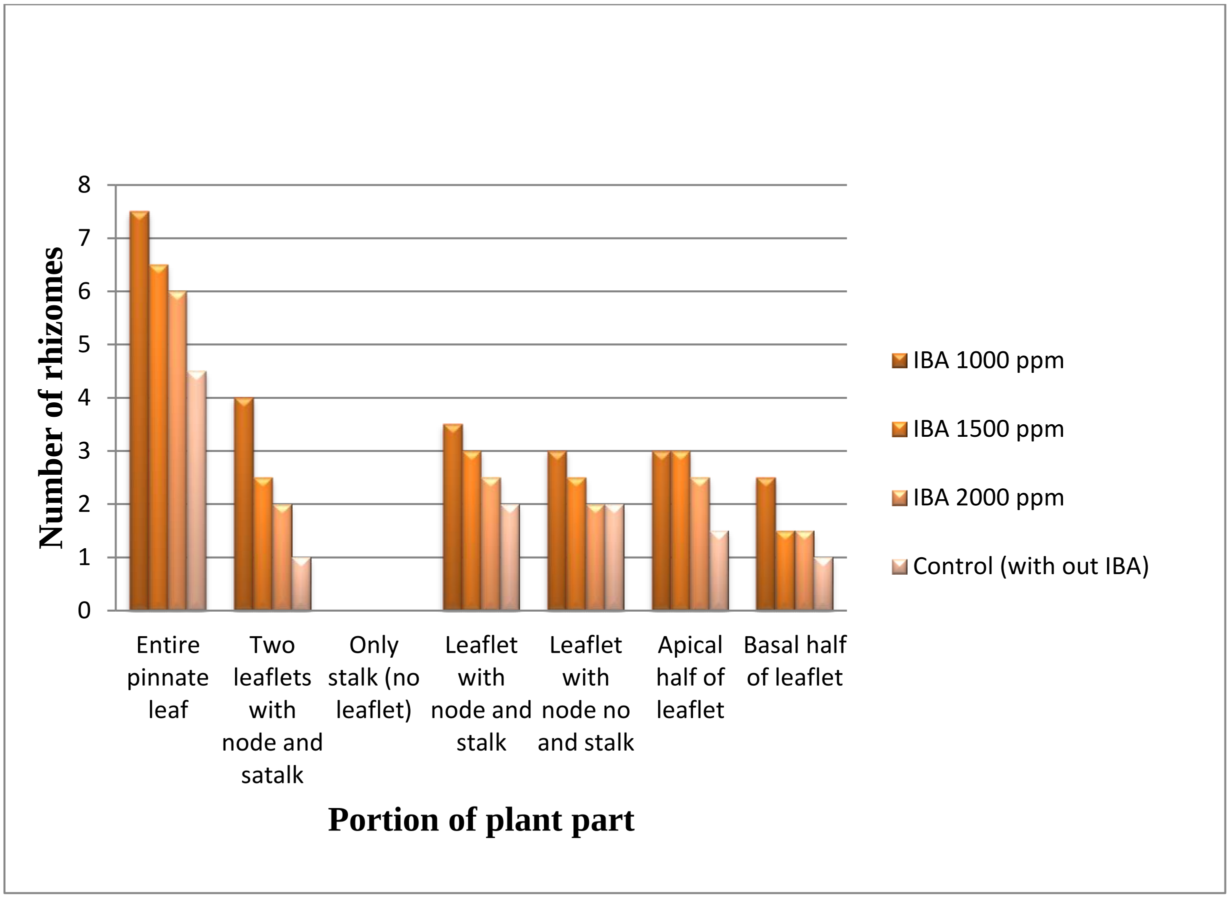


Fig. 3 Effect of portion of plant part and IBA on number of rhizomes per plant in *Zamioculcas zamiifolia* (Lodd.) Engl.

Plate 5: Increased number of rhizomes per plant in entire pinnate leaf with 1000 ppm IBA

significantly less number of (1.6) rhizomes per plant. In only stalk (with no leaflet) no rhizome formation was recorded.

Among the different IBA concentrations, IBA 1000 ppm recorded significantly maximum number of (3.3) rhizomes per plant. While, control (without IBA treatment) recorded significantly minimum number of (1.7) rhizomes per plant.

In interaction significantly maximum number of (7.5) rhizomes were recorded in entire pinnate leaf when they were treated with IBA 1000 ppm. And minimum number of rhizomes were recorded in basal half of leaflet (1.0) in control, and two leaflets with node and stalk in control (1.0).

IBA (Indole-3-butyric acid) is a phyto-hormone of auxin group produced in the shoot and root apices from where it is transported to other plant parts. The primary physiological effects of auxin are cell division and cell enlargement in the shoots and roots. Hence, the highest concentration of IBA is found in growing shoot tips, young leaves and developing auxiliary shoots that promote spike length, leaf length and number of corms (Tonecki, 1979).

The above results are in conformity with the Sarkar et al., (2009) reported that increased no. of bulbs per plants, weight of individual bulb and total bulb yield in tuberose when different growth regulators (NAA and IBA) were applied as dip treatment under north Indian conditions.

4.3 Diameter of rhizomes (cm)

Data regarding the influence of different IBA concentration and portion of plant part on diameter of rhizome are presented in table 4.3 and in fig. 4.

Data showed significant difference in the diameter of rhizomes when different portions of plant used. The maximum diameter (6.1 cm) of rhizomes was recorded in the entire pinnate leaf. While, the minimum diameter (1.4 cm) was recorded in the basal half of leaflet. Rhizome formation was not recorded in only stalk (no leaflets).

Table 4.3 Effect of portion of plant part and IBA concentration on diameter (cm) of rhizome per plant in *Zamioculcas zamiifolia* (Lodd.) Engl.

Portion of plant part (P)	**IBA** 1000 ppm (C_1)	**IBA** 1500 ppm (C_2)	**IBA** 2000 ppm (C_3)	**Control** Without IBA (C_4)	**Mean**
Entire pinnate leaf (P_1)	9.0	7.3	3.8	4.3	6.1
Two leaflets with node and stalk (P_2)	5.9	4.8	2.9	3.0	4.2
Only stalk (no leaflets) (P_3)	0.0	0.0	0.0	0.0	0.0
Leaflet with a node (P_4)	3.3	3.0	2.7	2.2	2.8
Leaflet with no node (P_5)	3.8	3.1	3.1	2.5	3.1
Apical half of leaflet (P_6)	1.8	1.5	1.4	1.0	1.4
Basal half of leaflet (P_7)	2.7	2.4	2.1	2.2	2.4
Mean	3.8	3.1	2.3	2.2	
	CD at 5 %		**SE(m) ±**		
P	0.36		0.12		
C	0.27		0.09		
PXC	0.73		0.25		

P = Portion of plant part,

C = IBA concentration

PXC = Interaction of portion of plant part and IBA concentration.

