ROOTING PERFORMANCE OF STEM CUTTINGS OF THREE ORNAMENTAL PLANTS AS INFLUENCED BY GROWTH REGULATORS

A THESIS
BY
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CERTIFICATE

This is to certify that thesis entitled, "**Rooting Performance of Stem Cuttings of Three Ornamental Plants as Influenced By Growth Regulators**" submitted to the Department of Horticulture & Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka. In partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in Horticulture, embodies the result of a piece of *bonafide* research work carried out by **Zuairia sultana** Registration No. **25288/00393** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Dated:
Dhaka, Bangladesh.

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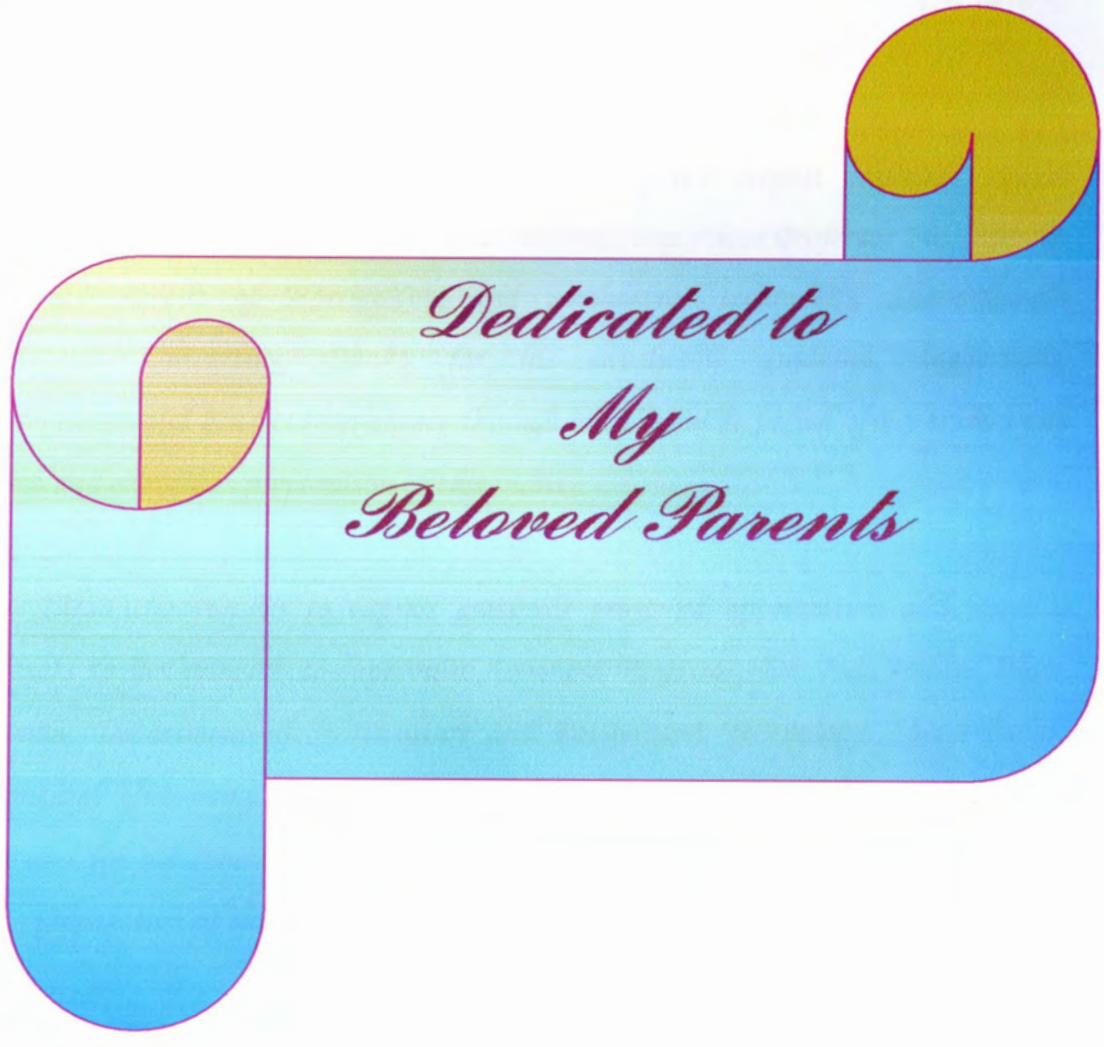
Dedicated to
My
Beloved Parents

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ABSTRACT

An experiment was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka during the period from mid June to mid August, 2005 to find out the effects of different concentrations of growth regulators, Indole Butyric Acid (IBA) and Napthalene Acetic Acid (NAA) on rooting performance of stem cutting of three ornamental plants viz. Nerium, Bougainvillea and Jasminum. The concentrations of growth regulators of both IBA and NAA were control, 200, 300 and 400 ppm. The cuttings were planted on 13 June, 2005 at a spacing of 15 cm x 15 cm. The experiment was laid out in a Randomized Complete Block Design with three replications. The results revealed that both growth regulators IBA and NAA had significant effects on the rooting performance of the ornamental species. Different concentration of growth regulators significantly influenced all the parameters studied. The highest number of root (25.38) was obtained with 400 ppm IBA in Bougainvillea while it was the lowest (8.75) in Nerium at control. The longest root (23.53cm) was produced by 400 ppm IBA in Bougainvillea while Nerium produced the shortest one (6.53 cm) at control. All the different concentrations of IBA and NAA showed higher percentage of success in rooting. Among the species, Bougainvillea showed the maximum percentage of success (95.60) when treated with 400 ppm IBA. On the contrary, Nerium showed the minimum percentage of success (44.33) at control.

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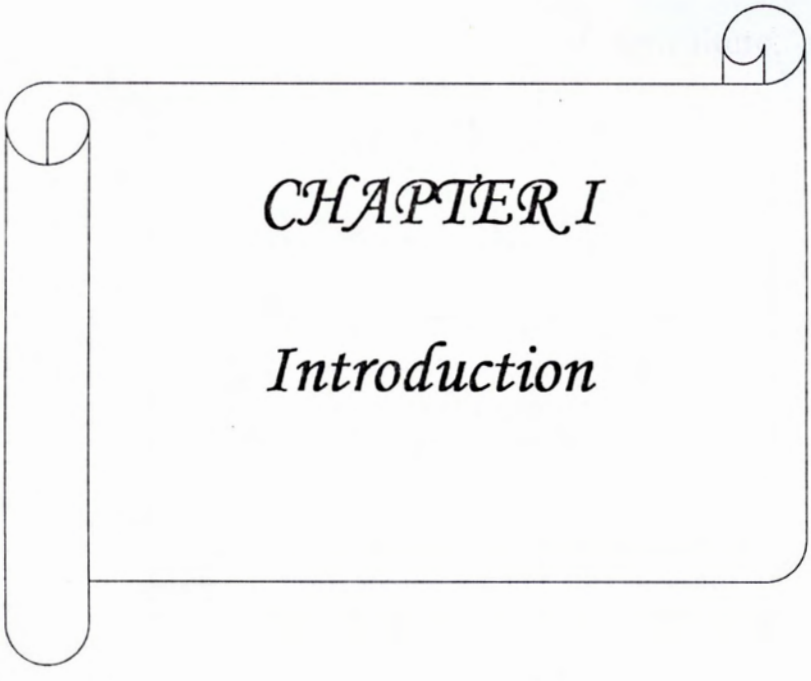
ABBREVIATIONS AND ACRONYMS

BARI	= Bangladesh Agricultural Research Institute
IBA	= Indole Butyric Acid
LSD	= Least Significant Difference
NAA	= Napthalene Acetic Acid
IAA	=Indole Acetic Acid
PGRs	=Plant Growth Regulators
NS	=Non Significant
RH	= Relative Humidity
Var.	= Variety
2,4 D	= 2, 4 Dichloro phenoxy acetic acid



CHAPTER I

Introduction

INTRODUCTION

In the present world, flowers and ornamentals have become important not only for its aesthetic and social values but also for its economic contribution. Production and trade with these crops are now very much specialized in the developed countries with a significant contribution to their national economy.

Plant propagation is an important aspect of agriculture, particularly in horticulture. Plants can propagate either sexually (by seed) or asexually (by vegetative means). A number of horticultural plants especially ornamental plants are propagated commercially by vegetative means. Many ornamental plants (for example rose, gardenia etc.) do not normally produce any viable seed. On the other hand, this unique characteristic may be deteriorated due to cross pollination when it is propagated through seed.

The utility and importance of ornamental plants like flowering shrub in a garden or a landscape is universally acknowledged (Randhawa and Mukhopadhyay, 1986). A garden or a park without shrub will lose much of its charm, attraction and beauty. Even in small home garden where planting of trees is not possible, some selected shrubs must find a place. Many flowering shrubs are also used as cut-flowers drawing considerable demand for flower shops. Among different flowering shrubs; Jasmine, Nerium and Bougainvillea are the most common ornamental plant species grown in Bangladesh.

Recently in certain areas, cultivation of flowers and ornamentals have been found to be more profitable than the production of many field and other horticultural crops by the growers. Production of floricultural crops is now spreading too many parts of the country and its consumers are increasing in number. Although gardening is mostly limited to public institutions and posh areas, peoples of all classes appreciate the aesthetic value of flowers and gardens. Recently, a considerable enterprise is gradually developing in urban areas for flower marketing.

Among the vegetative means, stem cutting is one of the easiest, cheapest and least time consuming methods of plant propagation (Bose and Mukharjee, 1977). The rootability of cutting of different plant species is different. There are certain plant species (for example apple, phalsha, etc.) which form roots easily on cutting while some others give root when external manipulating treatment is given.

Bougainvilleas are among the most floriferous shrubby climbing deciduous of the tropics, producing beautiful color effects which can hardly be excelled by any other plant. In recent years, these have become one of the most popular garden plants all over the world. It is a member of the family Nyctaginaceae, with the following three species; *Bougainvillea spectabilis, B. glabra,* and *B. peruviana* which are usually of commercial importance. Flowers are usually inconspicuous and surrounded by brilliantly colored papery bracts that persist on the plants for a long time.

Jasmines are highly prized for their fragrant flowers, which are used for the preparation of perfume. They are grown commercially for the extraction of the essential oil for perfume and for cut flowers which are commonly used for making garlands and bouquet.

Nerium is a tall flowering shrub widely grown in tropical gardens. It bears clusters of showy flowers at the top of the branches mainly during summer and few flushes in the rains. In dry area the plants are shorter in height and the shoots arising after pruning bear flower in the next year, while in humid atmosphere the new shoots require longer period to mature and initiate flowering.

Root initiation with the use of growth regulators occupies a significant position in the field of propagation (Mukherjee *et al.,* 1976). All the growth regulators are not equally suitable for rooting performances. Among the growth regulators Indole Butyric Acid (IBA) is the most commonly and widely used to achieve high percentage of rooting success for the ornamental species (Kundu *et al.,* 1987). Other exogenous hormones which regulate plant growth are Indole Acetic Acid (IAA), Napthalene Acetic Acid (NAA), 2, 4-Dichloro phenoxy acetic acid (2,4-D), Indole Propionic Acid.

When propagation through stem cutting becomes very difficult, treatments with growth regulators are applied in optimum concentration to promote rooting in stem cutting. Activity of growth regulators depends upon the amount of hormone applied and a particular concentration of growth

regulator may be more effective for initiation of root in stem cutting. Thus, optimum concentration of growth regulator needs to be determined for different plant species.

The objectives of this study are as follows:

1. to identify suitable growth regulators for better rooting performance in three ornamental plants by using Indole Butyric Acid (IBA) and Napthalene Acetic Acid (NAA), and

2. to identify suitable concentration of Indole Butyric Acid (IBA) and Napthalene Acetic Acid (NAA) for better rooting performance in three ornamental plants.

CHAPTER II

Review of Literature

REVIEW OF LITERATURE

Cutting is the most important technique for the propagation of ornamental plants. It is the easiest method of propagation and has been attempted in certain species, particularly those grown on commercial scale. Often nursery men are facing trouble with the formation of root in plants having hard wood or semi-hard wood. Some plants have no ability to produce root in normal condition. Several factors like type of cutting, rooting media, environmental conditions etc., influence root formation in cuttings. The use of auxin in rooting has brought about a vast quantitative change in plant propagation. According to Hartmann and Kester (1972) the most commonly and widely used auxins are IBA (as best one), NAA and IAA in promoting rooting.

Some of the important and informative works relevant to present work have been furnished in this chapter.

