

**EFFECT OF DIFFERENT GROWTH
REGULATORS ON ROOTING OF STEM
CUTTING IN *BOUGAINVILLEA***

Thesis

**Submitted to the Punjab Agricultural University
in partial fulfillment of the requirements
for the degree of**

**MASTER OF SCIENCE
in
FLORICULTURE AND LANDSCAPING
(Minor Subject: Botany)**

**By
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(L-2014-A-61-M)**

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CERTIFICATE I

This is to certify that the thesis entitled, “**Effect of different growth regulators on rooting of stem cutting in *Bougainvillea***” submitted for the degree of **M.Sc.** in the subject of **Floriculture & Landscaping** (Minor subject: **Botany**) of the Punjab Agricultural University, Ludhiana, is a bonafide research work carried out by **Anuradha (L-2014-A-61-M)** under my supervision and that no part of this thesis has been submitted for any other degree.

The assistance and help received during the course of investigation have been fully acknowledged.

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CERTIFICATE – II

This is to certify that the thesis entitled, “**Effect of different growth regulators on rooting of stem cutting in *Bougainvillea***” submitted by **Anuradha** (Admn. No. **L-2014-A-61-M**) to the Punjab Agricultural University, Ludhiana, in partial fulfillment of the requirements for the degree of **M.Sc.** in the subject of **Floriculture & Landscaping** (Minor subject: **Botany**) has been approved by the Student’s Advisory Committee after an oral examination on the same.

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ABSTRACT

The present investigations entitled “Effect of different growth regulators on rooting of stem cuttings in *Bougainvillea*” were undertaken at research farm of Department of Floriculture and Landscaping, Punjab Agricultural University, Ludhiana in difficult to root *Bougainvillea* varieties viz. Shubra, Lady Mary Baring and Zakiriana during 2015-16. In all the three varieties, stem cuttings were treated with different growth regulator concentrations and combinations for long duration (12h) and quick dip (<5 sec) and planted in the polybags containing garden soil. In the cuttings treated for quick dip (<5sec), IBA 2000 ppm resulted in maximum mean number of shoots (1.64), mean shoot length (7.07 cm), mean number of leaves (24.91), mean number of branches (2.17) and mean number of roots (3.75) of cuttings among all the growth regulator treatments. The treatment with NAA 2000 ppm resulted in maximum mean shoot emergence (35.56%) and establishment of plants (32.22%), however, treatment with NAA+IBA (100+500) ppm resulted in maximum mean root length (10.50 cm). Among all the three varieties, Zakiriana was the best with maximum shoot emergence (35.00%), number of shoots(1.30), average shoot length (5.10 cm), number of leaves (25.02), number of branches (1.30), number of roots (2.49), average length of roots (9.04 cm) and establishment of plants (32.33%). In the cuttings treated for long duration (12h), NAA+IBA (100+100) ppm resulted in maximum mean shoot emergence (40.00%) among all the growth regulator treatments. The treatment with IBA 500 ppm resulted in the maximum mean number of shoots (1.86), mean shoot length (7.11 cm), number of branches (1.84), number of roots (3.07). The treatment with NAA 500 ppm resulted in maximum mean number of branches (1.84), however, treatment with NAA+IBA (50+100) ppm resulted in the maximum mean number of leaves (28.81). The maximum mean per cent establishment (35.56%) of plants was observed in treatment with NAA+IBA (100+50) ppm. Among all the three varieties, Zakiriana was the best with maximum shoot emergence (44.33%), number of shoots(1.69), average shoot length (6.12 cm), number of leaves (30.80), number of branches (1.72), number of roots (2.64), average length of roots (13.25 cm) and establishment of plants (39.67%).

Keywords: *Bougainvillea*, growth regulators, stem cutting, rooting

Signature of Major Advisor

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ਸ਼ਾਰ

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CHAPTER-I

INTRODUCTION

The genus *Bougainvillea*, family Nyctinaginaceae, is one of the most versatile among the ornamental plants with varied flower colours for making the garden colourful for most of the year. It is native of South America, originated from West Brazil to Southern Argentina. It has rich varietal wealth and mainly suitable for tropical and subtropical conditions which requires full sunshine. There are eighteen different species in this genus, however, three are horticulturally important i.e. *Bougainvillea spectabilis* Willdenow, *Bougainvillea glabra* Choisy and *Bougainvillea peruviana* Bonpl. Many crosses among various species have produced new hybrid species and cultivars.

Bougainvillea is an evergreen plant which grows as a vine spreading horizontally or hanging downward with slender arching canes with stiff thorns growing even up to 12m tall. It can be used as bush, standard shrub, climber, hedge, flowering pot plant, hanging basket or as a ground cover for sloping land. It can also be used to create bonsai specimen (Hossain *et al* 2007). It has wide adaptability to different abiotic conditions like water scarcity, high temperature and salinity. They grow as an evergreen plant where rainfall occurs all the year around, or deciduous where there is a dry season. Recently, *Bougainvillea* has been recommended for plantation in heavy industrial and traffic area to absorb the pollutants and greenhouse gases from the environment (Kulshreshtha *et al* 2009).

The flowers known as bracts are usually rounded, red or dark pink bright from deep magenta to white, purple, mauve, orange, red, scarlet, crimson, pink or yellow in colour. The flowers are produced during Feb- June and Sept- Dec. The bracts retain their colour for several months after the flowering, gradually fading to texture of a paper. It is also called as “paper flower” because of its thin and papery bracts. The actual flowers are small, tubular and usually white in colour.