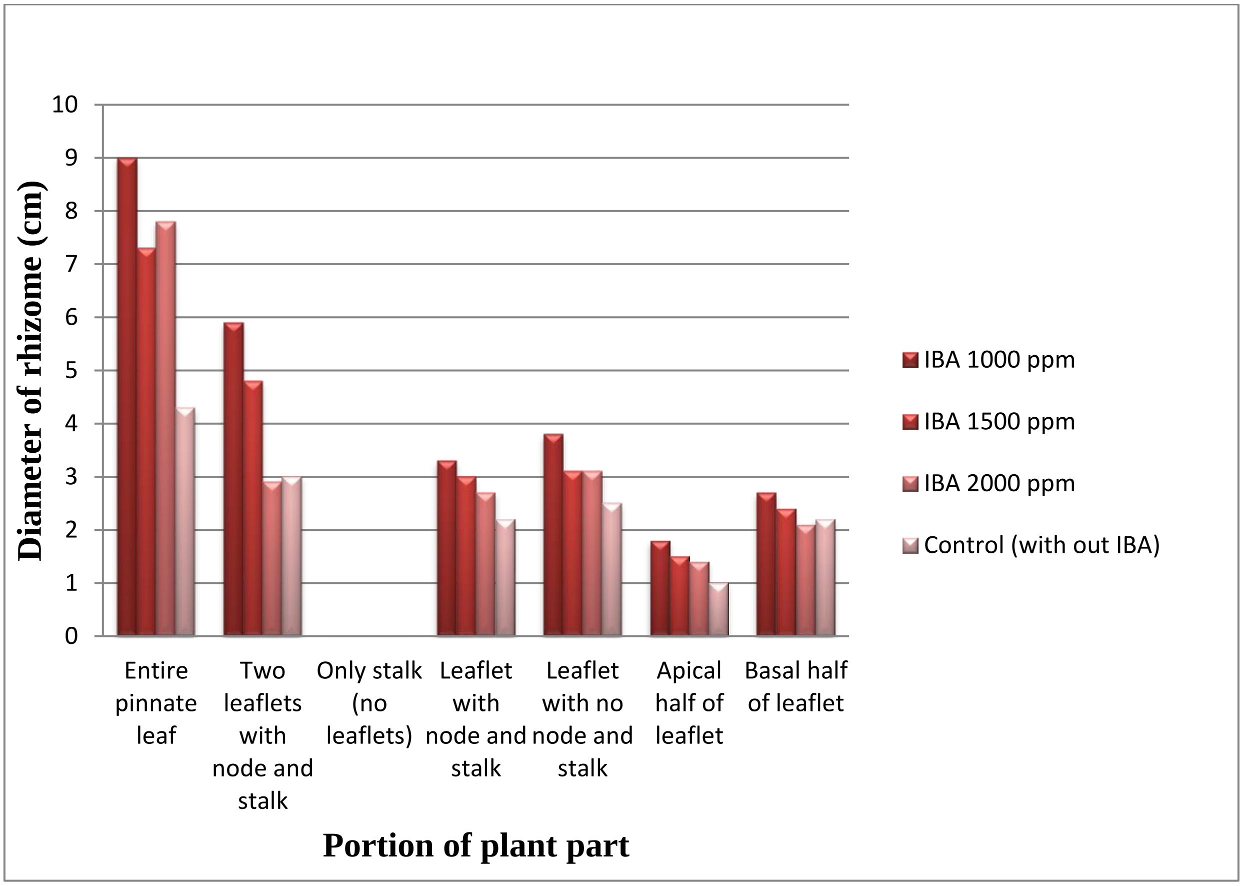


Fig. 4 Effect of portion of plant part and IBA on diameter (cm) of rhizome per plant in *Zamioculcas zamiifolia* (Lodd.) Engl.

Significantly maximum diameter (3.8 cm) of rhizomes was observed when the plant portion was treated with IBA 1000 ppm. While, minimum diameter (2.2 cm) was recorded in control (without IBA treatment) followed by IBA 2000 ppm recorded (2.3 cm) of rhizomes.

In interaction significantly maximum diameter (9.0 cm) of rhizome was observed in entire pinnate leaf when treated with IBA 1000 ppm concentration. While minimum diameter (1.0 cm) of rhizomes was found in apical half of leaflet in control (without IBA treatment).

GA3 and other bioregulators promoted cell division and enlargement and finally higher rate of photosynthesis and enhanced carbohydrate fixation in to plant sinks might have resulted in larger corms of gladiolus (Joshi et al., 2011). GA3 (5.55 cm) however it was onpar with IBA (5.23 cm) and (5.20 cm) thus IBA also promoting the diameter of corm. (Pradeep Chaudhary, 2016).

The results are in agreement with the previous research of (Muhammad Irfan Ashraf, 2016) in onion with 50 ppm IBA (7.62 cm) diameter.

4.4 Fresh weight of rhizomes (g)

Data regarding the fresh weight of rhizomes are presented in the table 4.4.

Plant portions had a significant difference in fresh weight of rhizomes. The maximum fresh weight (83.9 g) of rhizomes were recorded in the entire pinnate leaf. The minimum fresh weight (2.2 g) was observed in apical half of leaflet. Whereas only stalk (no leaflets) no rhizome formation was observed.

Significantly maximum fresh weight (32.7 g) of rhizomes were recorded in IBA 1000 ppm. And the minimum fresh weight (9.7 g) was recorded in control (without treatment) followed by IBA 2000 ppm (11.7 g).

In interaction effect significantly maximum fresh weight (156.3 g) of rhizomes was recorded in the entire pinnate leaf when they were treated with the

Table 4.4 Effect of portion of plant part and IBA concentration on fresh weight (g) of rhizome per plant in *Zamioculcas zamiifolia* (Lodd.) Engl.

Portion of plant part (P)	**IBA** 1000 ppm (C_1)	**IBA** 1500 ppm (C_2)	**IBA** 2000 ppm (C_3)	**Control** Without IBA (C_4)	**Mean**
Entire pinnate leaf (P_1)	156.3	98.6	41.9	39.1	83.9
Two leaflets with node and stalk (P_2)	39.8	19.5	16.8	10.8	21.7
Only stalk (no leaflets) (P_3)	0.0	0.0	0.0	0.0	0.0
Leaflet with a node (P_4)	11.2	9.9	9.0	6.5	9.2
Leaflet with no node (P_5)	10.7	7.1	7.3	5.6	7.7
Apical half of leaflet (P_6)	3.4	2.1	2.0	1.4	2.2
Basal half of leaflet (P_7)	7.4	5.9	5.0	4.2	5.6
Mean	32.7	20.4	11.7	9.7	
	CD at 5 %		**SE(m) ±**		
P	2.93		1.00		
C	2.22		0.76		
PXC	5.87		2.01		

P = Portion of plant part,

C = IBA concentration

PXC = Interaction of portion of plant part and IBA concentration.

IBA 1000 ppm. And minimum fresh weight of rhizome (1.4 g) in apical half of leaflet in control (without IBA).

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).

By increasing the IBA concentration there is a decrease in fresh weight. Individual root differentiation and growth tended to decrease as they received overloaded auxins beyond the external supply that required reinforcing the endogenous. (Caser G. Abdel, 2008)

The results are in conformity with the previous research of Caser G. Abdel (2008). In radish (*Raphanus sativus* L.) root fresh weight was highly increased as plants sprayed by IBA. Roots possesses their maximum values (124.49 g) with the rate of 30 $mg.l^{-1}$, then declined to reach a value (72.6 g) profoundly lower than that obtained from untreated plant (85.68 g). And Liu Jun-ke (2008) in *Zamioculcas zamiifolia* (Lodd.) Engl. with 300mg / l IBA promoted weight of tuber.

4.5 Moisture content of rhizomes (%)

Data regarding the moisture content of rhizomes as influenced by portions of plant part and different concentrations of IBA are presented in the table 4.5.