Effect of growth regulators on Bougainvillea, Jasminum, Nerium and others

Tripathi *et al.* (2003) conducted an experiment in Uttar Pradesh, India, in 1998 to investigate the effect of auxins on rooting and rooting quality of poinsettia. Poinsettia cuttings were treated with NAA (100, 200, 1000 and 2000ppm), IAA (100, 200, 2000 and 4000 ppm), IBA (100, 200, 2000 and 4000 ppm), and 2, 4, 5-TP [fenoprop] (5, 10, 50 and 100 ppm). The cuttings treated with 100 ppm IBA recorded the earliest number of days

(15 days) for sprouting which is significantly lower than control (20 days). The highest number of leaves per cutting was recorded in 50 ppm 2,4,5-TP (28.39) while the lowest was recorded in 200 ppm NAA (15.53). The various concentrations of IAA and IBA increased the number of leaves, which ranged from 19.76 to 28.39 and are significantly superior to the control (17.51). The highest rooting was observed in IAA treated cuttings (97.78%) while the highest number of roots per cutting was observed in 1000 ppm NAA. The longest root was observed in 200 ppm IAA, whereas, the highest root fresh weight was recorded with 100 ppm IAA (2.30 g).

Parminader and Kushal (2003) conducted an experiment in January 2000, at Ludhiana, Punjab, India semi-hardwood cuttings of Bougainvillea cv. Cherry Blossom were treated with 16 possible combinations of NAA (0, 1000, 1500 and 2000 ppm) and IBA (0, 1000, 1500 and 2000 ppm) by dipping the basal ends of the cuttings (5 cm) in the growth regulator solutions for 5 seconds. Data were recorded for rooting percentage, number of roots per cutting, root length, root fresh weight and root dry weight. NAA at 1500 ppm + IBA at 1000 ppm were identified as the best treatment.

Sharma *et al.* (2002) conducted an experiment to determine the effect of IBA and IAA on the stem cuttings of *Acalypha wilkesiana* cv. *Tahiti*. Upon dipping the basal ends of freshly prepared cuttings in 1000, 1500 and 2000 ppm IBA and IAA solutions for 5 seconds, 10 cuttings were planted for each treatment. The rooting percentage and average length of roots per cutting were highest upon treatment with 2000 ppm IBA, followed by

2000 ppm IAA. The number of roots per cutting and the fresh weight of roots were highest upon treatment with 2000 ppm IBA, followed by 1500 ppm IBA. All the shoot growth parameters (including the leaf number per cutting, sprout number per cutting and longest branch length) were higher in cuttings treated with 2000 ppm IBA, followed by cuttings treated with 2000 ppm IAA.

Navjot and Kahlon (2002) studied that the effects of cutting type (basal, middle and sub-apical portion of the shoots) and IBA concentration (0, 50, 100 and 200 ppm) on the rooting and growth of pomegranate (cv. Kandhari) were investigated during 2000/2001 at Amritsar, Punjab, India. Middle cuttings treated with 100 ppm IBA recorded the highest values for root number (32.72), root length (34.00 cm), fresh root weight (1048.24 g), plant height (49.79 cm), total leaf area (293.00), shoot girth (1.36 cm), shoot number (4.76) and shoot length (13.75 cm), while basal cuttings treated with 100 ppm IBA recorded the highest plant girth (4.21 cm).

Semi-hardwood cuttings from one-year-old gamma ray-induced mutants of bougainvillea cv. Los Banos Variegata were treated with 1000, 2000, 3000, 4000 and 5000 ppm IBA for 10 seconds and with 250, 500, 750 and 1000 ppm IBA for 24 hour. Dipping of cuttings in 1000 ppm IBA for 24 hour resulted in 100% rooting. Dipping of cuttings in 500 ppm IBA resulted with the highest number of root and shoots per cutting (Gupta *et. al.*, 2002).

Panwar *et al.* (2001) conducted an experiment with the basal end of hardwood and semi-hardwood Bougainvillea sp. cv. Mary palmer cuttings were dipped in 250, 500, 1000 and 2000 ppm IBA, NAA and IAA before transplanting in nursery beds to determine the effects of plant growth regulators (PGR) on the rooting of bougainvillea cuttings. The highest number of sprouted buds in the hardwood (1.20) and semi-hardwood cuttings (1.13) was recorded in cuttings dipped in 1000 and 2000 ppm IBA, respectively, although differences in the effects of the different PGR treatments on the number of sprouted buds were not significant. The number of leaves and roots, rooting percentage and root length increased with increasing concentration of auxins, with 2000 ppm IBA recording the most marked effect.

Singh (2001) conducted an experiment in Nagaland, India during 1998 to study the effects of wood type and growth regulators on the rooting ability of B. *peruviana* cv. Thimma. Three types of wood, viz. hard, semi-hard and soft wood cuttings, and five concentration of plant biological regulators (PBRs), i.e. IBA and NAA (each at 1000 and 2000 ppm) and control, were evaluated. Hardwood cuttings and 2000 ppm IBA significantly increased in rooting, number of sprouts per cutting, number of leaves per cutting, length of sprout, diameter of sprout and number of roots per cutting. However, no significant differences among different types of wood was observed for days to sprouting, while 2000 ppm IBA markedly induced early sprouting and resulted in maximum rooting percentage which was at par with that of 2000 ppm NAA. All cuttings treated with various concentration of PBRs were statistically superior to control as

regards all parameters. The interaction between wood type and PBR concentration was significant; with the highest interaction recorded for the number of leaves per cutting, length of sprout number of roots per cutting, length of roots and fresh weight of roots per cutting under hardwood cutting and 2000 ppm IBA combinations.

A study was carried out to assess the effect of auxins on rooting behavior of stem cuttings of *Berberis aristata*. The 9 treatments consisted of solutions of 250, 500, 1000, 2000 and 2500 ppm IBA; 2000 ppm IBA + 2000 ppm NAA; 2000 ppm IBA + 2000 ppm IAA; 2000 ppm IBA + 2000 ppm NAA + 200 ppm IAA and a control (water). IBA (500 ppm) showed the maximum number of roots per cutting (10.66 and 9.66), highest root length (6.40 cm and 5.50 cm) and highest rooting percentage (86.66 and 83.33) in comparison to other treatments during the year 1992 and 1993, respectively. (Shah *et al.*, 1999).

Basavarajeshwari *et al.* (1998) conducted an experiment to study the relative efficiency of different growth substances on the rooting and survival of rooted cuttings of *Jasminum grandiflorum, J. auriculatum* and *J. sambac*. Hardwood cuttings, 15-20 cm long, were prepared from the basal portion of matured stems. The cuttings were dipped for 2 seconds in 2000, 4000 and 6000 ppm IBA and NAA. Treatments with the growth regulators significantly promoted rooting and survival and recorded higher number of roots per cutting over the untreated cuttings for all Jasmine species. Treatment with 4000 ppm IBA recorded the maximum percentage of rooting, and the highest number of roots with increased length. Rooted

cuttings obtained by treatment with 4000 ppm IBA also resulted in the highest percentage of survival in all the three species. In *J. grandiflorum* and *J. sambac*, the beneficial effects of growth regulator on rooting of the cuttings were highest (84.33 and 84.75%, respectively) upon treatment with 4000 ppm NAA, while in *J. auriculatum*, 2000 ppm NAA was the best. In terms of cutting survival percentage, the highest in *J. grandiflorum* was recorded upon treatment with 4000 ppm NAA, while the highest in *J. auriculatum* and *J. sambac* was observed upon treatment with 2000 ppm NAA.

Maurya *et al.* (1996) carried out an investigation with hard wood and semi-hard wood cuttings of *Jasminum sambac* (cultivars single Mohra, double Mohra and a local strain) and *J. auriculatum*. Three were planted in sand, soil or a 1:1 mixture of sand + soil. Of the growing media, sand resulted in the highest percentage rooting and survival, number of root/cutting and root length (68.68%, 55.00%, 5-8 and 8.5 cm, respectively) followed by sand + soil. Of the 2 cutting types hard wood cuttings were superior to semi hard wood ones in terms of rooting (59.17 vs 47.50%), number of roots per cuttings (4.859 vs 3.711), root length (6.126 vs 4.358 cm) and survival (50.28 vs 42.22%). Of the genotypes, *J. sambac* cv double Mohra generally gave the best results (75% rooting and 65.55% survival), followed by the local strain of the same species, then cultivar single Mohra and finally *J. auriculatum* (37.7 8% rooting and 24.44%, survival).

Sari and Qrunfleh (1995) carried out an experiment where 10 cm long hard-wood cuttings of *J. grandiflorum* cv. were taken in January, March,

May, June or July for 2 successive years. The cuttings were treated with IBA, NAA, IAA, Abscisic Acid (ABA) or Alar (daminozide), each at 0, 500 or 1000 ppm. Rooting percentage of untreated controls was highest for cuttings taken in June and July. NAA treatments (500 or 1000 ppm) were found most effective in January having 20% rooting while 500 ppm Alar was found as best treatment in March and May having 70% rooting for hard wood cutting. In case of soft wood cutting the most effective treatment in January was 500 ppm. NAA and in March and May was 1000 ppm Alar. All or almost all (94-100%) of the soft wood cutting taken in July and treated with 1000 ppm NAA, 500 or 1000 ppm IAA or 50 ppm Alas rooted. ABA was the least effective treatment overall.

Panwar *et al.* (1994) worked with hard wood and semi hard wood cuttings of bougainvillea cv. Alok at 2000 ppm of IBA and observed that hard wood cuttings gave better growth than semi hard wood cuttings.

Singh (1993) worked with 4 concentrations of IBA (1000, 2000 3000 and 4000 ppm in quick dip solution) and found that IBA at 3000 or 4000 ppm gave more root per cutting than other treatment regardless of the season in semi hard wood cutting of bougainvillea.

An experiment was conducted by Verma *et al.* (1992) with 3 cultivars Pal (easy to root), Mahara (difficult to root) and Arjuna (failed to root) with IBA and ascorbic acid (0, 10, or 100 pm) and sucrose (0, 10, 10%) in all possible combinations. The best rooting of the stem cuttings of bougainvillea was obtained at 100 ppm IBA.

Gupta and Kher (1991) conducted an experiment in India with shoot tip cutting of bougainvilea var. Garnet Glory under intermittent mist. The cuttings were dipped in IAA, IBA or NAA (2000, 4000 or 6000 ppm in 50% alcohol) for 10 sec. IBA at 4000 ppm gave the best rooting (the highest root number and the greatest root length) in 37 days after planting.

Harris and Singh (1991) observed in their experiment in both spring and rainy season, that the semi hard wood cuttings of bouguinvillea gave the highest percentage of rooting across cultivars and number of root per cutting treated with IBA at 1000 ppm. Cuttings were dipped in IBA or NAA at 100, 200 or 400 ppm for 12 hours, cuttings were planted at 450 in a mist chamber and rooting success was noted down after 45 day of planting.

Nagaraja *et al.* (1991) carried out an experiment where hard wood, semi hard wood and soft wood cuttings of *Jasminum grandiflorum* were taken from one-year-old shoots and treated with 3000, 4000 or 5000 ppm IBA or NAA. Cuttings were placed in coarse sand and kept under intermittent mist for 60 days. Percentage of rooting, number of roots/cutting, length and thickness of longest root, number of sprouts/cutting and length of longest shoot were transplanted for survival studies. After further 60 days, survival % was recorded. IBA at 4000 ppm significantly increased % rooting in hard wood, semi hard wood and soft wood cuttings (100, 73.33 and 80%, respectively). Treatment with 4000 ppm IBA also resulted in the highest % survival of rooted cuttings in hard wood and semi hard wood cuttings (90 and 80%, respectively).

Hossain (1990) observed that bougainvillea and ixora gave the highest success (99%) when the cuttings were treated at 400 ppm IBA for 24 hours. He also found that this treatment also increased the number of root and shoots, length of roots and shoots and also fresh and dry weight of roots and shoots.

Thimmappa *et al.* (1990) studied that in stem cuttings of *Pelargonium graveolens* cultivars Algerian and Reunion, the effects of IAA, IBA and NAA at 1000, 2000 and 3000 ppm on the formation of adventitious roots was studied. Of the growth regulators, IBA gave the best results, as measured by percentage of rooted cuttings, number of roots/cutting and length of the longest root; the optimum concentration was 2000 ppm. To study the effect of woodiness of cuttings, rooting of cuttings of cv. Algerian taken from the tip, middle and basal portion of stems was compared. Root formation was best in tip shoot cuttings. Of the rooting media tested, vermiculite gave the best results, sand was next best and loamy soil was poorest.

Zaghloul *et al.* (1990) conducted an experiment during February 1988 and 1989. Stem cutting of a double flowered strain of *J. sambac* were dipped in NAA (500, 750 or 1000 ppm) for 2 hours or in kinetin (50, 75 or 100 ppm) for 2 hours, or in the 2 growth regulators successively (all concentration combinations). The untreated controls had the lowest rooting percentage (10%) while the highest success (90%) was achieved with combination of 750 ppm NAA and 75 ppm kinetin.