Bougainvillea can be propagated both by sexual (seeds) as well as asexual (vegetatively) methods, however, cutting, budding, layering, inarching, are commercially used for propagation as seed setting is extremely low. Seed propagation is mostly followed for breeding of new varieties only. Majority of varieties often fail to produce roots and result in poor survival, whereas, air layering is a laborious and expensive method as compared to stem cuttings. Besides, propagation of ornamental plants through stem cuttings is also cheap and sometimes is the only method available for multiplication. Under normal conditions, wide variability has been noticed in different cultivars of the same species, while some cultivar root easily and other are either difficult or fail to root. The propagation rate will depend upon the number of factors like stage of maturity, plant food reserves, hormonal balance, rooting media and environmental conditions for their propagation. In *Bougainvillea*, especially in difficult to

propagate varieties, the success of propagation by stem cuttings is very limited and mostly poor rooting percentage has been observed under normal conditions. It has also been observed that cuttings of *Bougainvillea* rooted better in one season but failed to produce roots during another season. So rooting in *Bougainvillea* is low and need more care.

The process of regeneration is largely controlled by internal and external factors and rooting of cuttings is greatly influenced by type of wood (Farooqi 1994). In *Bougainvillea*, hardwood cuttings are better than semi-hardwood cuttings for rooting (Panwar *et al* 1994). Further, propagation by cuttings is difficult due to fine root system and, therefore, rooting in *bougainvillea* needs more care. The treatment of cuttings with growth hormones for root initiation was a major milestone in the history of plant propagation especially with discovery of auxins in 1934. Among all the growth regulators, auxins are commonly used for rooting and Indole butyric acid (IBA) followed by Naphthalene acetic acid (NAA) and Indole acetic acid (IAA) are applied in liquid or in powder form for promoting rooting of stem cuttings. Auxin treatment can enhance rooting percentage and quality of the root system. The purpose of treating cuttings with growth regulators is to increase the percentage of cuttings which forms roots, hastens root initiation and increases the number of roots. The treatment with chemicals increased the number of adventitious roots that are naturally able to regenerate in to roots; however, their effectiveness varies among different species and varieties. The treatment of hardwood cuttings with NAA or IAA is less effective as compared to IBA. The mixture of two auxins is much more effective for inducing more rooting than when the auxin is used singly. The concentration of auxin varies from plant to plant and type of cuttings used, however, higher concentration may be required in difficult-to-root cultivars (Gilman 1999). Effectiveness of exogeneous application of auxin in promoting rooting of stem cuttings is dependent on adequate absorption of growth regulator solution by the plant tissue. The amount of time between cutting preparation and treatment also influences the absorption, with greater water loss from base of the cutting prior to treatment increasing the suction that develops at base of the cutting. Depth of treatment can also affect absorption and subsequent rooting response, with increased depth providing additional solution that can run down the epidermis and absorbed through cut end at the base. The effectiveness of auxin also depends on adequate translocation from the site of application to the site of adventitious root formation. Auxin translocation can occur in three primary manners: 1) basipetally by polar transport; 2) passively through the phloem; and 3) accropetally in the xylem (with exogenous application). The success of rooting of stem cuttings in *Bougainvillea* by auxins treatment has been documented by various workers (Panwar *et al* 1994, Chovatia *et al* 1995, Bose and Mandal 1973, Narayanagowda *et al* 1987 and Gautum and Chauhan 1990). Joshi *et al* (1989) observed that treatment with IBA 4000 ppm resulted in maximum survival of rooted cuttings of different varieties of *Bougainvillea*.

In Bougainvillea, since the response of different varieties with respect to rooting is variable, therefore, the present studies were conducted to ascertain the effect of different growth regulators on rooting of stem cutting in Bougainvillea cv. Shubra, Zakiriana and Lady Mary Baring with following objectives:

- 1) Standardization of concentration of growth regulator treatments for rooting of stem cuttings by using quick dip and long duration methods.
- 2) To study the effect of growth regulators on the establishment of plants after rooting.

CHAPTER-II

REVIEW OF LITERATURE

The vegetative propagation of plants ensures uniformity in the genetic makeup of plants and has been found useful for commercial multiplication of many ornamental plants. Therefore, the literature pertaining to the present studies “Effect of different growth regulator on rooting of Stem Cuttings in *Bougainvillea*” has been reviewed in the following chapter:

Akhtar *et al* (2015) reported in *Rosa centifolia* cuttings that rooting percentage was increased by applying plant growth regulators. In total 31 treatments with different concentrations (450 ppm, 700 ppm and 950 ppm) of IBA, IAA, NAA alone, in combination and with same concentrations of BAP were used. All three levels of IBA alone produced maximum results in case of all parameters as compared to all others treatments. Among three levels of IBA, 450 ppm concentration produced maximum shoot length (10.67 cm), shoot dry weight (3.02 g), number of roots (14.00), root length (11.90 cm) and root dry weight (0.50 g). Lower concentrations of plant growth regulators produced better results as compared to higher concentrations.

Rahdari *et al* (2014) reported in *Cordyline terminalis* that the highest fresh and dry weight of roots, root length and the number of branches were in treatment of NAA (2000 mg/l) + IBA (1000 mg/l).

Renuka and Sekhar (2014) studied the effect of IBA and NAA at different concentrations on the rooting of carnation (*Dianthus caryophyllus* L.) cuttings of cv. Dona. The treatment with IBA 200 ppm recorded less number of days for formation of root initials, highest percentage of rooting, maximum number of roots, cumulative length of roots per cutting and highest percentage of establishment of cuttings than the treatment of IBA 100 ppm + NAA 50 ppm. IBA treatment recorded superior rooting parameters over NAA treatment and with increase in the concentration of IBA and NAA showed increase in the rooting.

Singh *et al* (2014) studied the effect of IBA and NAA on rooting of Stem cuttings of *Morus alba*. They were treated with 1000, 1500 and 2000 ppm IBA and NAA solutions by quick dip method. Among all the treatments, numbers of sprouted cuttings, length of roots/cutting, percentage of rooted cuttings and lengths of longest sprouts of root were higher in IBA 2000 ppm.

Wazir (2014) studied the effect of NAA and IBA on rooting of camellia cuttings. Three types of cuttings:-Softwood, semi-hardwood and hardwood were prepared and dipped in 250 and 500 ppm NAA and 500 and 1000 ppm IBA for 5 minutes before planting. Among all, 1000 ppm IBA was found most effective. But the types of cutting have no effect on the parameters recorded.