Data pertaining to moisture content of rhizomes were significantly differed with portion of plant part. Maximum moisture content (87.7 %) was recorded in the entire pinnate leaf. Minimum moisture content (82.7 %) of rhizomes was recorded in basal half of leaflet. Whereas in only stalk (no leaflets) no rhizome formation was recorded.

IBA concentrations had significant effect on moisture content of rhizomes. The maximum moisture content (74.0 %) of rhizomes were recorded in the IBA

Table 4.5 Effect of portion of plant part and IBA concentration on moisture content (%) of rhizome per plant in *Zamioculcas zamiifolia* (Lodd.) Engl.

Portion of plant part (P)	**IBA** 1000 ppm (C_1)	**IBA** 1500 ppm (C_2)	**IBA** 2000 ppm (C_3)	**Control** Without IBA (C_4)	**Mean**
Entire pinnate leaf (P_1)	89.7	87.6	86.4	87.1	87.7
Two leaflets with node and stalk (P_2)	87.3	84.9	85.8	82.7	85.2
Only stalk (no leaflets) (P_3)	0.0	0.0	0.0	0.0	0.0
Leaflet with a node (P_4)	87.7	82.9	83.3	79.8	83.4
Leaflet with no node (P_5)	85.8	85.0	83.9	83.6	84.6
Apical half of leaflet (P_6)	84.0	82.9	83.4	82.7	83.3
Basal half of leaflet (P_7)	83.6	82.9	82.9	81.4	82.7
Mean	74.0	72.3	72.2	71.1	
	CD at 5 %		**SE(m) ±**		
P	0.95		0.32		
C	0.72		0.24		
PXC	1.91		0.65		

P = Potion of plant part

C = IBA concentration

PXC = Interaction of portion of plant part and IBA concentration.

1000 ppm concentration and the minimum moisture content (71.1 %) of rhizomes were recorded in control (without IBA).

The interaction between portion of plant part and different IBA concentrations were found to be effective for moisture content of rhizomes. Significantly maximum moisture content (89.715) of rhizomes was recorded in the entire pinnate leaf when treated with 1000 ppm IBA concentration. The minimum moisture content (79.8 %) of rhizomes was recorded in the leaflet with node and stalk in the control (without IBA).

The results are in agreement with the previous research of (Muhammad Irfan Ashraf, 2016) in onion at 50 ppm IBA 85.8 %.

4.6 Number of roots

Data regarding the number of roots per plant is presented in the table 4.6.

Among different portions of plant parts significantly more number (23.1) of roots were recorded in the entire pinnate leaf. The minimum number (6.1) of roots were recorded in the basal half of leaflet followed by apical half of leaflet (7.6). Whereas in only stalk (no leaflet) no root formation was recorded.

Among different concentrations of IBA significantly maximum number (12.5) of roots were recorded in IBA 1000 ppm. Minimum number of (7.0) roots were recorded in the IBA 2000 ppm followed by control (7.8).

In interaction significantly maximum number (30.0) of roots per cutting were recorded in the entire pinnate leaf when treated with 1000 ppm IBA. The minimum number of (5.5) roots were recorded in basal half of leaflet in IBA 2000 ppm.

Indole Buteric Acid significantly increased the number of roots per cutting. IBA at 1000 ppm concentration increased the number of roots. With the increasing concentration of IBA above 2000 ppm there is a decrease in number of roots. This may be because of the reason that auxin helps in rooting behaviour only upto certain limit. If higher concentrations beyond tolerable limits are given, it may results in

Table 4.6 Effect of portion of plant part and IBA concentration on number of roots per plant in *Zamioculcas zamiifolia* (Lodd.) Engl.

Portion of plant part (P)	**IBA** 1000 ppm (C_1)	**IBA** 1500 ppm (C_2)	**IBA** 2000 ppm (C_3)	**Control** Without IBA (C_4)	**Mean**
Entire pinnate leaf (P_1)	30.0	29.0	15.0	18.5	23.1
Two leaflets with node and stalk(P_2)	17.5	11.5	7.0	9.0	11.2
Only stalk (no leaflet) (P_3)	0.0	0.0	0.0	0.0	0.0
Leaflet with a node (P_4)	13.5	8.0	6.5	7.5	8.8
Leaflet with no node (P_5)	10.0	8.0	8.5	7.5	8.5
Apical half of leaflet (P_6)	9.5	7.5	7.0	6.5	7.6
Basal half of leaflet (P_7)	7.0	6.0	5.5	6.0	6.1
Mean	12.5	10.0	7.0	7.8	
	CD at 5 %		**SE(m) ±**		
P	1.65		0.56		
C	1.24		0.42		
PXC	3.30		1.13		

P = Portion of plant part

C = IBA concentration

PXC = Interaction of portion of plant part and IBA concentration.

inferior or unfavorable conditions, leading to toxicity of the exogenously applied substances (Hartmann and Kester, 1983).

The endogenous auxins reaching the cambial zone may not be adequate for initiation of rooting primordia. With external application of IBA at optimum levels, roots were initiated earlier in larger numbers.

Above results are in conformity with the (Neelima Netam, 2018) in Jasmine (*Jasminum sambac* (L.) Aiton) stem cuttings. Maximum number of main roots per rooted cutting (9.33) recorded at 1500 ppm IBA. Yeshiwas *et al* (2015) in rose with 1000 ppm increased the number of roots. Purnachandra *et al* (2017) in carnation increased the number of roots at IBA 200.

4.7 Length of roots (cm)

Data regarding the influence of portion of plant part and different concentrations of IBA on length of roots were presented in the table 4.7 and fig. 5.

Length of roots were significantly affected by the portion of plant part. Maximum length (17.0 cm) of roots were recorded in the entire pinnate leaf. The minimum root length (9.2 cm) was recorded in the apical half of leaflet. Whereas in only stalk (no leaflets) no root formation was recorded.

Length of root was significantly influenced by the application of IBA. The maximum root length (13.5 cm) was observed with IBA 1000 ppm. The minimum root length (9.2 cm) was observed in the control.

In interaction maximum length (19.2 cm) of roots were observed in the entire pinnate leaf with IBA 1000 ppm followed by two leaflets with a node and stalk (18.6 cm) with IBA 1000 ppm concentration. The minimum (5.6 cm) root length was observed in apical half of leaflet in control (without IBA).

The availability of food materials to the root development by effective translocation of starch and nitrogen to the base of the cuttings might have encouraged the growth of the root. The auxin activity might have accelerated cell

Table 4.7 Effect of portion of plant part and IBA concentration on length (g) of root per plant in *Zamioculcas zamiifolia* (Lodd.) Engl.

Portion of plant part (P)	**IBA** 1000 ppm (C_1)	**IBA** 1500 ppm (C_2)	**IBA** 2000 ppm (C_3)	**Control** Without IBA (C_4)	**Mean**
Entire pinnate leaf (P_1)	19.2	18.1	17.9	13.0	17.0
Two leaflets with node and stalk(P_2)	18.6	15.3	11.3	14.7	15.0
Only stalk (no leaflets) (P_3)	0.0	0.0	0.0	0.0	0.0
Leaflet with a node (P_4)	17.0	16.5	11.0	10.3	13.7
Leaflet with no node (P_5)	13.5	11.7	11.1	10.6	11.7
Apical half of leaflet (P_6)	12.2	10.3	8.6	5.6	9.2
Basal half of leaflet (P_7)	14.5	12.6	11.3	10.6	12.2
Mean	13.5	12.0	10.1	9.2	
	CD at 5 %		**SE(m) ±**		
P	0.66		0.23		
C	0.50		0.17		
PXC	1.33		0.45		

P = portion of plant part

C = IBA concentration

PXC = Interaction of portion of plant part and IBA concentration.