Cutting taken from apical, sub-apical and basal parts of current season's shoots were dipped in a solution of IBA +NAA, each at 1000, 2000 or 4000 ppm., and planted in sand under intermittent mist. The cuttings were assessed 35 days later for rooting success, number of roots/cutting, root length, and shoot length. The best results generally were obtained with sub-apical cuttings dipped in IBA + NAA, each at 2000 ppm. (36.66% rooting, compared with 6.66% in the control (Gowda *et al.,* 1989).

Dombeya natalensis and *D. tilliaceal* cuttings 15 cm in length were taken for healthy vigorous shoots treated with IAA, IBA or NAA, all at 1000, 2000, 3000, 4000 and 5000 ppm., and kept under intermittent mist for rooting. The optimum treatment for maximum rooting (90.00%) and survival of rooted cuttings (89.00%) were recorded with IBA at 4000 ppm. This treatment also gave a greater number of roots (19.81) and more root length (15.98 cm) per cutting than treatments with IAA or NAA. (Gupta *et. al.* 1989).

Gupta and Kher (1989) obtained highest percentages (86.7) of rooting, the highest number of primary roots (24.6) and highest cutting survival (96.16%) in Ixora. They also observed the performance of Ixora treated with 1000, 2000, 3000, 5000 ppm by using dip method for 10 seconds.

IBA increased rooting in cutting of *Bougainvillea glabra* taken in September or in March (Czekalshi, 1989). It was showed that for IBA treatment on cuttings the rooting percentage was reduced but improved the

quality of the root system. The highest rooting percentage was obtained in September.

Joshi *et al.* (1989) worked with hard wood cuttings of 5 bougainvillea cultivars and treated with IBA, NAA or IAA at 4000 or 6000 ppm. Cuttings treated with IBA at 6000 ppm gave 52.89% rooting. There was no significant difference between cultivars in rooting percentage

Rooting of shoot cuttings 1.5 cm or 2.0 cm in diameter was tested with different concentration of Indole Acetic Acid (IAA; at 50 or 100 ppm.) or Indole Butyric Acid (IBA; at 50 100, 500, 1000 or 2000 ppm.). Best rooting was obtained with 50 ppm. IBA and 100 ppm. IAA. Cuttings 2 cm in diameter with 50 ppm IBA were best, having the longest roots, greatest number of foliar shoots per cutting, highest percentage of cuttings with foliar shoots, and greatest number of transplantable foliar shoots. (Guzman *et al.*, 1989)

The 15-cm long cuttings were treated with IAA, IBA or NAA, each at 1000, 2000, 3000, 4000 or 5000 ppm using 10-second dip method. The best rooting (86.7%, the highest number of primary roots (24.6) and the highest cutting survival (96.16% were obtained with IBA at 2000 ppm.; the corresponding control figures were 40%, 5.25 and 66.7%. (Gupta *et. al.*, 1989).

Indole Butyric Acid alone at 50 ppm and 100 ppm gave the good rooting and the best survival (96.6%) of stem cutting of *Hibiscus rosa sinensis*

treated with IBA or NAA each at 0-500 ppm. This experiment was conducted by Widiastoety and Secbijanto (1988). Survival of rooted cutting was much better than in control.

Mukhopadhaya and Bankar (1988) studied in their experiment the effects of different concentration of IBA with the cutting of newly matured wood of 'Queen Elezabeth roses'. They showed that the cuttings untreated (control) and the cutting treated with 1000 ppm IBA as a quick basal dip failed to root. Cuttings treated with 2000 ppm IBA gave 88% rooting.

Stoltz and Anderson (1988) conducted an experiment with single node cutting of 8 cultivars of rose. They treated each cultivar with IBA at concentration of 125, 250, 500 and 750 ppm. They found that the rooting response differed between the cultivars and IBA concentration.

Widiastoetye and Soebijanto (1988) observed that stem cuttings of *Hibiscuss rosa sinensis* treated with IBA and NAA each at 0-500 ppm IBA alone at 50 ppm and 100 ppm gave good rooting and best survival (96.6%) while the survival was 70% in the control cuttings.

Better result was obtained by submerging the cuttings in solution of IBA over the powder form reported by Henting and Gruber (1988). They conducted an experiment on cutting of Correa feflexa cv. Manii with 4-8% IBA powder and 50-100 ppm IBA solutions.

Kundu *et al.* (1987) observed that growth regulator mainly IBA was very

much effective to achieve high percentage of success in rooting and higher number and length of roots per cutting were produced by *Ixora cocceinia.* They worked with IBA at different concentrations and found that 400 ppm was the best concentration for propagation of Ixora by stem cutting.

Georgakopoulou Vogiatzi (1987) conducted two experiments to find out the accurate rate of IBA, , one without leaf and other with leaves of rose cvs. Verhage and Arlene Francis each of which was treated with IBA at 0, 100, 200, 500, 1000, 2000, 4000 and 8000 ppm and placed for rooting under mist. Higher rooting percentage for leafless Dr. Verhage was observed at 100, 200 or 500 ppm of IBA and for Arlene francis 100 or 200 ppm of IBA. For leafy cuttings 100 ppm IBA for Dr. Verhage and 200 ppm for Arlene francis showed increased rooting percentage.

Season showed greater influence on the rooting of cuttings of *Codiaeum variegatum* with IBA stated by Khattab *et al.* (1987) from their experiment. They showed that rooting was best (95.8 and 100%) in cutting taken in August and September, respectively with IBA at the concentrations of 10 and 20 ppm. They soaked the terminal cuttings with 0-100 ppm IBA for 24 hours.

Srivastava (1987) conducted an experiment where terminal cuttings of *Jasminum grandiflorum* treated with four growth regulators (unspecified) were planted in a mixture of soil, sand and compost and covered with polythene bags. Over 81% rooting was obtained in 34 days.

Basu *et al.* (1986) observed that tannic acid and galic acid promoted rooting in leafy cutting of *Eratbenum tricolour* in combination with NAA and IBA. They also observed salicylic acid in combination with IAA, IBA and NAA greatly promoted rooting in the same species.

Decheva *et al.* (1985) conducted an experiment with Kazanlyk rose, soft wood cutting of which was treated with IBA at six concentrations. All treatments gave good rooting and increased number of root per cutting. Improved the rooting rate up to 1-17% of the treatment were given by IBA at 1 g per liter for 5-6 seconds or at 100 or 200 mg/L for 10 minutes.

To show the effect of IBA on rooting of Kazanluk rose Decheva *et al.* (1985) conducted an experiment with six concentrations of IBA. All IBA treatments gave the good rooting and increased the number of root per cutting. IBA at gm/liter for 5-6 sec. or at 100 or 200 mg/liter for 10 minutes improved the rooting rate by 6 to 17%.

Veeraragavathatham *et al.* (1985) conducted an experiment where soft wood, semi-hard wood and hard wood cuttings of *Jasminum auticulatum* (difficult to root) cv. Parimullai which were treated with IBA or NAA at different concentrations. Cuttings in all treatments were rooted under intermillent mist. The best rooting (60%) was observed by treating with IBA at 1000 ppm for 10 seconds.

Bhattacharjee and Balakrishna (1983) worked with 25 cultivars of bougainvillea cuttings (15 cm long) with 4 leaves were treated with IBA

each at 4000 ppm in dip method. Twelve cultivars responded better to IBA and others 4 to NAA.

The effect of different IBA concentrations (500, 1000 and 2000 ppm) on the rooting response of rose cvs. Baccara and Concerto hardwood cuttings with or without a heel at their base, was investigated in two years experiments by Oikonomou (1982). All parameters were increased with the increase of IBA concentrations. The most effective IBA concentration was 1000 ppm for rooting percentage and root length.

Philip and Gopalakrishnon (1981) in their experiment on cuttings of bougainvillea var. Mahara with IBA in dip method, obtained the highest percentage in rooting of cuttings when treated with 6000 ppm IBA. Data were collected 45 days after planting.

Singh and Motial (1981) worked with soft wood, semi hard and hard wood cuttings of the *J. sambac* cv. Madanban, treated with IBA at 1000-4000 ppm were struck in coarse sand under intermittent mist. The best rooting (97.5 -100%) and survival of rooted cuttings (100%) of all three types were obtained with IBA at 4000 ppm.

Jayapal *et al.* (1980) conducted an experiment with three commercial Jasmine species. They were propagated by 5 node apical or semi-hard woodcutting. The cuttings were struck in sand under mist. *J. gradiflorum* and *J. sambac* rooted best (98% and 94%, respectively) when propagated by semi hardwood cuttings.

Singh (1980) conducted an experiment with *Allamanda cathertica* by different types of stem cuttings, viz., softwood, semi hard wood and hard wood with 4 leaves per cutting in each case. The cuttings were treated with IBA at 100 to 4000 ppm for 15 second. After 30 days of planting, soft wood cuttings treated with 2000 ppm IBA gave the highest rooting followed by semi hard wood and hard wood cuttings with 3000 ppm of IBA.

Khosh-khul and Tatazoli (1979) stated that root number, length and dry weight per cutting of rose were significantly increased by acid treatment prior to application of 0, 1000, 2000 or 3000 ppm IBA or NAA.

Singh (1979) stated that the best concentration of IBA for rooting *J. sambac* cv. Madan ban, Mogra, Motia under mist was 4000 ppm. For the cv. Palampur 3000 ppm was better. Singh (1976) also reported that application of IBA at 4000 ppm to the cuttings of *J. sambac* cv. Motia having 3-4 leaves caused the highest percentage of rooting under intermittent mist.

Singh and Motial (1979) in their experiment showed IBA at the concentration of 3000 ppm gave the highest percentage of rooting (65%) and subsequent plant survival (100%). They also observed that soft wood cuttings were rooted better than semi hard wood cutting of bougainvillea.

Bose *et al.* (1975) studied that the percentage of rooting and root numbers per cutting were highest with cuttings of 15 cm length having two leaves, taken from the middle portion of the shoot (Semi-hard wood), treated with IBA at 300 ppm and planted in sand under mist. In another trial with tip cuttings of 10, 15 or 20 cm in length, rooting was better with 20 cm cuttings than the others.

Bose *et al.* (1973) studied the effects of IAA and NAA on rooting of soft and hardwood cuttings. The highest rooting of 90 percent was recorded in softwood cuttings treated with IAA 1000 ppm and in hard wood cuttings treated with 500 ppm. also confirmed the effectiveness of IAA and NAA in rooting of cuttings of this species. They also found that IBA at 5000 ppm stimulated rooting in cuttings.

Bose *et al.* (1973) conducted an experiment with ten species and cvs. of Ixora, 11 cvs. of *Hibiscuss rosa sinensis, Jasminum auriculatum and J. grandiflorum* which failed to root from cuttings or show a low percentage of rooting. Under ordinary propagation facilities they developed roots under intermittent mist. Treatment with IBA and NAA further increased the rooting percentage and number of roots

Cuttings of *Jasminum auriculatum* which failed to root or show a low percentage of rooting under ordinary propagation facilities showed high percentage of rooting under intermittent mist. Better survival and satisfactory growth after transplanting was also observed in cutting rooted under mist (Bose *et al.*, 1973). Veeraragha vathatham *et al.* (1985) reported

better rooting in cutting of *J. auriculatum* by etiolation, girdling and treatment with IBA.

Kale and Bhujbal (1972) conducted an experiment to study the response of IBA on root formation of Marypalmer variety of bougainvillea. They showed that hard wood cutting of that variety gave higher percentage of rooted cuttings at the concentration of 1500 ppm by quick dip method. They also stated that it was the easiest and most convenient method of propagation of Marypalmer of bougainvillea over other traditional methods.

Mukhopadhaya and Bose (1966) in their experiment with 4 bougainvillea varieties using IBA, NAA, Seradix-3 and control separately, showed that IBA produced greater number of roots per cutting than other treatments. In variety "H. C. Buck" beneficial effects were recorded with both the concentration (10 and 100 ppm) of IBA. In variety Scarlet Queen, only IBA 100 ppm produced roots.

Auxin was the most important factor for enhancing roots of semihardwood and hardwood cuttings of sapota, guava and straw berry plants. The number of roots always increased with the increase of growth regulator concentration was stated by Leopold (1963).