Abu-Zahra *et al* (2013) reported in Rosemary, Hedera, *Syngonium* and *Gardenia* that the cuttings treated with NAA (3000 ppm) resulted in the highest per cent rooting in Rosemary and Hedera, whereas, (NAA 1000 ppm and 4000 ppm) resulted in the best rooting in *Syngonium* and *Gardenia* respectively.

Alshammary *et al* (2013) reported in *Bougainvillea peruviana* cv. Shubra and *Hamelia patens* that IBA (2000 ppm) resulted in highest bud break percentage (73.9% and 59.2%), rooting percentage (53.6% and 28.4%), number of roots per cutting (15.5 and 24.8). root length per cutting (31.6 mm and 27.2 mm) and establishment percentage (60.3% and 42.3%) and number of branches per cutting (3.6 and 5.4). However, the response of hardwood cuttings to treatments was not consistent in both the species.

Hassanein (2013) studied all the possible factors affecting efficiency of plants propagation via stem cuttings. Several factors including type of cuttings, culture medium, type and concentration of growth regulators were studied on *Ficus Hawaii* and *Chrysanthemum morifolium*. Peat moss and sand media showed significant higher survival, rooting, and growth compared to perlite and the mixture 1:1:1 of the three media. Treatment of cuttings by IAA was more effective than by either IBA or NAA. All concentrations were better than control and 50 ppm proved the best. Therefore, the optimum propagation efficiency of *Ficus* can be obtained by intermediate cuttings in peat moss after treating by 50 ppm of IAA. For *Chrysanthemum*, the optimum propagation efficiency can be obtained by the cultivation of terminal cuttings in a mixture 1:1:1 of peat moss, sand and perlite after treating by 50 ppm of IAA.

Kumari *et al* (2013) reported in *Jatropha curcas* that IBA (200 ppm) treatment resulted in early emergence of shoots (25.92 days), the maximum number of shoots per cutting (5.58), shoot length (10.57 cm), average number (38.95), sprouting (81.10%) and rooting (49.83%).

Memon *et al* (2013) observed in *Bougainvillea* that sprouting and rooting of stem cuttings were significantly influenced by various concentrations of NAA, whereas, varieties had non-significant influence on these characters with the exception of number of sprouts per cutting, sprouting and rooting percentage. The treatment of cuttings with NAA (6000 ppm) resulted in the maximum sprouts per cutting (3.133), sprouting percentage (78.33), length of sprouts (0.680 cm), rooting percentage (75.00), length of roots (13.862 cm), roots per cutting (27.833 cm) , leaves per cutting (28.02) and length of leaves (6.007 cm).

Seyedi *et al* (2013) investigated the effect of stem type and different levels of IBA on the rooting of *Bougainvillea glabra*. The cuttings treated with IBA (4000 mg/l) showed the most rooting compared to other treatments. The number and length of the roots and wet weight of the root were affected in a high level of auxin treatment and type of the cutting, however, semi-hardwood cuttings were the best for rooting of *Bougainvillea glabra*.

Sahariya *et al* (2013) studied the effect of IBA (0, 1000, 1500, 2000 ppm), on rooting of *Bougainvillea* var. Thimma cuttings in open field and polyhouse conditions. In polyhouse conditions, IBA showed to be more advantageous than open field conditions, however, increase in concentration of IBA (1500 to 2000 ppm) showed a significant effect in both the conditions but effects were more pronounced under polyhouse conditions. The treatment with IBA 2000 ppm resulted in the maximum number of rooted cuttings (6.33), percentage of rooting (63.33%), length of shoots per cutting after one month (3.07 cm), length of shoots per cutting after two month (14.73 cm), number of roots per cutting (30.00), length of roots (12.85 cm) and dry weight of roots (0.43 g).

Shabha and Alshammary (2013) reported in *Bougainvillea* cv. Shubra that treatment of cuttings with IBA (500 ppm) resulted in the highest rooting percentage (55.6% after 12 hours and 59.4% after 24hours of treatment), more number of roots per cutting (20.5 and 19.8 at 12 and 24 hours) and the highest establishment percentage (68.3 and 53.3% after 12 and 24 hours, respectively). The effect of time of soaking (12- or 24 h) was not consistent and was different among individual treatments.

Susila and Reddy (2013) reported in *Adathoda vasica* that IBA (1500 ppm) resulted in the maximum rooting (67.50%) and longest root length (22.18 cm), whereas, the treatment with NAA (1500 ppm) resulted in maximum roots per cutting (40.89), root fresh (3.22 g) and dry weight (1.12 g).

Ullah *et al* (2013) conducted the experiment for optimization of auxin: - IBA and NAA required for regeneration of marigold. The maximum branches per plant (6.8) were observed at 400ppm. The maximum leaves per plant (44.00) were observed at 100 ppm IBA concentration while 200 ppm showed minimum leaves per plant (6.0). At 100 ppm IBA maximum plant height (9.40cm) was observed. IBA 400ppm had maximum effect on roots per plant (84.4).Root size increased at (6.50) at 100ppm IBA concentration, while increasing the IBA concentration decreased root size. Increases in leaves per plant were observed with increase in NAA concentration. Maximum plant height (7.80) was recorded at 100 and 200 ppm NAA concentration. Higher concentration of NAA showed the maximum increase in roots per plant (123.2) and root size (6.8). 300 ppm showed maximum value for non-bloom flower and 200 ppm showed the minimum value (3.2).

Abu-Zahra *et al* (2012) Parthenocissus plant was one of the most attractive outdoor deciduous vine. Six treatments (0, 1000, 2000, 3000, 4000 and 5000 ppm NAA) were used Results showed that in most cases cuttings treated with 1000 ppm NAA produced the best results or results which were not significantly different from the higher concentrations of NAA, so it's better to save in using the auxin hormone and use the lowest concentration in rooting the Parthenocissus cuttings.