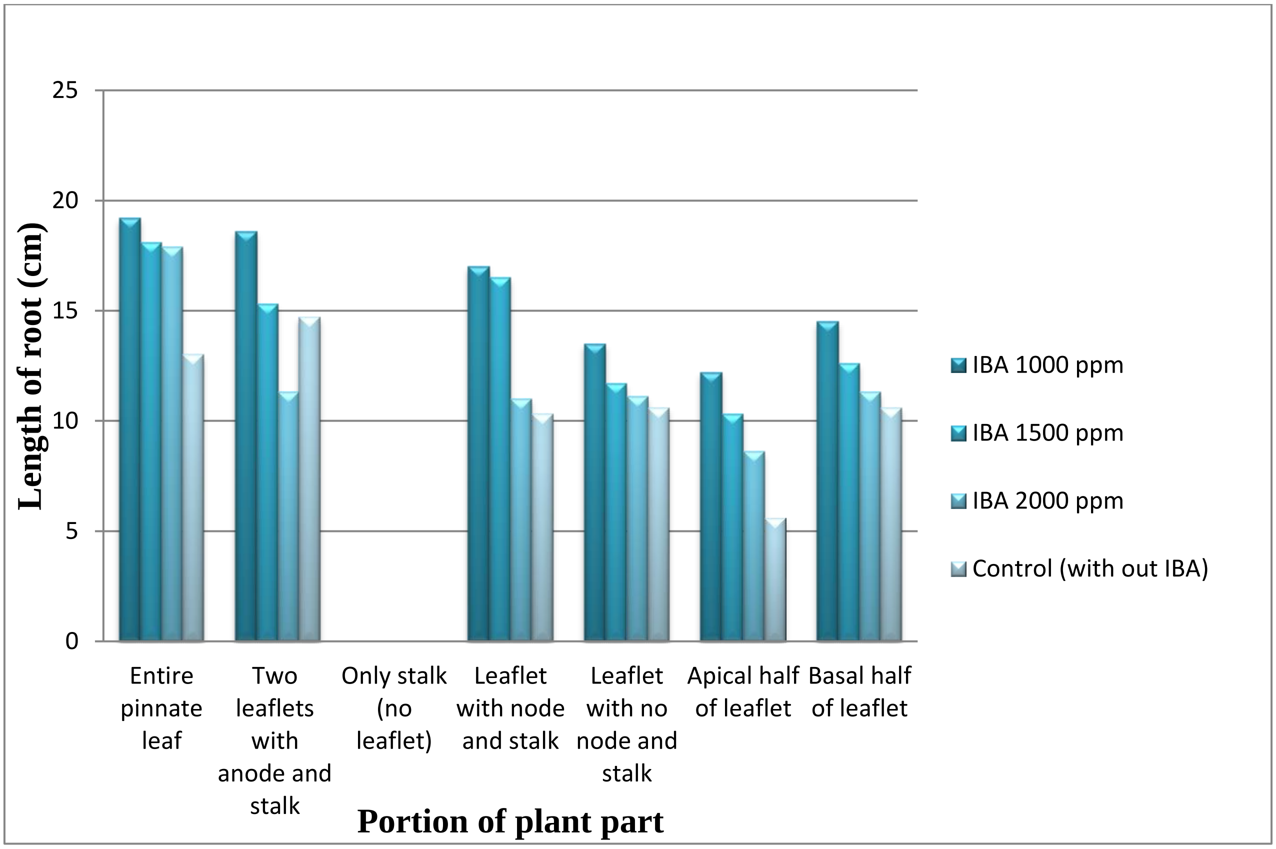


Fig. 5 Effect of portion of plant part and IBA on length (cm) of root in *Zamioculcas zamiifolia* (Lodd.) Engl.

Plate 6: Increased root length in the plant portion treated with 1000 ppm IBA

elongation and cell division coupled with suitable environment which might have possibly helped in increasing the root growth like rooting percentage, root number and root length. (Ch. Pulla Reddy, 2003) in scented geranium (*Pelargonium graveolens* (L) Herit).

More root length in entire pinnate leaf may be due to the interaction of IBA and presence of more stored food in the petiole and more photosynthetic area may be resulted in the more root length than other type of leaf cuttings.

The results obtained are in conformity with the Mehraj *et al* (2013) in (*Bougainvillea spectabilis*) stem cuttings with 1000 ppm IBA increased root length. Siddiqui *et al* (2007) in (*Ficus hawaii*) cuttings with 4000 ppm IBA increased root length. And Liu Jun-ke (2008) in (*Zamioculcas zamiifolia*) 300 mg / l IBA promoted the length and quantity of root.

4.8 Number of days to leaf stalk emergence

Data pertaining to number of days to leaf stalk emergence with portion of plant part and different IBA concentrations were presented in the table 4.8.

The number of days to leaf stalk emergence was significantly affected by portion of plant part. The minimum number (92.0) of days to leaf stalk emergence was observed in entire pinnate leaf. And maximum number (109.7) of days to leaf stalk was noticed in basal half of leaflet. In case of only stalk (no leaflet) no leaf stalk formation was recorded.

Number of days to leaf stalk emergence showed significant difference due to different levels of IBA application. The minimum number (85.1) of days to leaf stalk emergence was observed in the IBA 1000 ppm. And maximum number (92.6) of days to leaf stalk emergence was observed in control (without IBA).

In interaction significantly minimum number (86.5) of days to leaf stalk emergence was noticed in entire pinnate leaf with IBA concentration of 1000 ppm.

Table 4.8 Effect of portion of plant part and IBA concentration on number of days taken for leaf stalk emergence in *Zamioculcas zamiifolia* (Lodd.) Engl.

Portion of plant part (P)	**IBA** 1000 ppm (C_1)	**IBA** 1500 ppm (C_2)	**IBA** 2000 ppm (C_3)	**Control** Without IBA (C_4)	**Mean**
Entire pinnate leaf (P_1)	86.5	87.5	94.5	99.5	92.00
Two leaflets with node and stalk (P_2)	95.5	101.5	103.5	105.5	101.5
Only stalk (no leaflets) (P_3)	0.0	0.0	0.0	0.0	0.0
Leaflet with a node (P_4)	98.5	102.5	104.5	107.5	103.2
Leaflet with no node (P_5)	103.5	105.5	106.0	109.5	106.1
Apical half of leaflet (P_6)	104.5	105.5	107.5	113.0	107.6
Basal half of leaflet (P_7)	107.5	108.5	109.5	113.5	109.7
Mean	85.1	87.2	89.3	92.6	
	CD at 5 %		**SE(m) ±**		
P	1.08		0.37		
C	0.81		0.28		
PXC	2.16		0.74		

P = portion of plant part,

C = IBA concentration

PXC = Interaction of portion of plant part and IBA concentration.