Srivastava (1962) reported that a set of hard wood cuttings of Jasmine were treated by dipping the basal ends for 12 or 24 hours in 100 ppm and 200 ppm concentration of NAA and IBA. In general, NAA treatment was

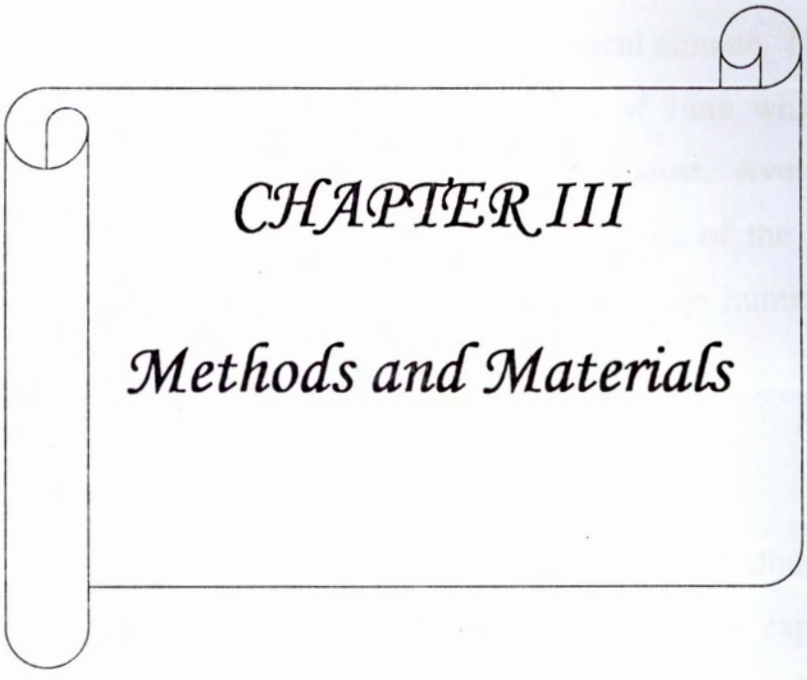
more effective than IBA. The best results were obtained with 12 hours dip in 100 ppm of NAA followed by IBA at the same concentration and duration.

Teaotia and Pandey (1961) stated that IBA at 100 ppm gave the satisfactory result in Govt. Research Station Basti, U.P., India but the same concentration gave unsatisfactory result in semihardwood and hardwood cuttings and etiolated cutting.

Singh and Bhatnagar (1955) in *J. grandiflorum,* studied the effects of IAA and NAA on rooting of soft and hard wood cuttings. The highest rooting of 90 percent was recorded in softwood cutting treated with IAA 1000 ppm and in hardwood cuttings treated with NAA 500 ppm. Bose *et al.* (1973) also confirmed the effectiveness of IAA and NAA in rooting of cuttings of this species IBA at 5000 ppm in 91 per cuttings.

Root formation was activated by using phenoxy compound even at low concentration (Hitchcock and Zimmermann, (1937). IBA increased the rooting percentage and number of roots per cutting in fig as observed by Crans and Mollah (1952).

From the above review of literature it was observed that IBA and NAA were more effective in the propagation of shrubby ornamental plants by stem cutting than other hormones. Further it was noted that IBA was used in two ways viz, quick dip method at a very high concentration and soaking method at lower concentration.



CHAPTER III

Methods and Materials

METHODS AND MATERIALS

The experiment was carried out at the Horticultural Garden, Sher-e-Bangla Agricultural University, Dhaka, during June to August, 2005.

3.1 Climate

The experimental area was under the sub-tropical climate. The total rainfall of the locality was 259 mm in the months of June while the average maximum air temperature was 32.0°C in August. Average maximum relative humidity was 79 percent in June. Details of the meteorological data in respect of temperature, rainfall and relative humidity during the experimental period are presented in Appendix I.

3.2 Soil

The soil of the experimental area belongs to the Modhupur Tract. The analytical data of the soil sample collected from the experimental area were determined in Soil Resources Development Institute, Farmgate Dhaka (Appendix II).

The experimental site was a medium high land and pH of the soil was 5.6. The morphological characters of soil of the experimental plots are given below –

AEZ No. : 28
Soil series : Tejgaon
General soil : Non-calcarious dark grey

3.3 Preparation of land

The land for the experiment was spaded several times and big and small clods were broken to obtain a good tilth. The weeds and stubbles were removed from the land. The land was divided into 72 plots. The plots were raised to about 6 cm high from the soil surface. No chemical fertilizers were used in the soil.

3.4 Nursery bed

Nursery beds having the size of 3m (length) X 1m (breadth) X 15cm (height) were prepared between two adjacent beds, a distance of 30cm width and 15cm depth were kept for ease of movement and proper drainage of rain water.

3.5 Materials

Three ornamental shrubs, viz. Nerium, Bougainvillea and Jasminum; two plant growth regulators, viz. Indole Butyric Acid and Napthalene Acetic Acid having four of their concentrations including control was used as experimental materials.

3.6 Treatments

The experiment was a factorial one. The three factors of the experiment with their levels are given below-

Factor A:

Ornamental Plants

The species of the shrubs were

i) Nerium *(Nerium oleander)*

ii) Bougainvillea(*Bougainvillea spectabilis*) and

iii) Jasminum *(Jasminum auriculatum*)

Factor B:

Growth regulators

There were two growth regulators

i) Indole Butyric Acid (IBA)

ii) Napthalene Acetic Acid (NAA)

Factor C:

Different concentrations of growth regulators

i) 0 ppm

ii) 200 ppm

iii) 300ppm

iv) 400ppm

There were 24 treatment combinations.

3.7 Experimental design:

The experiment was laid out in Randomized Complete Block design (RCBD) with three replications.

3.8 Preparation of growth regulators

3.8.1 Indole Butyric Acid (IBA)

To prepare 200 ppm of Indole Butyric Acid solution 200 mg of IBA was dissolved in 10 ml of ethanol taking in a volumetric flask and then the volume was made to one liter by adding required amount of distilled water followed by frequent stirring. A 300 ppm IBA solution was prepared by dissolving 300 mg of IBA powder in 10 ml of ethanol taking in a volumetric flask and then the volume was made to one liter by adding sufficient distilled water with frequent stirring. Similarly 400 ppm of IBA solution was made by dissolving 400 mg of IBA in 10 ml of ethanol taking in a volumetric flask and then the volume was made to one liter by adding required quantities of distilled water with frequent stirring.

3.8.2 Napthalene Acetic Acid (NAA)

To prepare 200 ppm of NAA, solution 200 mg of NAA was taken, 10 ml of ethanol was taken in a volumetric flask and then the volume was raised to one liter by adding distilled water with frequent stirring. 300 mg of NAA powder was dissolved in 10 ml of ethanol taking in a volumetric flask and then the volume was made to one liter by adding sufficient amount of distilled water with frequent stirring to prepare 300 ppm of NAA solutions. Similarly 400 ppm of NAA solution was prepared when 400 mg of NAA powder was dissolved in 10 ml of ethanol taking in a

volumetric flask and then the volume was made to 1000 ml by adding required amount of distilled water with frequent stirring.

3.8.3 Control solution

Distilled water and ethanol was used for this purpose.

3.9 Preparation of stem cutting

For preparation of stem cutting, about one year old healthy and disease free stems were selected and separated from the mother plants of species Nerium, Bougainvillea and Jasminum. Cuttings were prepared 15 cm length having 2-3 nodes depending on the species. All the leaves were cut off and 25 cuttings were used in each treatment combination. The lower cuts of the stems were made slanting below the nodes and the upper cuts were horizontal above the nodes.

Growth regulators and stem cuttings

The prepared cuttings were then dipped in the plastic bowl for 24 hours, immerging 2.5 to 5 cm of their basal portion before planting in the field. On the contrary, the stems were dipped in distilled water only in case of control treatments.

3.10 Planting of cuttings

Cuttings of three species of ornamental shrubs (Nerium, Bougainvillea and Jasminum) were planted in the beds on 13th June, 2005 at a spacing of 15cm X 15cm. Two thirds of the length of the cuttings was inserted into the soil at an angle of 45°. Immediately after inserting watering was done uniformly by water can. Shading was provided by bamboo made overhead chatai at a height of 2 m to protect the cuttings from excessive rainfall and sunlight. The shading was kept for 2 weeks.

3.11 After cares

Weeding and earthing up was done as and when needed for proper growth and development of the cuttings. Watering was done according to the necessity. There was no incidence of insect and disease in the experimental cuttings. The plots were kept free from weeds by weeding six times.

3.12 Experimental observations

The cuttings were kept under observation for 60 days. After that 10 cuttings were collected randomly from each of the 72 plots for data

collection. Cuttings were uprooted from each plot by digging soils without tearing the roots. Base of each cutting was washed carefully in a bucket of clear water without damaging the roots. Then data were collected for the following parameters-

i. Percent success (survival) of the cutting
ii. Number of shoot per cutting
iii. Number of root per cuttings
iv. Length of shoot per cutting
v. Length of root per cutting
vi. Fresh weight of shoot per cutting
vii. Fresh weight of root per cutting
viii. Dry weight of shoot per cutting
ix. Dry weight of root per cutting

3.12. 1 Percent of success in cutting

The number of successfully rooted cuttings was recorded . Then the percentage of success in rooting of individual treatment was calculated by using the following formula:

$$\text{Percent of success} = \frac{\text{Number of successfully rooted cutting}}{\text{Number of cutting planted per treatment}} \times 100$$

3.12.2 Number of roots per cutting

From randomly selected 10 cuttings the number of roots per cutting was recorded. Then the number of roots per cutting was calculated by dividing the total number of roots by 10.

3.12. 3 Length of root per cutting

The roots of selected cuttings were measured with the help of a scale and the total length was recorded . Then the length (cm) of roots per cutting was calculated by dividing the total length of roots by 10.

3.12.4 Fresh weight of roots per cutting

The fresh weight of roots of selected cuttings was taken by an electronic balance. Then the fresh weight of roots per cutting was calculated by dividing the total fresh weight of roots by 10.

3.12.5 Dry weight of roots per cutting

The fresh roots were again kept inside the marked envelops treatment wise and dried in the electronic oven at a temperature of 70°C for 72 hours in the horticulture laboratory. The dry weights were calculated in the same way as stated before.

3.12.6 Number of shoots per cutting

New developed shoots were considered for the following shoots. Total number of shoots of 10 cuttings was counted. Then the number of shoot per cutting was calculated by dividing the total number of shoots by 10.

3.12.7 Length of shoot per cutting

The shoot lengths of selected cuttings were measured with the help of a scale and the total length was recorded. Then the shoot length (cm) per cutting was calculated by dividing the total length of shoots by 10.

3.12.8 Fresh weight of shoots per cutting

The shoots of selected cutting were detached from the cutting and the fresh shoot weight was taken by an electronic balance. Then the fresh weight (mg) of shoot per cutting was calculated by the same way.

3.12.9 Dry weight of shoots per cutting

The detached shoots were dried in an oven at 70° C for 72 hours. Then the dry weights of shoots were taken using electronic balance. Finally the mean dry weight (mg) of shoot per cutting was calculated by the same way.

3.13 Statistical analysis

The recorded data on different parameters were statistically analyzed using MSTAT software to find out the significance of variation resulting from the experimental treatments. The mean for the treatments was calculated and analysis of variance for each of the characters was performed by F (variance ratio) test. The differences between the treatment means were evaluated by LSD test at 1% or 5% probability whenever applicable.

CHAPTER IV

Results and Discussion

RESULTS AND DISCUSSION

A study was made to assess the effects of different concentrations of Indole Butyric Acid (IBA) and Naphthalene Acetic Acid (NAA) on the rooting performance in ornamental plants Nerium, Bougainvillea and Jasminum. The results are presented in tables, figures, appendices and discussed under the following sub-headings.

4.1 Number of shoots per cutting

The results related to number of shoots per cutting showed that there was a variation in number of shoots produced per cutting (Table 1).

The effect of the hormones IBA and NAA was found to be non-significant in respect of number of shoots per cutting. The effect of different concentrations of growth regulators was found to be highly significant in respect of number of shoots per cutting. The highest number of shoots per cutting (3.59) was recorded in the stem cutting treated with 400 ppm concentration and the lowest (1.75) with control (Table 1). Hossain (990) also found similar results working with Ixora.

Table 1: Main effect of hormones and their concentrations on three ornamental plants on number of shoots/cutting, length of shoot/cutting, fresh weight of shoots and roots, dry weight of shoots and roots and percent success (60 days after planting)

	Number of shoots/cutting	Length of Shoot/cutting (cm)	Fresh weight of		Dry weight of		Percent success (%)
			Shoots (mg)	Roots (mg)	Shoots (mg)	Roots (mg)	
Factor A							
P1	2.37	20.81	1878.96	6.74	329.96	1.96	67.83
P2	3.01	16.14	1625.83	15.02	329.87	3.19	77.84
P3	2.62	16.06	1640.00	10.18	305.53	1.93	73.63
LSD 1%	0.14	0.80	63.56	0.46	9.20	0.09	0.92
LSD 5%	0.10	0.60	47.08	0.34	6.81	0.07	0.68
Factor B							
G1	2.67	17.20	1699.31	10.53	310.05	2.33	73.43
G2	2.67	18.14	1730.56	10.76	333.52	2.40	72.76
LSD 1%	0.11	0.66	51.90	0.37	7.51	0.08	0.75
LSD 5%	0.08	0.49	38.44	0.28	5.56	0.06	0.56
Factor C							
C0	1.75	13.16	1133.61	5.50	243.92	1.33	51.86
C1	2.44	16.92	1590.00	10.36	299.45	2.30	73.23
C2	2.89	19.48	1834.44	11.78	356.44	2.55	78.26
C3	3.59	21.13	2301.67	14.95	387.32	3.26	89.05
LSD 1%	0.16	0.93	73.40	0.53	10.62	0.11	1.06
LSD 5%	0.12	0.69	54.37	0.39	7.87	0.08	0.79

P1= Nerium,
P2=Bougainvillea,
P3=Jasminum.
G1=IBA,
G2=NAA
Co= 0ppm,
C1= 200 ppm,
C2=300 ppm,
C3=400 ppm

Table 2: Interaction effect of ornamental plants and growth regulators on number of shoots and roots/cutting, length of shoot and root, fresh weight of shoots and roots, dry weight of shoots and roots and percent success in stem cutting of different ornamental plants (60 days after planting).