Adekola and Akpan (2012) reported in *Jatropha curcas* that the stem cuttings treated with growth hormone had non significant effect on survival and sprouting and the untreated cuttings (control) performed better than the hormone treated cuttings. However, in terms of rooting behaviors, significant effects treatment differences were observed and the cuttings treated with IBA were found to be root better than those of NAA, however, the control resulted in the best performance.

Asl *et al* (2012) studied the effect of IBA treatment for 7 seconds on the rooting ability of semi-hardwood cuttings of *Bougainvillea*. This had significant effect on rooting percentage and IBA (2000 ppm) resulted in the highest number of roots (8.67 roots per plant). The root length (151.42 mm) was highest in the control and there was non significant difference between control and IBA (2000 or 4000 ppm).

Kako (2012) studied the effect of cutting diameter and IBA doses on hardwood cuttings of black Mulberry. Different doses of IBA (0, 1000, 2000, 3000 and 4000 mg/l) were applied. The cuttings diameter and IBA had significant effects on rooting percentage, length and diameter of transplants. Applications of IBA and kinetin gave significant effects on percentage of successful budding scion (%), length and diameter of scions. The best treatment was found from treatment T4 (12-14) mm + 4000 ppm IBA in rooting percentage was (80.72%), and treatment T3 (10-11) mm + 2000 ppm IBA for both length (180.50 cm) and diameter (14.28 mm) of transplants, while the best treatment in percentage of budding success scion, length and diameter of scions was found in high concentration of IBA and kinetin.

Singh (2012) studied the effect of different concentrations of Indole butyric acid (IBA) on *Bougainvillea* varieties Louise Wathen, Thimma, Mrs. Butt and Shubra stem cuttings. It was observed that IBA and variety had significant effect on sprouting, rooting, callusing and establishment of cuttings. Louise Wathen cuttings treated with IBA (1000 ppm) were superior in response with respect to sprouting (85.39%), rooting (75.36%), callusing (80.78%) and establishment (100%) of plants.

Rahbin *et al* (2012) investigated the effect of location of shoot for taking stem cuttings and IBA on rooting in 'Night Jasmine'. This study was performed in mist greenhouse and each cutting was treated with IBA (0, 1000, 1500, 2000 and 4000 ppm) for 5 seconds and planted in the pots containing sand and peat moss. The treatment with IBA (2000 and 4000 ppm) was significantly better than all the other treatments.

Ogunwa (2011) studied the stimulation of rooting in *Bougainvillea spectabilis* and *Bougainvillea glabra* using coconut water. Cuttings were treated with dip solutions: short duration dipping (5 minutes and 10 minutes), medium duration dipping (1 hour, 2hours and 3 hours), long duration dipping (6 hours and 10 hours) and no dipping as control. Results showed that dipping duration had significant ($P<0.05$) effects on the rooting ability of *Bougainvillea spectabilis* with cuttings dipped for 1 hour having the best performance, while

B. glabra cuttings had no roots. Therefore root initiation in cuttings of *B. spectabilis* could be enhanced when dipped in coconut water for 1 hours.

Karimi (2011) conducted an experiment that was a completely randomized design (CRD) with two factors: rootstock and the concentration of indole butyric acid (IBA) (0 and 500 mg/L), in three replications. The rootstock were 'Gorj-e-Dadashi', 'Gorj-e-Shahvar' and 'Gool Safid-e-Ashk-e-Zar', and the scion were of the cultivar Malas-e-Yazdi. The results indicated that rootstock type and IBA treatment influenced bud take and root formation. The highest bud-take percentage was obtained with 'Gorj-e-Dadshi' in combination with 500 mg/L IBA.

Singh *et al* (2011) observed the influence of different concentration of IBA on rooting potential of *Bougainvillea glabra* var. Torch Glory during winter season. The maximum (100.00%) rooting and sprouting of cuttings were recorded in IBA (2000, 2500 and 3000 ppm), whereas, IBA (3000 ppm) resulted in the maximum length of sprout/cutting (18.87 cm) and number of roots/cutting (21.22) in the month of February 15. The length of root/cutting was the maximum (15.32 cm) in IBA (5000 ppm) in February 15.

Singh and Singh (2011) studied the effect of IBA on rooting potential of hardwood cuttings of different varieties of *Bougainvillea* *i.e.* Louise Wathen, Thimma, Mrs. Butt and Shubra. The IBA concentration and variety both had significant effect on sprouting, rooting, callusing and cv. establishment of cuttings, whereas, in Lousie Wathen cuttings treated with 1000 ppm IBA exhibiting more per cent sprouting (85.39%), rooting (75.46%) and callusing (80.78%) and 100% establishment of plants.

Karami and Salehi (2010) studied the application of NAA and IBA had significant effect on rooting of cutting in *Tecomella undulata*. The application of NAA (0.3%) resulted in rooting 82.92% and 89.37% rooting of semihardwood cuttings and hardwood cuttings, whereas, in IBA (0.4%) resulted in 80.61% and 81.65% rooting of semihardwood cuttings and hardwood cuttings, respectively.

Parmar *et al* (2010) conducted an experiment on effect of different plant growth regulator treatments on *Bougainvillea peruviana* cv. Torch Glory hardwood cuttings. The treatment with IBA (4000 ppm) was the best with respect to number of days taken to sprouting. However, IBA (3000 ppm) and IBA (2000 ppm) +NAA (2000 ppm) were better in respect of root and shoot characters as well as survival percentage of rooting cuttings.

Swamy and Rao (2009) studied Brassinosteroids. They influence varied growth and development processes such as growth, germination of seeds, rhizogenesis, flowering, senescence and abscission. In this study emphasized the study of 28-homobrassinolide and 24- epibrassinolide in the root formation and root growth in case of *Coleus*. The study revealed the ability of brassinosteroids in increasing the root formation and root growth of treated cuttings over control.

Bhatt *et al* (2008) observed in *Lavendula officinalis* that the cuttings treated with IBA resulted in callusing (86.66%), early root emergence (21.66 days), maximum rooting percentage (86.66), number of roots (7.00), length of roots (10.30 cm) and field survival (93.33%).