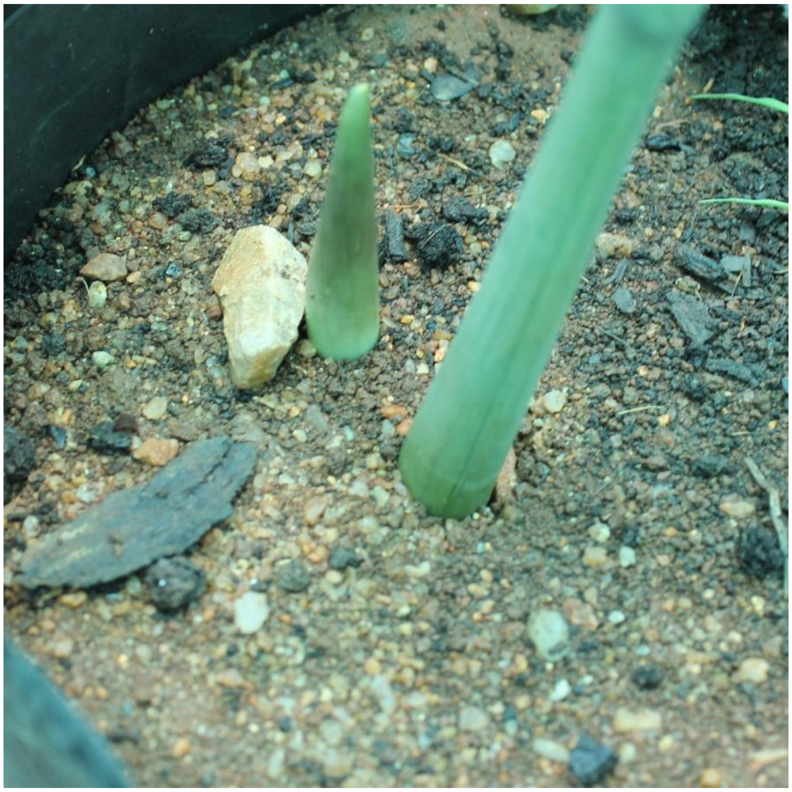


Plate 7: Early leaf stalk initiation in entire pinnate leaf with 1000 ppm IBA

Plate 7: Early leaf stalk initiation in basal half of leaflet with 1000 ppm IBA

Plate 7: Early leaf stalk initiation in leaflet with a node with 1000 ppm IBA

Maximum number of (113.5) days to leaf stalk emergence was noticed in basal half of leaflet in control followed by apical half of leaflet (113.0) in control.

Less number of days for leaf stalk emergence may be due to the presence of stored food in the rhizomes utilized for early emergence along with growth regulator IBA 1000 ppm.

Hardwood cuttings having high amount of stored carbohydrate and low to moderate amount of nitrogen which was utilized by cutting to produce shoot system with the help of IBA by hydrolysis, mobilization and utilization of nutritional reserves in region of shoot formation (Kraus and Kraybill, 1918).

The stored food material present in the cutting was mobilized with the aid of growth regulators. This might have hastened the sprouting, thereby enhancing the utilization of carbohydrates, at the base of cuttings through creation of sink and better utilization of photosynthesis (Singh et al. 2010).

Above findings are in agreement with Krishna moorthy *et al* (2017) days to sprout (6 days) in rose cuttings were recorded at 1500 ppm IBA. And Netam *et al* (2018) in jasmine less days to sprouting per cutting (8.25) at 1500 ppm.

4.9 Length of leaf stalk (cm)

Data pertaining to the length of leaf stalk was presented in the table 4.9.

Among different portion of plant part, significantly maximum length (41.1 cm) of leaf stalk was noticed in entire pinnate leaf. Minimum length (8.2 cm) of leaf stalk was noticed in apical half of leaf let followed by basal half of leaflet (8.4 cm).

Among the different IBA concentrations, significantly maximum leaf stalk length (16.2 cm) was observed in IBA 1000 ppm. Minimum leaf stalk length (11.0 cm) was noticed in control (without IBA) followed by IBA 2000 ppm (11.8 cm).

Table 4.9 Effect of portion of plant part and IBA concentration on length of leaf stalk (cm) in *Zamioculcas zamiifolia* (Lodd.) Engl.

Portion of plant part (P)	**IBA** 1000 ppm (C_1)	**IBA** 1500 ppm (C_2)	**IBA** 2000 ppm (C_3)	**Control** Without IBA (C_4)	**Mean**
Entire pinnate leaf (P_1)	52.2	40.9	36.6	34.6	41.1
Two leaflets with node and stalk(P_2)	17.8	13.1	12.0	10.5	13.3
Only stalk (no leaflet) (P_3)	0.0	0.0	0.0	0.0	0.0
Leaflet with a node (P_4)	12.8	9.5	9.3	8.7	10.0
Leaflet with no node (P_5)	12.0	9.2	8.5	8.0	9.4
Apical half of leaflet (P_6)	8.8	8.3	7.9	7.8	8.2
Basal half of leaflet (P_7)	9.7	8.0	8.2	7.6	8.4
Mean	16.2	12.7	11.8	11.0	
	CD at 5 %		**SE(m) ±**		
P	1.95		0.67		
C	1.48		0.50		
PXC	3.91		1.34		

P = portion of plant part

C = IBA concentration

PXC = Interaction of portion of plant part and IBA concentration.

In interaction significantly maximum leaf stalk length (52.2 cm) was noticed in the entire pinnate leaf with IBA at 1000 ppm concentration. Minimum leaf stalk length (7.6 cm) was noticed in basal half of leaflet in control, followed by apical half of leaflet in control (7.8 cm) and apical half of leaflet in 2000 ppm (7.9 cm).

Maximum length of leaf stalk was obtained with 1000 ppm concentration in entire pinnate leaf. This may be due to the stored reserve food in the rhizomes in combination with IBA might caused the length of leaf stalk.

The reduction in the length of longest shoot at higher concentration might be due to the inhibitory or toxic effect at higher level of IBA. (Patel Kavan Jayantkumar, 2016).

Auxin enhanced cell division and cell enlargement, promotion of protein synthesis which might have resulted in enhanced vegetative growth (Evans, 1973).

The above findings were in conformity with the (Thayamini H. Seran, 2015) Dragon Fruit (*Hylocereus undatus*) shoot length (9.5 cm) at 6000 ppm concentration of IBA and Babaie *et al* (2014) in *F. binnendijikii* cuttings 4000 mg/l IBA showed greatest length of new shoots. And CH. Pulla Reddy, 2003 in scented geranium (*Pelargonium graveolens* (L) Herit). Shoot length maximum at IBA 2000 ppm.

4.10 Number of leaf stalks

Data related to the effect of portion of plant part and IBA concentration on number of leaf stalks was presented in the table 4.10.

Among portion of plant part, maximum number of leaf stalks was observed in entire pinnate leaf (2.5) which is on par with two leaflets with a node and stalk (2.0). Minimum number (1.5) of leafstalks was observed in basal half of leaflet followed by leaflet with no node and stalk (1.7).

More number of leaf stalks (1.9) was observed in 1000 ppm and 1500 ppm (1.9). compared to number of leaf stalks in control (1.5 cm) (without IBA) and 2000 ppm (1.5).

Table 4.10 Effect of portion of plant part IBA concentration on number of leaf stalks per plant in *Zamioculcas zamiifolia* (Lodd.) Engl.