Treatment combination	Number of		Length of		Fresh weight of		Dry weight of		Percent success (%)
	shoots/cutting	roots/cutting	shoot (cm)	root (cm)	shoots (mg)	roots (mg)	shoots (mg)	roots (mg)	
P1G1	2.15	16.42	21.48	8.56	1742.92	6.68	288.02	1.82	64.60
P1G2	2.60	17.51	20.14	8.88	2015.00	6.80	371.90	2.09	71.05
P2G1	3.20	18.49	15.50	15.67	1667.50	15.19	344.04	3.53	79.53
P2G2	2.82	16.48	16.77	13.59	1584.17	14.85	315.69	2.86	76.15
P3G1	2.64	16.25	14.63	13.06	1687.50	9.72	298.08	1.63	76.17
P3G2	2.59	16.27	17.50	12.25	1592.50	10.64	312.97	2.23	71.09
LSD 1%	0.19	0.78	1.14	0.96	89.89	0.65	13.00	0.13	1.30
LSD 5%	0.14	0.58	0.84	0.71	66.59	0.48	9.63	0.10	0.96

P1= Nerium,
P2=Bougainvillea,
P3=Jasminum.
G1=IBA,
G2=NAA

Table 3: Interaction effect of ornamental plants and different concentrations of growth regulators on number of shoots and roots/cutting, length of shoots and roots/cutting, fresh weight of shoots and roots, dry weight of shoots and roots and percent success in stem cutting of different ornamental plants (60 days after planting).

Treatment combination	Number of shoots/cutting	Number of roots/cutting	Length of Shoots/cutting (cm)	Length of Roots/cutting (cm)	Fresh weight of shoots (mg)	Fresh weigh of roots (mg)	Dry weight of shoots (mg)	Dry weight of roots (mg)	Percent success (%)
P1C0	1.73	9.13	15.47	6.72	1485.83	4.47	255.98	1.17	47.74
P1C1	2.19	16.13	20.35	7.97	1615.00	6.45	277.67	2.04	68.08
P1C2	2.38	19.20	23.20	9.35	1950.00	6.90	345.58	2.19	75.21
P1C3	3.20	23.41	24.23	10.85	2465.00	9.15	440.60	2.43	80.26
P2C0	1.77	10.65	11.90	7.45	870.00	5.35	240.38	1.47	54.08
P2C1	2.52	16.75	15.20	12.33	1600.00	15.00	303.02	3.05	79.59
P2C2	3.43	19.55	17.70	17.33	1713.33	16.65	392.94	3.25	83.79
P2C3	4.33	22.99	19.75	21.42	2320.00	23.08	383.13	5.01	93.92
P3C0	1.75	8.85	12.10	7.30	1045.00	6.67	235.42	1.36	53.75
P3C1	2.63	15.58	15.20	9.48	1555.00	9.63	317.67	1.82	72.01
P3C2	2.87	18.08	17.53	16.20	1840.00	11.80	330.80	2.21	75.78
P3C3	3.22	22.56	19.42	17.65	2120.00	12.62	338.22	2.34	92.97
LSD 1%	0.27	1.10	1.61	1.35	127.13	0.92	18.39	0.18	1.84
LSD 5%	0.20	0.82	1.19	1.00	94.17	0.68	13.62	0.14	1.36

P1= Nerium,
P2=Bougainvillea,
P3=Jasminum.
Co= 0ppm, C1=200 ppm, C2=300 ppm, C3=400 ppm

Interaction effect of different ornamental plants and growth regulators was found to be significant. The highest number of shoots per cutting (3.20) was found in Bougainvillea with IBA and the lowest number of shoots per cutting (2.15) was found in Nerium with IBA (Table-2).

Interaction effect between plants and doses of growth regulators also showed significant variation. The highest number of shoot per cutting 4.33 was found in Bougainvillea by 400 ppm concentration and the lowest was 1.73 in Bougainvillea by 0 ppm concentration (Table 3).

Combined effects of plants, growth regulators and doses of growth regulators showed a wide range of significant variation. The highest number of shoots per cutting 4.50 was found with 400 ppm concentration of NAA in Bougainvillea and the lowest one (1.65) was found with 0 ppm NAA in Bougainvillea (Table 4).

4.2 Length of Shoot per Cutting

The length of shoot varied significantly among the ornamental plants. The longest shoot (20.81 cm) was produced by Nerium while the shortest one (16.06 cm) by Jasminum (Table 1). Growth regulators had significant effect on length of shoot. The highest length of shoot per cutting (18.14 cm) was found with NAA and the lowest 17.20 cm was noted when treated with IBA.

Concentrations showed significant variation in getting desired length of shoot. The highest length 21.13 cm of shoot was found with 400 ppm concentration while the lowest one 13.16 cm was found with 0 ppm treatment. Interaction effect of plants and growth regulators was found to be significant. The highest length of shoot per cutting was 21.48 cm with IBA in Nerium, and the lowest 14.63 cm with IBA in Jasminum (Table 2).

Interaction effect of plants and levels of growth regulators was insignificant. Combined effect of plants, growth regulators and their doses also showed a wide range of significant differences (Table 4).The longest shoot 25.60 cm was found with 400 ppm concentration of IBA in Nerium. The smallest shoot 10.50 cm was found with the control treatment of IBA in Jasminum .

Table 4: Combined effects of ornamental plants, growth regulators and their different concentrations on number of shoot/cutting, length of shoot, fresh weight of shoot and root and dry weight of shoot and root in stem cutting of different ornamental plants (60 days after planting).

Treatment combination	Number of shoot/cutting	Length of shoot (cm)	Fresh weight of shoot (mg)	Fresh weigh of root (mg)	Dry weight of shoot (mg)	Dry weight of root (mg)
P1G1C0	1.67	15.93	1461.67	4.43	251.27	1.10
P1G1C1	2.15	20.80	1510.00	6.40	270.35	1.90
P1G1C2	2.30	23.60	1650.00	6.90	290.10	2.00
P1G1C3	2.50	25.60	2350.00	9.00	340.35	2.30
P1G2C0	1.80	15.00	1510.00	4.50	260.70	1.25
P1G2C1	2.23	19.90	1720.00	6.50	285.00	2.17
P1G2C2	2.45	22.80	2250.00	6.90	401.05	2.38
P1G2C3	3.90	22.85	2580.00	9.30	540.85	2.56
P2G1C0	1.90	12.30	890.00	5.40	250.25	1.60
P2G1C1	2.88	14.80	1610.00	15.10	310.33	3.25
P2G1C2	3.87	16.70	1780.00	16.80	405.00	3.40
P2G1C3	4.17	18.20	2390.00	23.47	410.60	5.86
P2G2C0	1.65	11.50	850.00	5.30	230.50	1.33
P2G2C1	2.15	15.60	1590.00	14.90	295.70	2.85
P2G2C2	2.99	18.70	1646.67	16.50	380.88	3.10
P2G2C3	4.50	21.30	2250.00	22.70	355.67	4.17
P3G1C0	1.70	10.50	1070.00	5.20	210.60	1.22
P3G1C1	2.75	13.60	1550.00	9.50	310.10	1.87
P3G1C2	2.88	16.35	1860.00	11.80	330.85	1.55
P3G1C3	3.25	18.05	2270.00	12.39	340.76	1.87
P3G2C0	1.80	13.70	1020.00	8.15	260.23	1.50
P3G2C1	2.50	16.80	1560.00	9.75	325.23	1.77
P3G2C2	2.85	18.70	1820.00	11.80	330.76	2.87
P3G2C3	3.20	20.80	1970.00	12.85	335.67	2.80
LSD 1%	0.38	2.28	179.78	1.29	26.01	0.26
LSD 5%	0.28	1.69	133.17	0.96	19.27	0.19

P1= Nerium, P2= Bougainvillea, P3= Jasminum . G1=IBA, G2=NAA, Co= 0ppm, C1=200 ppm, C2=300 ppm, C3=400 ppm

4.3 Fresh weight of shoot per cutting

Fresh weight of shoot per cutting was statistically significant among the ornamental plants. The highest fresh weight (874.96mg)was found in Nerium (Table 1). The effect of growth regulators on fresh weight was insignificant.

Doses of growth regulators showed significant results. The highest fresh weight of shoot per cutting 2301.67 mg was found at 400 ppm concentration and lowest fresh weight 1133.61 mg was found at control treatment.

Interaction effect of plants and growth regulators varied significantly producing the highest weight of shoot 2015.00 mg with NAA in Nerium, and the lowest 1584. 17 mg with NAA in Bougainvillea (Table 2).

Interaction effect between plants and doses of growth regulators also showed significant variation. The highest fresh weight of shoot per cutting 2465.00 mg in Nerium with 400 ppm concentration and lowest was 870.00 mg in Bougainvillea in case of 0 ppm concentration (Table-3). Combined effect of plants, growth regulators and doses of growth regulators showed a wide range of significant variation. The highest fresh weight of shoot per cutting was found 2580.00 mg with 400 ppm of NAA in Nerium, the lowest one 850.00 mg was found with 0 ppm in Bougainvillea (Table-4).

4.4 Dry weight of shoot per cutting

The effect of ornamental plant was significant in respect of dry weight of shoots (Table-1). The greater dry weight of shoot per cutting was recorded in (329.96mg) in Nerium and the lowest weight 305.53 mg was found on Jasminum.The effect of growth regulators on dry weight was statistically significant. The highest dry weight of shoot per cutting (333.52 mg) was found when treated with NAA and the lowest (310.05 mg) was noted when treated with IBA.

Doses of growth regulators also showed statistically significant effect. The highest dry weight (387.32 mg) was found from 400 ppm concentration. The lowest dry weight was (243.92 mg) due to 0 ppm treatment. Significant variation was found when ornamental plants and growth regulators interacted together (Table-2). The highest dry weight (371.90 mg) was found with NAA in Nerium and lowest dry weight (288.02 mg) with NAA in Nerium.

Interaction effect of ornamental plants with doses of growth regulators in respect of dry weight of shoots per cutting was also found significant. The highest dry weight (440.60 mg) was found in Nerium from 400 ppm concentration and lowest dry weight (235.42 mg) in Jasminum by o ppm treatment (Table 3).

Combined effect of ornamental plants, growth regulators and doses of growth regulators were found significant (Table 4).The highest dry weight of

shoots per cutting (540.85 mg) was obtained from 400 ppm of NAA in Nerium. The lowest amount of dry weight of shoot per cutting (210.60 mg) was found with 0 ppm of IBA in Jasminum.

4.5 Number of roots per cutting

Significant variation in respect of number of roots produced per cutting was observed in the investigation (Fig. 1). The highest number of roots per cutting (17.49) was recorded in Bougainvillea, which was statistically different from the two other species while Jasminum showed the lowest number (16.26).

The growth regulators IBA and NAA showed insignificant effects on the number of roots per cutting. But effect of doses of growth regulators on number of roots per cutting was significant (Fig. 2 and 3). The highest number of roots (22.99) per cutting was found with 400 ppm concentration. The lowest number of roots (9.54) was found with the control treatment.

Interaction effects of ornamental plants and growth regulators were found to be significant. The highest number of roots per cutting (18.49) was found from IBA in Bougainvillea. The lowest number of roots (16.25) was obtained from IBA in Jasminum (Table 2.).No significant results was found when ornamental plants and doses of growth regulators interacted (Table 3).