Hussein (2008) studied on semi-hardwood stem cuttings of *Thunbergia grandiflora* and planted them on different time *i.e.* March 21, June 21, September 21 and December 21. After 4 months after each planting date showed that planting of cuttings on March 21 produced significant increase in rooting percentage, number of roots/plant as well as number of leaves, fresh and dry weight of leaves and dry weight of branches/plant compared to other planting dates. The highest total carbohydrates content, C/N ratio and total soluble indole contents, as well as the lowest content of total soluble phenols were recorded in the basal parts of the stem cuttings planted on March 21, whether before recommended that early planting was positive in improving the rooting and the vegetative growth.

Kumar *et al* (2008) studied the effect on rooting of growth regulator on *Thunbergia grandiflora*. Treatment at concentrations of IBA and NAA and IBA+NAA combinations that 0, 1000, 1500 and 2000 ppm was used. Maximum results rooting are at IBA+NAA 2000 ppm concentration.

Laubscher and Ndakidemi (2008) studied the effect the different concentrations of IAA on *leucedendron laxum* in a shade tunnel house. The IAA treatments included a control, 500, 1000, 2000 and 4000 ppm IAA. The growth mediums tested were bark/polystyrene (1:1), peat moss/polystyrene (1:1), bark/riversand/polystyrene (1:1) and perleite/riversand (1:1). Overall, the auxin had positive effect. Results indicated that the bark/polystyrene and peat/polystyrene mediums significantly superior in promoting different aspects of rooting when compared with the other mediums. From that study was concluded that the shade tunnel was an economical and successfully environment in rooting.

Reddy *et al* (2008) reported in *Ficus carica* that the cuttings treated with IBA (2500 ppm) + NAA (2500 ppm) exhibiting maximum percentage of rooting, number of roots, average root length and survival percentage of rooted cuttings followed by IBA (2500 ppm) in both hardwood and semi hardwood cuttings. The treatment of cuttings with NAA (5000 ppm) resulted in the highest percentage of rooting and hardwood cuttings resulted in maximum percentage of rooting, survival percentage and other root characters as compared to the semi hardwood cuttings.

Hashemabadi and Sedagathoor (2007) reported in *Camellia japonica* that the cuttings treated with IBA (4000 mg/l) recorded highest number of roots, the treatment of cuttings with IBA (4000 mg/l + NAA 2000 mg/l) resulted in maximum length of roots, whereas, the treatment of cuttings with IBA (4000 mg/l) resulted in the highest rooting percentage.

Parvez *et al* (2007) studied the effect of IBA and planting times on the growth and rooting of Peach cuttings. Cuttings were treated with 0, 500, 1000, 1500 and 2000 ppm IBA. IBA concentrations increased the growth parameters irrespective of planting time. Planting time × IBA levels interactions showed that maximum number of branches per plant (8.55), number of roots per plants (23.00), root length (19.62), root weight (13.25), ant plant survival (85.71%) were observed in cuttings treated with 2000 ppm IBA.

Lima *et al* (2006) reported the use of NAA solutions (0, 1, 500 and 3,000 mg L⁻¹) for 10 sec. and carbonized rice hull and vermiculite for rooting of semi-hardwood cuttings in *Calliandra selloi* (rose and white stamens) and *C. tweediei* (red stamens). It was observed that the carbonized rice hull was the best substrate with respect to rooting percentage (*C. selloi* rose – 90.00%, *C. selloi* white – 73.345 and *C. tweediei* red – 11.67%). The analysis showed no interaction between the substrate × NAA concentrations and substrates × species and, non significant difference among NAA treatments.

Thorat *et al* (2006) observed in Nerium that the cuttings treated with IBA (100 ppm) for 24 h resulted in the highest sprouting, rooting and survival percentage of plants.

Gupta *et al* (2005) reported that in semi-hardwood cuttings of *Bougainvillea* cv. Pallavi, root length was more when the cuttings were treated with IBA (4000 ppm) than all other lower concentration of IBA and NAA. It was concluded that in semi-hardwood cuttings of cvs. Pallavi and Mahara variegata, the treatment with IBA (4000 ppm) was the most effective for large scale vegetative propagation.

Khan *et al* (2005) studied in Damask rose cuttings that average number of roots and rooting percentage gradually increased with the increase in the hormone concentration. The highest number of roots (15.72) and rooting percentage (94.17%) were recorded in the cuttings treated with NAA (50 mg/l), while the maximum length of roots (7.30 cm) was in control.

Adiga *et al* (2004) reported in *Bougainvillea* that hardwood cuttings treated with NAA (1000 ppm) recorded the highest (85.42%) mean percent rooting in *Vernonia*, whereas, NAA (1000 ppm) resulted in the highest average number of root in *Hibiscus*. In *Jasminum multiflorum*, the cutting treated with IBA (500 ppm) resulted in the highest rooting (94.43%).

Singh (2002) studied the response of the IBA and NAA on root formation terminal and sub terminal cuttings of *Bougainvillea* cv. Thimma. The results indicated that IBA (4000 ppm) resulted in the maximum percentage of rooting. It was reported that this was the easiest and most convenient method of propagating Thimma variety of *Bougainvillea* over the traditional method of air-layering.

Singh and Singh (2002) studied the influence of wood type and growth regulators (IBA and NAA) on rooting ability in *Bougainvillea peruviana* cv. Thimma. The hardwood cuttings and IBA (2000 ppm) significantly increased rooting, number of sprouts/cuttings,

number of leaves/cuttings, length of sprout, diameter of sprout, number of roots/cuttings, length of root, diameter of root, fresh weight of roots/cutting. However, no significant differences were observed among the different types of wood on days taken to sprouting, whereas, IBA (2000 ppm) induced early sprouting and had maximum rooting percentage. Interactions between type of wood and growth regulators concentration was significant and the maximum value was obtained in hardwood cutting and treatment with IBA (2000 ppm).