Portion of plant part (P)	**IBA** 1000 ppm (C_1)	**IBA** 1500 ppm (C_2)	**IBA** 2000 ppm (C_3)	**Control** Without IBA (C_4)	**Mean**
Entire pinnate leaf (P_1)	3.5	2.5	2.0	2.0	2.5
Two leaflets with node and stalk(P_2)	2.5	2.5	1.5	1.5	2.0
Only stalk (no leaflet) (P_3)	0.0	0.0	0.0	0.0	0.0
Leaflet with a node (P_4)	2.0	2.5	2.5	3.0	2.5
Leaflet with no node (P_5)	2.0	2.0	2.0	1.0	1.7
Apical half of leaflet (P_6)	2.0	2.0	2.0	2.0	2.0
Basal half of leaflet (P_7)	1.5	2.0	1.0	1.5	1.5
Mean	1.9	1.9	1.5	1.5	
	CD at 5 %		**SE(m) ±**		
P	0.43		0.14		
C	0.32		0.11		
PXC	0.87		0.29		

P = Portion of plant pat

C = IBA concentration

PXC = Interaction of portion of plant part and IBA concentration.

In interaction effect more number (3.5) of leaf stalks was observed in entire pinnate leaf with 1000 ppm IBA. Less number (1.0) of leafstalks was observed in leaflet with no node in control and basal half of leaflet (1.0) leaflet along with 2000 ppm followed by basal half of leaflet (1.5) leaflets in control, and two leaflet with a node and stalk (1.5) in control as well as in 2000 ppm, two leaflet with a node and stalk (1.5) in control and in basal half of leaflet (1.5) in 1000 ppm.

Number of leaf stalks varied with the concentration. Different portions of plant part performed differently at different concentrations.

Exogenous application of IBA increases the endogenous level of auxin. Mobilization and utilization of the stored carbohydrates due to influence of the auxin was increased the number of sprouts (Severino et al. 2011).

Exogenous IBA application affected significantly on shoot parameters because it enhance hydrolysis of nutritional reserves under the influence of exogenous auxin (Kochhar et al. 2008).

The results obtained were conformity with the previous research of Muhammad Ismail Siddiqui *et al* (2007) in *Ficus hawaii* cuttings maximum number of shoots per plant (13) with 4000 ppm IBA and Mehraj *et al* (2013) number of branches per cutting (4.7) at 1000 ppm IBA in *Bougainvillea spectabilis.*

4.11 Number of leaflets on leaf stalk

Data regarding the effect of portion of plant part and IBA concentration on number of leaf lets was presented in the table 4.11.

Significantly maximum number (9.6) of leaflets was found in the entire pinnate leaf. Minimum number (3.1) of leaflets was found in basal half of leaf let followed by apical half of leaflet (3.2) and leaflet with no node (3.3). In only stalk (no leaflet) no formation of leaflet was recorded.

Table 4.11 Effect of portion of plant part and IBA concentration on number of leaf lets per leafstalk in *Zamioculcas zamiifolia* (Lodd.) Engl.

Portion of plant part (P)	**IBA** 1000 ppm (C_1)	**IBA** 1500 ppm (C_2)	**IBA** 2000 ppm (C_3)	**Control** Without IBA (C_4)	**Mean**
Entire pinnate leaf (P_1)	13.0	9.0	9.5	7.0	9.6
Two leaflets with node and stalk (P_2)	9.5	7.5	4.5	5.5	6.7
Only stalk (no leaflet) (P_3)	0.0	0.0	0.0	0.0	0.0
Leaflet with a node (P_4)	7.5	5.5	3.5	3.5	5.0
Leaflet with no node (P_5)	5.5	3.5	2.5	2.0	3.3
Apical half of leaflet (P_6)	4.0	3.0	3.0	3.0	3.2
Basal half of leaflet (P_7)	4.5	3.0	2.5	2.5	3.1
Mean	6.2	4.5	3.6	3.3	

	CD at 5 %	**SE(m) ±**	
P	1.05	0.36	
C	0.79	0.27	
PXC	NS	0.726	

P = Portion of plant part

C = IBA Concentration

PXC = Interaction of portion of plant part and IBA concentration.

Significantly maximum number (6.2) of leaf lets was found in IBA 1000 ppm. Minimum number (3.3) of leaflets was found in control (without IBA) followed by 2000 ppm IBA (3.6) leaflets.

Interaction between portion of plant part and IBA concentration found to be non significant.

4.12 Length of leaf let (cm)

Data regarding the effect of portion of plant part and IBA concentration on length of leaflet was presented in table 4.12.

Among the portion of plant part significantly maximum leaflet length (10.2 cm) was noticed in entire pinnate leaf. Minimum length of leaflet (7.3 cm) was noticed in apical half of leaflet followed by basal half of leaflet (7.4 cm).

Data regarding the effect of IBA on the length of leaflets had significant difference. Maximum length (8.1 cm) of leaflet was found in the leaf cuttings treated with IBA @ 1000 ppm. Minimum length (6.3 cm) of leaf let was found in the control (without IBA).

In the interaction effect significantly maximum length (11.6 cm) of leaflet was noticed in entire pinnate leaf with IBA 1000 ppm. Minimum length (6.6 cm) of leaflets was noticed in apical half of leaflet in control (without IBA) which is on par with basal half of leaflet and leaflet with no node (6.8 cm) in control (without IBA) and leaflet with no node (6.8 cm) in control (without IBA).

The growth regulators promoted cell division, cell elongation and further enhanced the translocation of sugars there by significantly influencing the leaf length (Kumar et al., 2008). Stored food reserves in the rhizomes and vigorous root system may promoted the leaflet length.

The results are in conformity with the finding of Bhagat Ram Kumawat, (2009) in Pomegranate (*Punica granatum* L.) cv. "Mridula increased leaf length

Table 4.12 Effect of portion of plant part and IBA concentration on length (cm) of leaflet in *Zamioculcas zamiifolia* (Lodd.) Engl.

Portion of plant part (P)	**IBA** 1000 ppm (C_1)	**IBA** 1500 ppm (C_2)	**IBA** 2000 ppm (C_3)	**Control** Without IBA (C_4)	**Mean**
Entire pinnate leaf (P_1)	11.6	10.9	10.1	8.2	10.2
Two leaflets with node and stalk(P_2)	10.1	9.5	9.2	7.9	9.2
Only stalk (no leaflet) (P_3)	0.0	0.0	0.0	0.0	0.0
Leaflet with a node (P_4)	10.2	8.7	8.7	7.6	8.8
Leaflet with no node (P_5)	9.3	7.6	7.3	6.8	7.7
Apical half of leaflet (P_6)	8.0	7.3	7.2	6.6	7.3
Basal half of leaflet (P_7)	7.8	7.4	7.5	6.8	7.4
Mean	8.1	7.3	7.1	6.3	
	CD at 5 %		**SE(m) ±**		
P	0.18		0.06		
C	0.13		0.04		
PXC	0.36		0.12		

P = Portion of plant part

C = IBA Concentration

PXC = Interaction of portion of plant part and IBA concentration.

(4.88 cm) at 1500 ppm IBA and Muhammad Irfan Ashraf (2016) in onion (47.28 cm) at 100 ppm IBA.

4.13 Width of leaf let (cm)

Data pertaining to leaflet width are presented in table 4.13 and in fig 6.

Significantly maximum leaflet width (4.7 cm) was found in entire pinnate leaf. Minimum leaflet width (3.5 cm) was found in apical half of leaflet followed by basal half of leaflet (3.6). Whereas, in only stalk (no leaflet) no formation of leaf let was recorded.

Width of leaflet was found significant with different concentrations of IBA. Maximum width (3.8 cm) of leaf let was found in IBA 1000 ppm. Minimum leaflet width (3.0 cm) was found in control (without IBA).