But number of roots per cutting varied widely when cuttings of ornamental plants, growth regulators and their doses were interacted together (Fig. 4). The highest number of root (25.38) per cutting was found when cutting of

Bougainvillea was treated by 400 ppm of IBA. Hossain (1990) and Akhter (2001) reported similar results. Plate 1 shows abundant of roots that grew from Bougainvillea by using 400 ppm of IBA. Plate 2 presents the effect of NAA on number of roots/cutting in Jasminum and from plate 3 we found the effect of IBA on number of roots/cutting in Nerium at control treatment

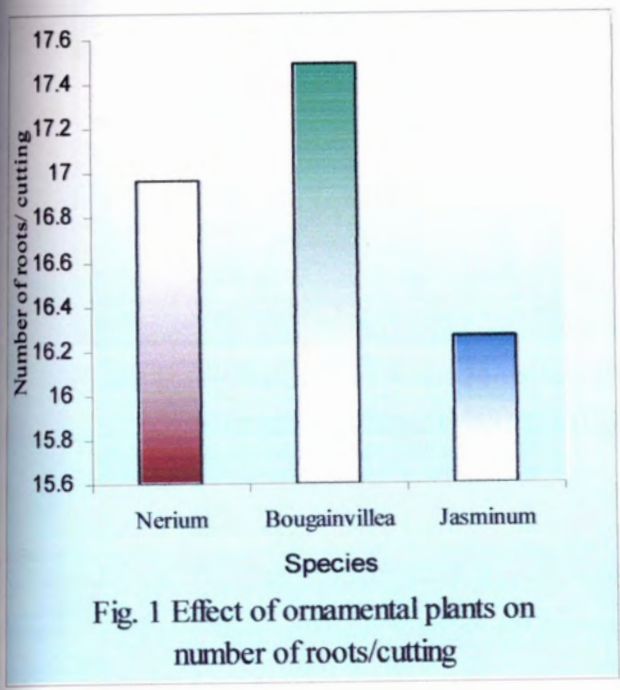


Fig. 1 Effect of ornamental plants on number of roots/cutting

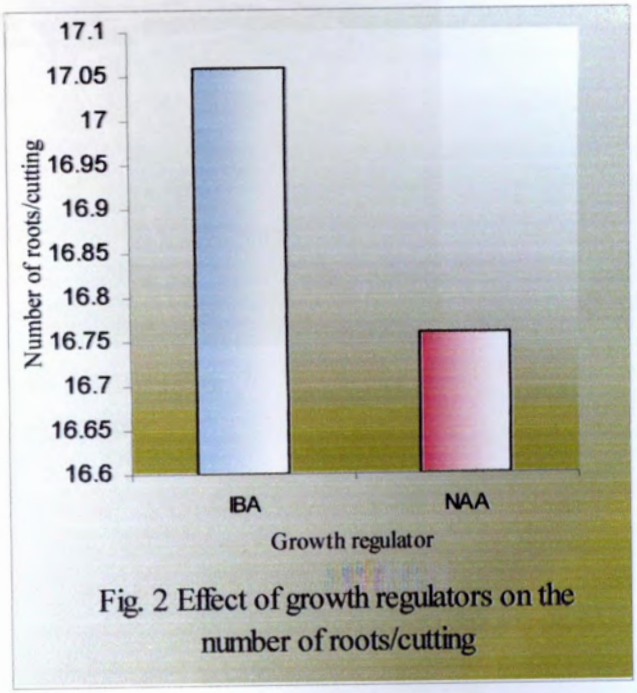


Fig. 2 Effect of growth regulators on the number of roots/cutting

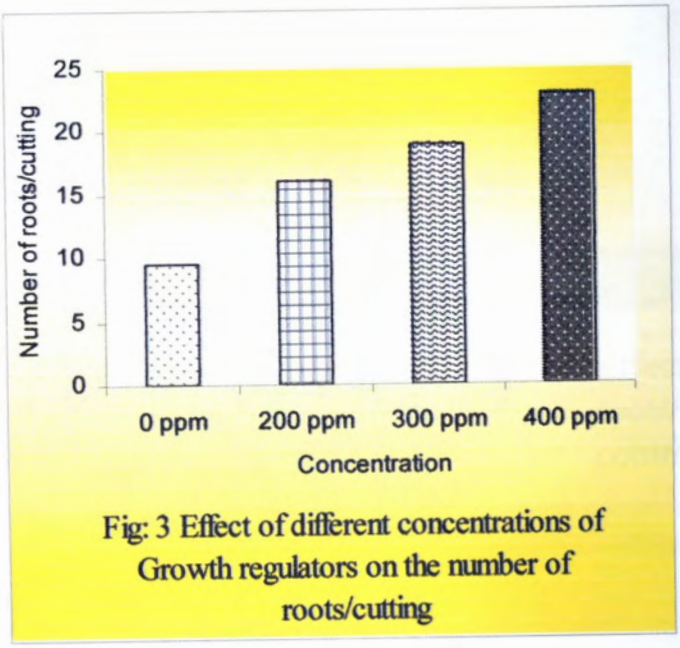


Fig: 3 Effect of different concentrations of Growth regulators on the number of roots/cutting

Plate 1. Effect of IBA on Number of roots /cutting in Bougainvillea at 400 ppm concentration

Plate 2. Effect of NAA on number of roots/cutting in Jasminum at 400 ppm concentration

Plate 3. Effect of IBA on number of roots/cutting in Nerium at control treatment

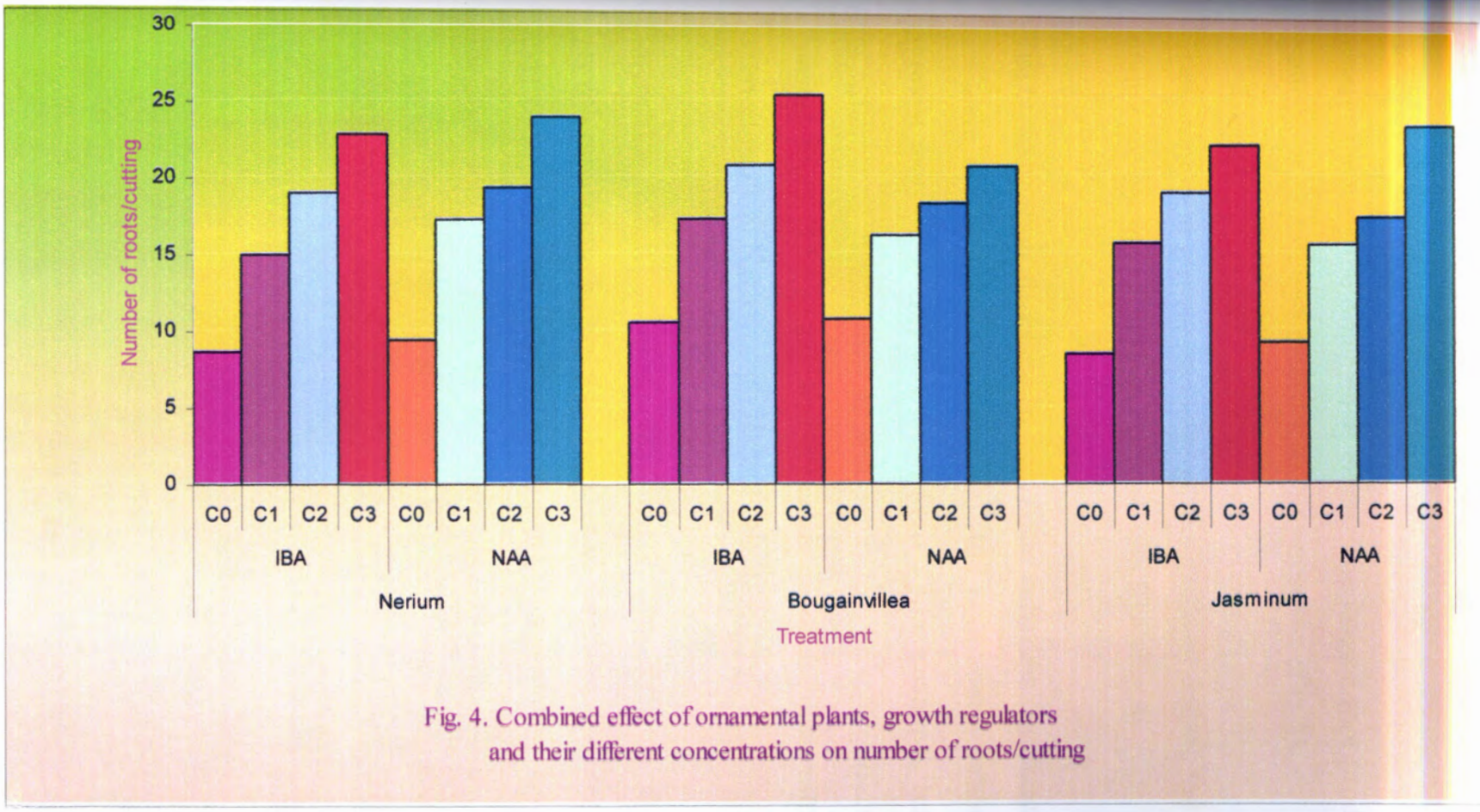


Fig. 4. Combined effect of ornamental plants, growth regulators and their different concentrations on number of roots/cutting

4.6 Length of root per cutting

Significant variation in respect of root length produced per cutting was observed among the ornamental plants. The longest root produced per stem cutting (14.63 cm) was recorded in Bougainvillea (Fig 5).

The variation in growth regulator gave significant output, the highest length of root per cutting (12.43) was treated with IBA (Fig 6).

The concentration also showed significant variation. The longest roots 16.64 cm were produced by the treatment 400 ppm concentration (Fig 7). The shortest roots (7.16 cm) was found from 0 ppm treatment. Interaction effect of ornamental plants and growth regulators gave significant result. The longest roots (15.67 cm) was found in Bougainvillea with IBA and the shortest roots in Nerium with IBA (Table 2).

Interaction effect of ornamental plants with different concentration of growth regulators showed a wide range of variation. The longest root (21.42 cm) was found with 400 ppm in the plant Bougainvillea. It was followed by the treatment 400 ppm in Jasminum (17.65 cm) (Table 3). Findings of Nagaraja *et al.* (1991) and Hossain (1990) were in agreement with the present result.

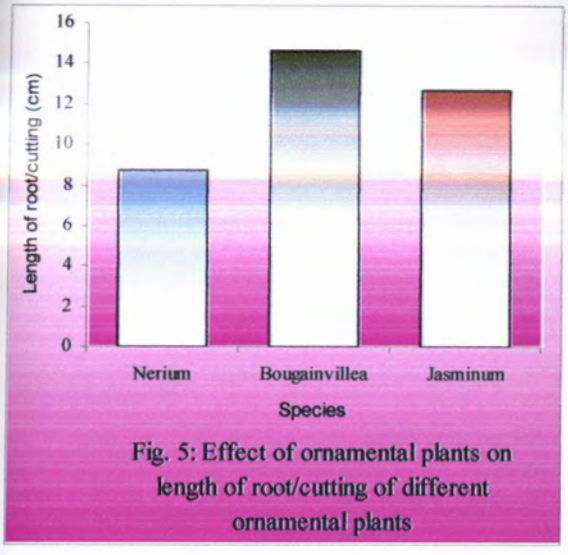


Fig. 5: Effect of ornamental plants on length of root/cutting of different ornamental plants

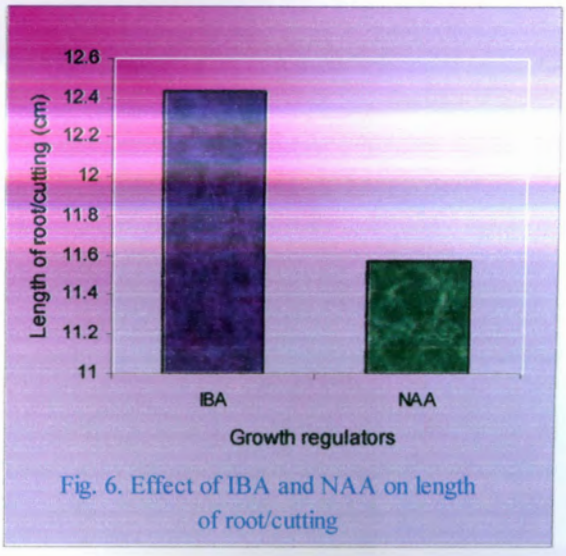


Fig. 6. Effect of IBA and NAA on length of root/cutting

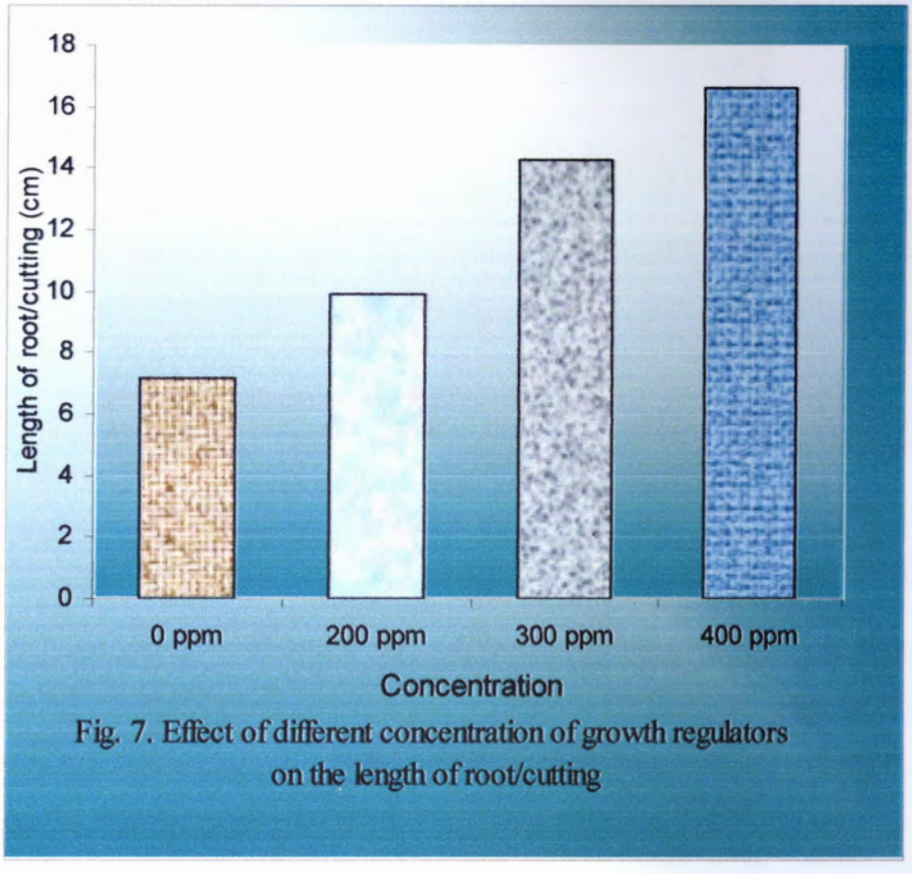


Fig. 7. Effect of different concentration of growth regulators on the length of root/cutting