Singh (2000) reported in *Bougainvillea peruviana* cv. Shubra, the treatment of cuttings with IBA (500 ppm) resulted in significantly more sprouting (71.67%), rooting (57.5%), number of shoots per cutting (1.37), number of leaves per cutting (41.4), average shoot length (128.86 cm) and establishment of plant (51.67%) than all other treatment, irrespective of duration (12, 24 h) of treatment and method of planting.

Panwar *et al* (1999) studied the effect of growth regulator on cuttings of *Bougainvillea* cv. Thimma. It was observed that IBA (2000 ppm) was the best treatment to increase the sprouting of cuttings, number of leaves, shoot length, percentage of cutting, number of roots and length of roots. The hardwood cuttings produced more number of sprouts, leaves, roots, length of roots and percentage of rooting in comparison to semi-hardwood cuttings.

Chauhan and Bhardwaj (1998) observed that in *Robinia Pseudocacia*, the cuttings treated with 4000, 6000, 8000 and 10,000 ppm NAA and planted in river sand under intermittent misting gave best sprouting with NAA (10,000 ppm).

Atzmon *et al* (1997) studied that biosolids improved rooting of *Bougainvillea glabra* cuttings. The cuttings were kept in various concentrations of biosolids (1, 2.5, 5 and 7.5 %) from two different sources (Herzliyya and Haifa); two biosolids-free control media were used (with or without addition of mini-osmocote fertilizer). The rooting percentage was improved in fifty percent of the cuttings treated with IBA and treating the cuttings with IBA without biosolids was inferior. The root development was stimulated significantly with the biosolids as compared to the slow release fertilizer treatment. The high concentrations of Herzliyya biosolids showed the best results in rooting and growth, whereas, Haifa biosolids were best at low concentration.

Mishra and Sharma (1995) studied the effect of plant growth regulators on rooting of stem cuttings of *Bougainvillea*. The higher concentration of IBA (2000 ppm) significantly increased the rooting performance in *Bougainvillea* cvs. Dr. R. R. Pal and Mrs. H. C. Buck, which were difficult to root and cv. Dr. R. R. Pal performed better than Mrs. H. C. Buck.

Eloky and El-sennawy (1993) studied in *Ficus deltoidea* that the maximum rooting percentage was in the cuttings taken in February and treated with IBA (3000 ppm) before planting under intermittent mist conditions.

Bhattacharjee and Balakrishana (1992) observed that in *Hamelia patens* that IBA treatment 4000 ppm significantly increased rooting and number of roots per cutting.

Harris and Singh (1991) reported that the cuttings of *Bougainvillea* cvs. Shubra, Refulgence, Formosa, Mangnifica, dipped in IBA (100 ppm) for 12 h and placed under mist chamber, resulted in highest mean percentage rooting and maximum number of roots per cuttings in all the cultivars.

Singh (1993) reported in *Bougainvillea* cv. Thimma that the cuttings resulted in more number of roots/cuttings in treatment with IBA (3000 or 4000 ppm) regardless of the stem.

Jhon and Paul (1991) reported in difficult to root *Eunymous japonica* that the highest per cent survival of cuttings resulted in treatment with IBA (6000 ppm) and planted in washed coarse sand bed, covered with transparent polythene sheets.

Buraskar *et al* (1990) observed that *Bougainvillea* cv. Mary Palmer and Mahara, on soaking in 2500 ppm, IBA +2500 ppm, frulic acid for 10 minutes before planted in polythene bags containing sterilized white sand, produce the best rooting response in both cultivar. This treatment resulted in highest percentage (100 per cent) in Mahara cuttings, percentage survival in the both Mahara (73.33 per cent) and Mary Palmer (37.78 per cent) cuttings, final shoot length in Mahara (20.32 cm) and Mary Palmer (8.14 cm) cutting and number of roots/cuttings (13.11) in Mary Palmer.

Mukhopadhaya and Bose (1996) reported in *Bougainvillea* cv. Mary Palmer that the cuttings treated with NAA (400 ppm) produced 12.5 percent rooting, whereas, the cutting treated with NAA (100 ppm) and in the control failed to exhibit rooting.

Chovatia *et al* (1995) reported in *Bougainvillea* var. Mary Palmer the highest root initiation (88.55%), longest roots (51.47 cm), longest shoot (36.78 cm) and the highest number of root/cutting (6.08) in treatment of cuttings with IBA 4000ppm (15 sec.) before planting in pots containing garden soil.

Sohair and Taleb (1995) observed that *Bougainvillea alba* stem cuttings resulted in highest and percentage of roots and survival of cuttings when dipped for 24 hr in 500 ppm IBA + 10 ppm Co and planted in a 2:1 mixture of Nile silt and sand.

Gupta (1995) studied the effect of intermittent mist and auxins on rooting in semi-hardwood cuttings of *Buddlea asiatica*. These cuttings were treated with IAA, IBA and NAA at 1000, 2000, 3000, 4000 and 5000 ppm concentrations. It is concluded that IBA at 4000 ppm proved significantly effective in rooting, root length and survival of rooted cuttings of *Buddlea asiatica*.

El-Shazy and El-Sabrou (1994) reported in Le conte pear that the best rooting percentage (32.75%), number of roots/cutting (2.03%), number of leaves/cutting (19.13) and average shoot length (17.63) were observed in treatment with IBA (4000 ppm).

Shirol *et al* (1992) reported that *Euphorbia pulcherimma* wild var. Alba Hort. gave highest per cent rooting (50.77%) and length of longest primary root/ cutting (8.33 cm) when treated with 3000 ppm IBA+NAA and planted in immediately after treatment.

Wiesman *et al* (1989) Indole-3-butyric acid is rapidly metabolized by mung bean cutting during rooting. Twenty four hour after application, less than 20% of the applied IBA remained in the free form and its level decreased continuously in the later stages of rooting. Indole-3-butyryaspartic acid (IBAsp) and at least two high molecular weight conjugate increased were the major metabolites in IBA-treated cuttings. In the later conjugates, at least part of the IBA moiety is attached to a higher molecular weight constituent in an amide linkage. IBAsp level peaked 24 hours after application of IBA to the cuttings and then declined. The level of the high molecular weight conjugates increased continuously throughout the rooting process. The conjugates were active in inducing rooting of cuttings, with IBAsp Being superior to free IBA. It is suggested that IBA conjugates, and particularly IBAsp, serve as the source of auxin during the later stages of rooting.