In interaction effect, significantly maximum leaflet width (5.4 cm) was found in entire pinnate leaf with 1000 ppm IBA. Minimum leaflet width (3.2 cm) was found in basal half of leaflet in control (without IBA) followed by apical half of leaflet (3.3 cm) in control.

Increase in leaf number, leaflet length and leaflet width may be due to significant effect of growth regulators on inducing vigorous rooting system thus enabling more nutrient absorption (Prati et al. 1999). Thus IBA promoted root growth which absorbs more nutrients and also stored food reserves in the rhizomes which increased the leaf width.

This results are in conformity with the findings of Bhagat Ram Kumawat, (2009) in Pomegranate (*Punica granatum* L.) cv. "Mridula , leaf width (1.81 cm) at 1500 ppm IBA and Muhammad Irfan Ashraf (2016) in onion (1.2 cm) at 100 ppm IBA. Vikas Kumar Khatik in Damask rose cuttings (*Rosa damascena*. Mill) var. Ranisahiba maximum leaflet width (1.30 cm) with 200 ppm IBA.

Table 4.13 Effect of portion of plant part and IBA concentration on width (cm) of leaflet in *Zamioculcas zamiifolia* (Lodd.) Engl.

Portion of plant part (P)	**IBA** 1000 ppm (C_1)	**IBA** 1500 ppm (C_2)	**IBA** 2000 ppm (C_3)	**Control** Without IBA (C_4)	**Mean**
Entire pinnate leaf (P_1)	5.4	4.7	4.9	3.8	4.7
Two leaflets with node and stalk (P_2)	4.7	4.3	4.1	3.6	4.2
Only stalk (no leaflet) (P3)	0.0	0.0	0.0	0.0	0.0
Leaflet with a node (P4)	4.5	4.2	4.2	3.6	4.1
Leaflet with no node (P5)	4.4	4.3	4.3	3.6	4.1
Apical half of leaflet (P6)	4.0	3.5	3.4	3.3	3.5
Basal half of leaflet (P7)	4.0	3.7	3.5	3.2	3.6
Mean	3.8	3.5	3.5	3.0	
	CD at 5 %		**SE(m) ±**		
P	0.19		0.06		
C	0.14		0.05		
PXC	0.39		0.13		

P = Portion of plant part

C = IBA concentration

PXC = Interaction of potion of plant part and IBA concentration.

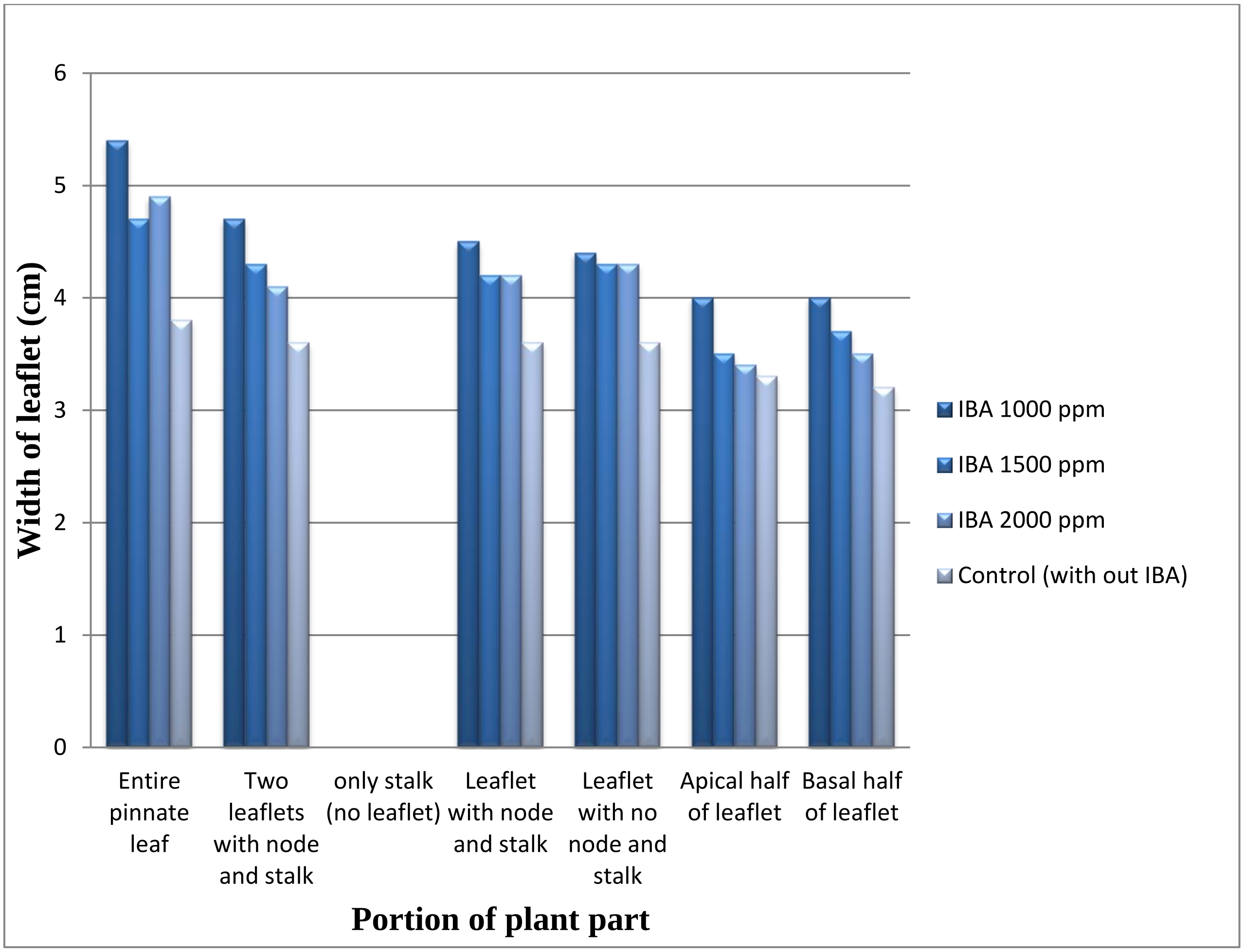


Fig. 6 Effect of portion of plant part and IBA on width (cm) of leaflet in *Zamioculcas zamiifolia* (Lodd.) Engl.

4.14 Number of days taken for finishing of pot plant

Data regarding number of days taken for finishing of pot plant was presented in table 4.14.

The data presented on number of days taken for finishing of pot plant indicated that portion of plant part had a significant effect. Minimum days (220.1) required by entire pinnate leaf. Maximum days (274.5) required by basal of leaflet. In only stalk (no leaflet) plant was not observed.

Data pertaining to number of days taken for finishing of pot plant significantly affected by application of IBA. Minimum days (202.2) required by IBA 1000 ppm. Maximum days (227.3) required in control without IBA.

In interaction effect significantly minimum days (208.0) required by entire pinnate leaf with IBA 1000 ppm. Maximum days (287.5) required by apical half of leaf let in control (without IBA) followed by basal half of leaflet (285.5) in control (without IBA) and leaflet with a node (282.5) in control.

The minimum number of days taken for finishing of pot plant might be influenced by above all parameters including rhizome parameters, shoot parameters, root parameters. And effect of IBA which influence the growth of the plant by cell division and cell elongation, which might have caused the increase in root length which absorb nutrients from soil and stored food reserves in the rhizomes.

Table 4.14 Effect of portion of plant part and IBA on number of days taken for finishing of pot plant of *Zamioculcas zamiifolia* (Lodd.) Engl.