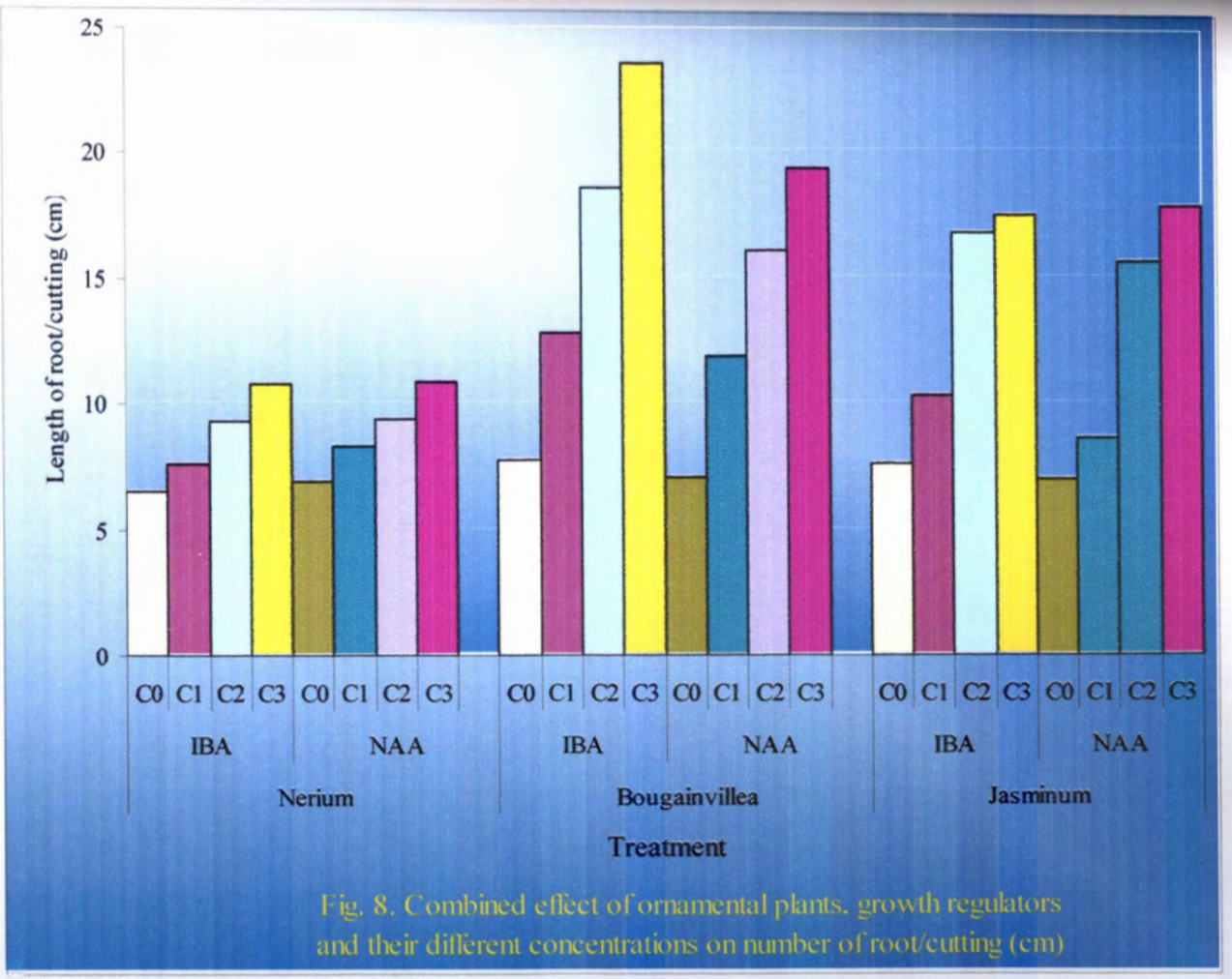


Fig. 8. Combined effect of ornamental plants, growth regulators and their different concentrations on number of root/cutting (cm)

Interaction effects of ornamental plants with different growth regulators and their concentration were found to be significant (Fig-8). The longest root (23.53 cm) was found when treated with 400 ppm of IBA in Bougainvillea. Kundu *et al.* (1987) and Hossain (1990) also found similar results in case of Ixora. The lowest root length (6.53 cm) per cutting was produced by o ppm concentration of IBA in Nerium.

4.7 Fresh weight of root per cutting

Fresh weight of root per cutting varied significantly among the ornamental species used in the experiment. The highest fresh weight (15.02 mg) was recorded in Bougainvillea which was statistically significant. The lowest fresh weight (6.74 mg) was found in Nerium (Table 1).

Growth regulators, IBA and NAA showed insignificant variations in respect of fresh weight of root per cutting.

Concentration of growth regulators had significantly affected the fresh weight of root per cutting (Table 1). The highest fresh weight of root (14.95 mg) was found with 400 ppm concentration of growth regulators. The lowest fresh weight of root per cutting (5.50 mg) was found with the control treatment. Interaction between ornamental plants and growth regulators showed significant variations (Table 2). The highest fresh weight of root per cutting (15.19 gm) was found in Bougainvillea treated with IBA which was preceded by (14.85 mg) fresh weight of root per

cutting in Bougainvillea treated with NAA. The lowest fresh weight was found with IBA in Nerium giving (6.68 mg) fresh weight.

Ornamental plants and doses of growth regulators interacted which was also significant. The highest fresh weight per cutting (23.08 mg) was found in Bougainvillea by 400 ppm concentration. The lowest value was (4.47 mg) was found in Nerium due to 0 ppm concentration (Table3). Interaction effect of ornamental plants, growth regulators and their doses of growth regulators showed significant variations. The highest fresh weight of root per cutting (23.47 mg) was found with 400 ppm concentration of IBA in Bougainvillea (Table 4) the lowest fresh weight of root per cutting (4.43 mg) was noted in control treatment of IBA in Nerium

4.8 Dry weight of root

The effect of plants was significant in respect of dry weight of roots. The highest dry weight of root (3.19 mg) was found in Bougainvillea (Table 1).

The effects of IBA and NAA in respect of dry weight of root was found statistically significant for highest dry weight of root per cutting (2.40 mg) with NAA.

The effect of concentration was found to be significant. The highest dry weight of root per cutting (3.26 mg) was found with 400 ppm concentration, lowest dry weight of root per cutting (1.33 mg) was found in control treatment.

Interaction effects of ornamental plants and growth regulators were found significantly different. The highest result (3.53 mg) was found with IBA in Bougainvillea, The lowest results (1.63 mg) was found with IBA in Jasminum (Table 2).

Interaction effect of ornamental plants and doses of growth regulators were found to be significant also. The highest value(5.01 mg) was found in Bougainvillea treated with 400 ppm concentration. The lowest result (1.17 mg) was found in Nerium in control treatment (Table 3).

The combined effect among ornamental plants, growth regulators and their doses varied significantly (Table 4).The highest dry weight of root per cutting (5.86 mg) was found in Bougainvillea with 400 ppm concentration of IBA. The lowest dry weight of root per cutting (1.10 mg) was found in Nerium with 0 ppm IBA.

4.9 Percent of success

Percentage of success in rooting of the three ornamental plants used was significant. The highest percentage of success (77.84)% was found with Bougainvillea (Table 1).

The effect of growth regulators on the percentage of success was found to be significant. The highest percentage of success (73.43)% was found with IBA (Table 1).

The effect of doses of growth regulators was also significant. the highest percentage of success (89.05)% was achieved by 400 ppm concentration of growth regulators which was followed by (78.26)% with 300 ppm concentration while it was the lowest (51.86)% with the control treatments (Table 1).

Interaction effect of ornamental plants and growth regulators on the percentage of success showed significant variations (Table 2).The highest percentage (79.53)% was found in Bougainvillea with IBA. The lowest percentage of success (64.60)% was in Nerium with IBA.

Interaction effects of ornamental plants and doses of growth regulators on percentage of success was found to be significant. The highest percentage of success (93.92)% was found in Bougainvillea with 400 ppm concentration which followed by (92.97)% in Jasminum with 400 ppm concentration the lowest percentage (47.74)% was found in Nerium with 0 ppm concentration (Table 3).

The combined effect among ornamental plants, growth regulators and doses of growth regulators varied significantly (Fig. 9). The higher percentage of success (95.60)% and (95.10)% were found in Bougainvillea and Jasminum with 400 ppm concentration of IBA.

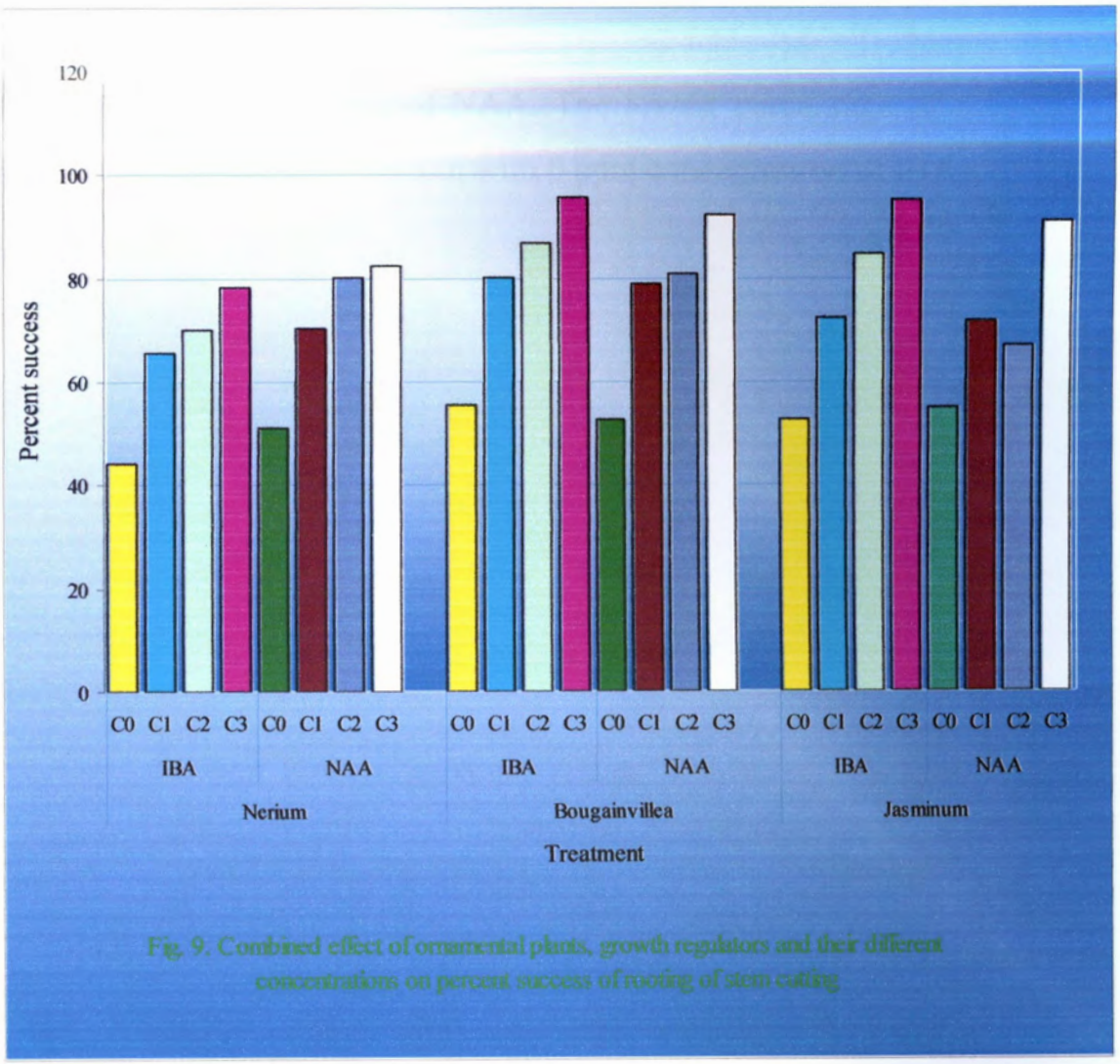


Fig. 9. Combined effect of ornamental plants, growth regulators and their different concentrations on percent success of rooting of stem cutting

This finding agrees with the results of Singh and Motial (1981). Again the highest value (92.29)% was followed by success achieved in Bougainvillea with 400 ppm concentration of NAA. The lowest percentage of success (44.33)% was observed in Nerium with 0 ppm concentration of IBA.