Lal *et al* (1971) reported that the cuttings of *Bougainvillea* spp. Thimma when treated with NAA (500 ppm) for one minute gave more rooting percentage (81 per cent) than NAA (100 and 1000 ppm) (30 and 48 per cent respectively). However, the maximum number of roots per cutting was given by 1000 ppm NAA.

Rao (1967) reported the effect of certain plant growth regulating substances on the rooting of *Bougainvillea spectabilis* L. stem cuttings. The propagation of *Bougainvillea* spp. stem cutting was influenced by IAA, IBA and NAA with dip, soak and dust method of application and treatment with IAA (8000 ppm) dip method induced about 95% rooting.

CHAPTER-III

MATERIALS AND METHODS

The present investigations entitled “Effect of different growth regulators on rooting of stem cuttings in *Bougainvillea*” were conducted at Research Farm of Department of Floriculture and Landscaping during 2015-16.

3.1 Geographical location

Ludhiana is situated at 30°56′ North latitude and 75°52′ East longitude and has elevation of 247 meter from sea level.

3.2 Climate

The climate of Ludhiana is subtropical with very low temperature during winter season (mid December and mid January) and very high temperature during summer season (May and June). Frequent rains occur during month of July-August.

3.3 Plan of Work

In the present investigations, three varieties of *Bougainvillea* were taken to study the effect of growth regulators on rooting of their stem cuttings:

Plant material:

The following varieties were used:

- 1) Shubra-White
- 2) Lady Mary Baring-Golden yellow
- 3) Zakiriana-Peach red

The established grown up plants of above varieties were maintained by regular pruning from time to time to get disease free healthy hardwood cuttings.

3.4 Methodology

Preparation of cuttings:

The hardwood cuttings of pencil thickness were prepared and planted immediately after growth regulator treatment directly in the polythene bags for callusing. The leaves were removed carefully from the shoots to avoid damage of the axillary buds after cuttings from the mother plants. The cuttings were prepared by giving slanting cut on upper end and a straight cut on lower end to distinguish both ends while planting.

Preparation of stock solution

The stock solutions to dipping the cuttings with growth regulators were prepared as follows:

Stock solution of NAA: The stock solution of NAA was prepared by dissolving 2000 mg of NAA in ethyl alcohol in 100 ml flask. The total volume of the solution was raised to 100 ml by adding distilled water and few drops of ammonia were added to avoid precipitation and thus completely dissolving NAA.

Stock solution of IBA: Likewise, the stock solution of IBA was prepared by dissolving 2000 mg of IBA in ethyl alcohol in 100 ml flask and total volume of the solution was raised to

1000 ml by adding distilled water. Few drops of ammonia were added to avoid precipitation and completely dissolving IBA and required concentration of growth regulators were calculated.

Stock solution of NAA+IBA: Stock solution for NAA and IBA was prepared separately and different concentrations were made by mixing required amount of stock solutions and distilled to make final volume of 100 ml in each jar for the treatments.

Treatments of cuttings:

a. Short duration treatment (quick dip; <5 seconds):

Various concentrations of NAA, IBA or their combinations were used for quick dip (<5 seconds) treatment by dipping basal end of cuttings in jars containing 100 ml growth regulator solution as mentioned below :

Growth regulators	Concentrations (ppm)
NAA	1000
NAA	1500
NAA	2000
IBA	1000
IBA	1500
IBA	2000
NAA+IBA	500+1000
NAA+IBA	1000+500
NAA+IBA	1000+1000
Control	-

Observations:

- 1) **Shoot emergence:** The number of cuttings emerged out in each treatment was recorded at monthly intervals and measured in percentage.
- 2) **Number of shoots:** The number of shoots per cutting in each treatment was recorded at monthly intervals.
- 3) **Average shoot length:** Shoot length (cm) of all the cuttings was measured by using a measuring scale at monthly intervals up to four months.
- 4) **Number of leaves:** The number of leaves per cutting was counted at monthly intervals up to four months.
- 5) **Number of branches:** The number of branches per cutting was counted at monthly intervals up to four months.
- 6) **Number of cutting exhibiting rooting:** The number of cuttings exhibiting rooting was counted after four months.
- 7) **Per cent of cutting exhibiting rooting:** Total per cent of cutting exhibiting rooting was calculated after four months.

- 8) **Number of roots:** The cuttings were uprooted carefully to avoid any damage to root system. The roots of each cutting were thoroughly washed to remove sand in running tap water and number of roots on each cutting was recorded.
- 9) **Average length of roots:** The roots were removed from cutting with help of a sharp razor. The length of primary roots of each cutting was recorded.
- 10) **Per cent establishment of plants:** Per cent survival of cuttings was recorded in each treatment after four month by counting the total number of surviving plant out of number of treated cuttings.

Statistical analysis: The experiments were conducted in the factorial completely randomized block design and each treatment was replicated thrice. The data were analysed by the method developed by Fisher (1950). The CPSC1 software was used to analyse the data.

b. Long duration (12 hours)

Various concentrations of NAA, IBA or their combinations were used for long duration (12 hours) treatment by dipping basal end of cuttings in jars containing 100 ml growth regulator solution as mentioned below:

Growth regulators	Concentrations (ppm)
NAA	100
NAA	300
NAA	500
IBA	100
IBA	300
IBA	500
NAA+IBA	50+100
NAA+IBA	100+50
NAA+IBA	100+100
Control	-

Observations:

- 1) **Shoot emergence:** The number of cuttings emerged out in each treatment were recorded at monthly intervals.
- 2) **Number of shoots:** The number of shoots per cuttings in each treatment was recorded at monthly intervals.
- 3) **Average shoot length:** Shoot length (cm) of all the cuttings were measured by using a measuring scale at monthly intervals up to four months.
- 4) **Number of leaves:** The number of leaves per cutting was counted at monthly intervals up to four months.
- 5) **Number of branches:** The number of branches per cutting was counted at monthly intervals up to four months.