Portion of plant part (P)	**IBA** 1000 ppm (C_1)	**IBA** 1500 ppm (C_2)	**IBA** 2000 ppm (C_3)	**Control** Without IBA (C_4)	**Mean**
Entire pinnate leaf (P_1)	208.0	211.0	224.0	237.5	220.1
Two leaflets with node and stalk (P_2)	215.0	236.5	243.5	245.0	235.0
Only stalk (no leaflet) (P_3)	0.0	0.0	0.0	0.0	0.0
Leaflet with a node (P_4)	219.0	235.0	242.5	282.5	244.7
Leaflet with no node (P_5)	242.5	246.5	249.0	253.5	247.8
Apical half of leaflet (P_6)	264.0	262.5	277.5	287.5	272.8
Basal half of leaflet (P_7)	267.5	270.0	275.0	285.5	274.5
Mean	202.2	208.7	215.9	227.3	
	CD at 5 %		**SE(m) ±**		
P	3.06		1.05		
C	2.31		0.79		
PXC	6.13		2.10		

P = Portion of plant part

C = IBA Concentration

PXC = Interaction of portion of plant part and IBA concentration.

CHAPTER-V

SUMMARY AND CONCLUSION

Chapter V

SUMMARY AND CONCLUSION

The present experiment "Standardization of portion of plant part used and IBA concentration on commercial production of ZZ plant (*Zamioculcas zamiifolia*) (Lodd.) Engl.''was conducted during the year 2017-18 at Floriculture Research Block, College of Horticulture, Mojerla.

The present experiment consist of seven different portions of plant parts *viz*. Entire pinnate leaf, two leaflets with a node and stalk, only stalk, one leaflet with a node and stalk, one leaflet with no node and stalk, apical half of leaflet, basal half of leaflet along with four different levels of IBA *viz*., 0, 1000, 1500, 2000. The treatments were replicated twice. Experiment was laid out in Factorial Completely Randomized Design. Various parameters like days to rhizome initiation, number of rhizomes, diameter of rhizomes (cm), fresh weight of rhizomes (g), moisture content of rhizomes (%), number of roots, length of roots (cm), number of days taken for leaf stalk emergence, length of leaf stalk (cm), number of leaf stalks, number of leaflets on leaf stalk, length of leaflet (cm), width of leaflet (cm), number of days taken for finishing of pot plant were studied. The salient features of the experimental findings are summarized in this chapter.

5.1 Effect of portion of plant part

5.1.1 Significantly minimum number of (31.6 days) days taken for rhizome initiation in two leaflets with a node and stalk.

5.1.2 Significantly minimum number of days (92.0 days) taken for leaf stalk emergence in entire pinnate leaf.

5.1.3 Number of rhizomes (6.1), diameter of rhizomes (6.1 cm), fresh weight of rhizomes (83.9 g), moisture content of rhizomes (87.7 %), number of roots (23.1), length of roots (17.0 cm), length of leaf stalk (41.1 cm), number of (9.6) leaflets on leaf stalk, length of leaflet (10.2 cm), width of leaflet (4.7 cm), were significantly maximum in entire pinnate leaf.

5.1.4 Number of leaf stalks was more (2.5) in entire pinnate leaf and leaflet with node (2.5) which is on par with two leaflets with a node and stalk (2.0) and apical half of leaflet (2.0).

5.1.5 Significantly minimum number of days (220.1 days) taken for finishing of pot plant was recorded in entire pinnate leaf.

5.2 Effect of IBA

5.2.1 Minimum number of days (30.5 days) to rhizome initiation was found with 1000 ppm IBA over control.

5.2.2 Maximum number of (3.3) rhizomes, diameter of rhizome (3.8 cm), fresh weight of rhizomes (32.7 g), moisture content of rhizomes (74.0 %) was recorded with 1000 ppm IBA over control. Maximum number (12.5) of roots and length of roots (13.5 cm) was found at 1000 ppm IBA over control. Maximum number of (6.2) leaflets on leaf stalk and maximum length of leaflet (8.1 cm), width of leaflet (3.8 cm) was observed in 1000 ppm IBA over control. Maximum number of leaf stalks (1.9) was observed in 1000 ppm and 2000 ppm IBA.

5.2.3 There is a significant difference in minimum number of (85.1 days) days taken for leaf stalk emergence and maximum length (16.2 cm) of leaf stalk with 1000 ppm IBA concentration over control.

5.2.4 Minimum number of (202.2 days) days taken for finishing of pot plant was observed in 1000 ppm IBA over control. There is a significant difference between treatment combinations.

5.3 Interaction effect

5.3.1 Best results were obtained with interaction between entire pinnate leaf with 1000 ppm IBA in all most all parameters number of rhizomes (7.5) per plant, diameter of rhizome (9.0 cm), fresh weight of rhizomes (156.3 g), moisture content of rhizomes (89.7 %), number of roots (30.0) per plant, length of root (19.2 cm), number of days (86.5 days) taken for leaf stalk emergence, length of leaf stalk (52.2 cm), number of leaf stalks (3.5) per plant, length of leaflet (11.6 cm), width of leaflet (5.4 cm), number of days taken for finishing of pot plant, except in one parameter number of days (44.5 days) to rhizome initiation was highest in entire pinnate leaf.

5.3.2 Number of leaflets on leafstalk found to be non significant in interaction effect. Significantly minimum number of (29.0) days to rhizome initiation was recorded in two leaflets with node and stalk.

5.4 Conclusion

Based on the results obtained by present investigation it can be concluded that entire pinnate leaf with 1000 ppm IBA proved better individually as well as in their interaction, except for days taken to rhizome initiation, rest of all parameters, *viz.*, number of rhizomes, diameter of rhizomes, fresh weight of rhizomes, moisture content of rhizomes (%), number of roots, length of roots, number of days taken for leaf stalk emergence, length of leaf stalk, number of leaf stalks, number of leaflets on leaf stalk, length of leaflet, width of leaflet, number of days taken for finishing of pot plant. Whereas only stalk (no leaflets) did not form callus tissue or rhizome with any of the IBA concentration.

5.5 FUTURE LINE OF WORK

Based on the experience gained and results obtained, following suggestions are made for future line of work

1. Experiment should be repeated using different dipping times and with lower concentrations of IBA.
2. Studies on different media combinations need to be studied for quick growth of ZZ plant.

3. ZZ plant is a slow growing ornamental plant, studies on use of other plant growth regulators should be conducted for quick establishment and market ready of plants.
4. As it can withstand poor light and drought condition, studies on various growing conditions and potting media should be conducted for its use in indoor scaping.
5. Studies on rhizome division should be conducted using growth regulators.

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LITERATURE CITED

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APPENDICES

APPENDIX I

Monthly meteorological data during plant growth period from November 2017 to July 2018.

Month	**Temperature (˚C)**		**Rainfall (mm)**	**Relative humidity (%)**	
	Maximum	**Minimum**		**Maximum**	**Minimum**
November	33.41	18.19	-	107.17	36.08
December	31.84	15.64	-	78.64	30.90
January	32.44	16.18	-	73.57	30.08
February	34.53	17.34	-	67.89	23.14
March	37.42	21.2	-	123.40	42.90
April	39.84	25.56	7.0	60.43	22.28
May	41.14	26.91	26.1	60.09	25.58
June	36.33	24.95	58.2	74.19	39.41
July	33.48	23.89	69.8	77.15	50.30