CHAPTER V

Summary and Conclusion

SUMMARY AND CONCLUSION

A study was carried out at the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka during June to August, 2005 to assess the effects of different concentration of IBA (Indole Butyric Acid) and NAA (Napthalene Acetic Acid) on the rooting performance of stem cuttings in three ornamental plants eg. Nerium, Bougainvillea and Jasminum. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The four concentrations of each of IBA and NAA were 0, 200, 300 and 400 ppm. Before planting, the basal parts of the stem cuttings were soaked in the solutions of different concentration for 24 hours and planted in the beds at 45° angle. Sixty days after planting, the cuttings were uprooted and the parameters were studied. Data were recorded and analyzed statistically.

The application of IBA and NAA caused statistically significant effects on the rooting performance. The highest number of shoots per cutting (3.59) was recorded in stem cuttings treated with 400 ppm concentration while the lowest (1.75) with the control treatment. The concentration of 400 ppm NAA in Bougainvillea gave the highest number of shoots per cutting and the lowest value was observed with 0 ppm concentration of NAA.

The concentrations of 400 ppm gave the longest shoot (21.13 cm) while the shortest one (13.16 cm) was found with the control treatment.

Nerium produced the longest (21.48 cm) shoot with IBA and smallest shoot (15.50 cm) was found with IBA in Bougainvillea. Nerium produced the longest (25.60 cm) shoot with 400 ppm concentration of IBA. The smallest shoot (10.50 cm) was given by Jasminum in control treatment of IBA.

The highest fresh and dry weights of shoot (1878.96 mg and 329.96 mg) were observed in Nerium. Again NAA produced the highest dry weight of shoot than that of IBA. The concentration of 400 ppm was the most effective in producing fresh weight and dry weight. Among the plants Nerium gave the highest fresh and dry weights of shoot (2015.00 mg and 371.90 mg) with NAA. Bougainvillea gave the lowest fresh weight of shoot when treated with NAA, and Nerium gave lowest dry weight of shoot when treated with IBA.

Bougainvillea produced the highest number of roots (17.49) as well as the longest root (14.63 cm) per cutting. The concentration 400 ppm produced the longest and the highest number of roots in the cutting.

The shortest and the lowest number of roots were observed with 0 ppm concentration. Both IBA and NAA at the concentration of 400 ppm produced the longest and the maximum number of roots in the plant Bougainvillea.

Bougainvillea gave the highest (15.02 mg) fresh weight of root per cutting while Nerium the lowest. The concentrations of 400 ppm produced the

highest (14.95 mg) fresh weight of root per cutting and 0 ppm gave the lowest (5.50 mg) fresh weight of root per cutting. Bougainvillea gave the highest (15.19 mg) fresh weight of root while Nerium gave the lowest (6.68 mg) when treated with IBA.

Bougainvillea was found to give the highest amount of fresh root weight (23.47 mg) when treated with 400 ppm concentration of IBA. Nerium gave the lowest (4.43 mg) fresh weight of root per cutting with 0 ppm concentration of IBA.

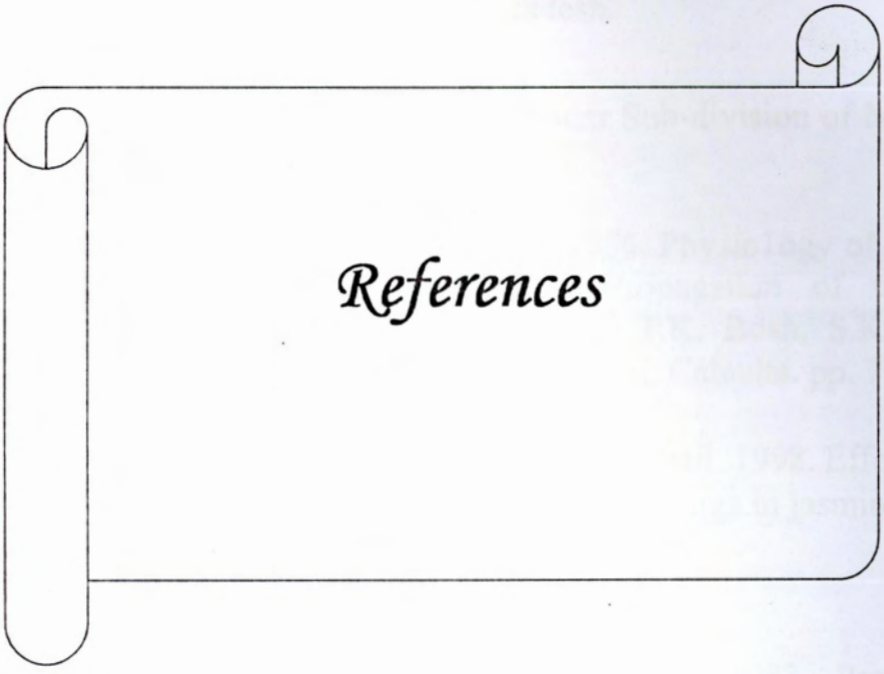
The highest dry weight of root (3.19 mg) per cutting was recorded in Bougainvillea. The growth regulator NAA gave higher (2.40 mg) dry weight of root than IBA (2.33 mg) and concentration of 400 ppm was found to give the highest (3.26 mg) dry weight of root and control treatment gave the lowest (1.33 mg) dry weight of root per cutting. Cutting of Bougainvillea produced the highest (3.53 mg) dry weight of root when treated with IBA while Jasminum interacting with 1BA showed the lowest weight (1.63 mg). The treatment 400 ppm IBA produced highest (5.86 mg) dry weight root per cutting in Bougainvillea and the lowest (1.10 mg) dry weight of root per cutting was found in 0 ppm concentration of IBA.

Bougainvillea showed the highest percentage of success (77.84)%, and IBA gave higher (73.43) percentage of success of root than NAA (72.76). The highest percentage of success (89.05) was observed with 400 ppm concentration while the lowest percentage of success (51.86) was observed with 0 ppm. Interaction between Bougainvillea and IBA gave highest

percentage (79.53) of success while interaction between Nerium and IBA gave the lowest percentage of success (64.60). Interaction between Bougainvillea and 400 ppm concentration gave the highest (93.92) percentage of success while interaction between Nerium and control treatment gave the lowest (47.74) percentage of success.

Both IBA and NAA had positive effect on the most of the rooting parameters and percentage of success in cutting . The higher percentage of success (95.60) and (95.10) were observed in Bougainvillea and Jasminum when treated with 400 ppm concentration of IBA. Nerium showed the lowest percentage of success (44.33) at control.

However, there exists further scopes to study the effect of these growth regulators with wide range of concentration on the rooting performance of these plants.



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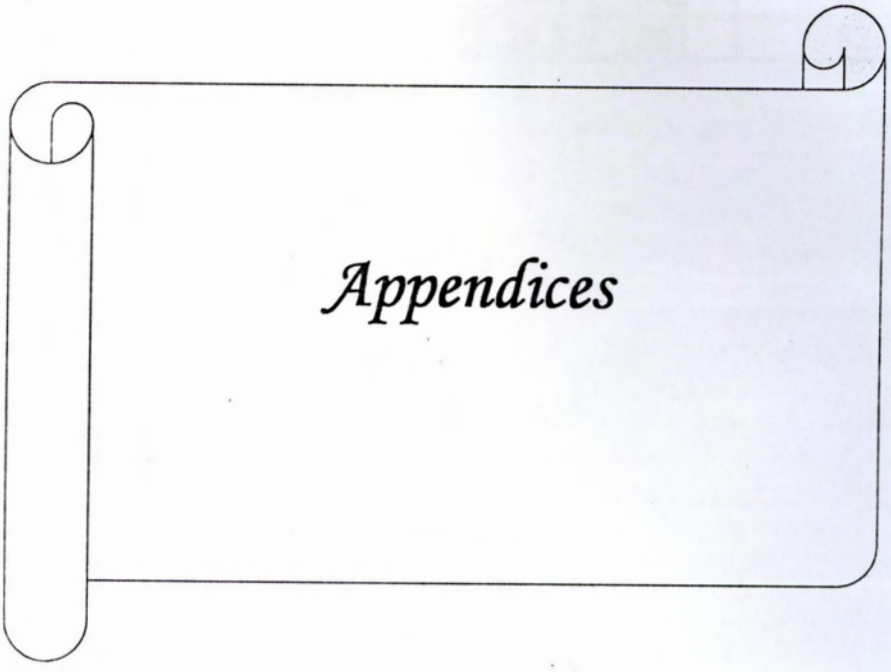
Appendices

Appendix I: Monthly record of air temperature, rainfall, relative humidity and sunshine hours during the period from May 2005 to April 2006

year	Month	Average air temperature (°C)			Total rainfall (mm)	Average relative humidity (%)	Total sunshine hours
		Maximum	Minimum	Mean			
2005	June	33.4	26.8	30.1	259	79	96.0
	July	31.4	25.8	28.6	542	81	127.1
	August	32.0	26.6	29.3	361	82	108.5

Source: Dhaka meteorology center

Appendix II. Characteristics of Horticulture farm soil is analyzed by Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Horticulture Garden, SAU, Dhaka
AEZ	Modhupur Tract (28)
General soil type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not applicable

B. Physical and chemical properties of the initial soil

Characteristic	Value
Partical size analysis	
% Sand	27
% Silt	43
% Clay	30
Textural Class	Silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Drailable P (ppm)	20.00
Exchangeable k (me/100 g soil)	0.10
Available S (ppm)	45

Source: SRDI

Appendix III. Analysis of variance of the data of ornamental shrubs, growth regulators, and their concentration on different aspect in stem cutting of Nerium, Bougainvillea and Jasminum.

Source of variation	Degrees of freedom (df)	Mean square								
		Number of shoot/cutting	Number of root/cutting	Length of shoot	Length of root	Fresh weight of shoot	Fresh weigh of root	Dry weight of shoot	Dry weight of root	Percent success
Replication	2	0.021	0.462	0.847	1.134	8375.347	0.551	133.389	0.010	1.459
Treatment	23	2.02 **	78.83**	48.03**	72.04**	671973.54**	87.20**	15528.77**	3.52**	678.03**
Variety (A)	2	2.496**	9.017**	177.538 **	217.186**	485496.181**	415.202**	4757.887**	12.508**	607.153**
Growth regulators (B)	1	0.001 NS	1.626 NS	15.727**	13.227**	17578.125 NS	0.952 NS	9917.952**	0.085*	8.060*
Interaction (A X B)	2	1.03**	15.032**	27.244**	8.703**	261207.292**	2.427**	19228.426**	2.605**	232.691**
Concentration of growth regulator	3	10.682**	575.305**	217.203**	327.355**	4272496.644**	278.521**	72338.032**	11.415**	4394.551**
Interaction (A X C)	6	0.666**	1.116 NS	1.753NS	32.333**	129589.699**	54.180 **	6838.147**	2.091**	53.776**
Interaction (B X C)	3	0.704**	3.78**	0.42NS	0.933NS	38787.384**	1.119*	1532.778**	0.353**	38.176**
Interaction (A X B X C)	6	0.196**	3.243**	2.672NS	2.167*	38835.995**	0.925*	6104.959**	0.489**	47.688**
ERROR	46	0.03	0.502	1.065	0.754	6650.710	0.345	139.186	0.014	1.387

** Significant at 1% level, * Significant at 5% level, NS Not-significant