- 6) **Number of cutting exhibiting rooting:**-The number of cuttings exhibiting rooting was counted after four months.
- 7) **Per cent of cutting exhibiting rooting:** Total per cent of cutting exhibiting rooting after four months.
- 8) **Number of roots:** The cuttings were uprooted carefully to avoid any damage to root system. The roots of each cutting were thoroughly washed to remove sand in running tap water and number of roots on each cutting was recorded.
- 9) **Average length of roots:** The roots were removed from cutting with help of a sharp razor. The length of primary roots of each cutting was recorded.
- 10) **Per cent establishment of plants:** Per cent survival of cuttings was recorded in each treatment after four months by counting the total number of surviving plants out of number of treated cuttings.

Statistical analysis: The experiments were conducted in the factorial completely randomized block design and each treatment was replicated thrice. The data were analysed by the method developed by Fisher (1950). The CPSC1 software was used to analyse the data.

CHAPTER-IV

RESULTS AND DISCUSSION

The results pertaining to the present investigations “Effect of different growth regulators on rooting of stem cuttings in *Bougainvillea*” along with the relevant literature are being presented in this chapter. The propagation of *Bougainvillea* through stem cuttings using growth regulators for quick dip (<5sec) and long duration (12h) methods were investigated by planting the cuttings directly in polythene bags (Plate 1). The results obtained with respect to different parameters are as follows:

4.1 Growth regulator treatment of hardwood cuttings of *Bougainvillea* by using quick dip (<5s) method

4.1.1 Shoot emergence

The hardwood cuttings of all three varieties viz. Shubra, Lady Mary Baring and Zakiriana planted after growth regulator treatments by quick dip (<5s) exhibiting sprouting and observations were recorded at monthly intervals (Fig. 1, 2, 3). It was observed that the treatment of cuttings with growth regulators had significant effect on shoot emergence (Table 1). The mean shoot emergence was significantly more in NAA 2000 ppm (35.56%) than all other growth regulator treatments and minimum was observed in NAA 1000 ppm (5.55%), irrespective of the varieties. Among the varieties, per cent shoot emergence was significantly more in Zakiriana (35.00%), followed by Lady Mary Baring (18.00%) and Shubra (12.67%), irrespective of growth regulator treatment (Plate 2). In Shubra, the shoot emergence was maximum in IBA 1500 ppm (23.33%) and cuttings failed to exhibiting sprouting in NAA 1000 ppm (0.00%). Maximum shoot emergence was in NAA 2000 ppm (43.33%) and was minimum (10.00%) in NAA 1000 ppm, NAA 1500 ppm and NAA+IBA (500+1000) ppm in Lady Mary Baring. Likewise, in Zakiriana, shoot emergence was maximum in IBA 2000 ppm (60.00%) and minimum in NAA 1000 ppm (6.67%). The interaction with respect to number of shoot was non significant among the varieties.

The present findings with respect to shoot emergence after sprouting of cuttings after quick dip (<5s) treatments with growth regulators are in confirmation with the earlier findings. Kumar *et al* (2008) observed significantly higher percentage of rooting of cuttings in *Clerodendron splendens* with NAA 1000 ppm (72.45%), however, the number of primary roots was more in NAA 2000 ppm (12.25). Kumari *et al* (2013) reported that IBA 2000 ppm gave maximum sprouting (81.10%) in *Jatropha curcas*. Montarone *et al* (1999) reported that shoot cuttings of *Protea* rooted the best (>40%) with IBA 2000 ppm as compared to 500 ppm (<15%).



Plate 1: Layout of experiments: treatment (<5 sec, 12h) of stem cuttings of *Bougainvillea* var. Shubra, Lady Mary Bearing and Zakiriana



Plate 2: Showing sprouting of cuttings of *Bougainvillea* var. Zakiriana of treated with growth regulators for <5 sec.

Fig. 1: Comparative effect of growth regulators treatments (<5sec) on shoot emergence in *Bougainvillea* var. Shubra at monthly intervals

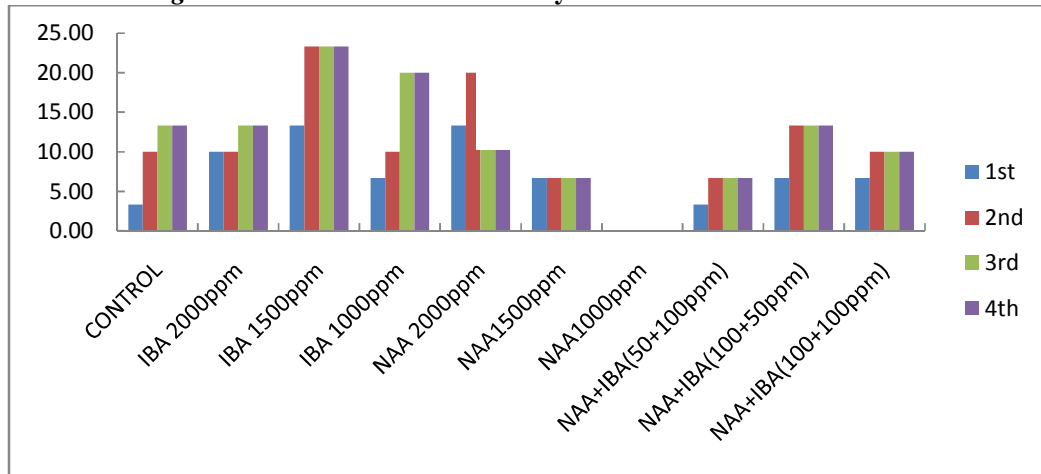


Fig.2: Comparative effect of growth regulators treatments (<5sec) on shoot emergence in *Bougainvillea* var. Lady Mary Baring at monthly intervals

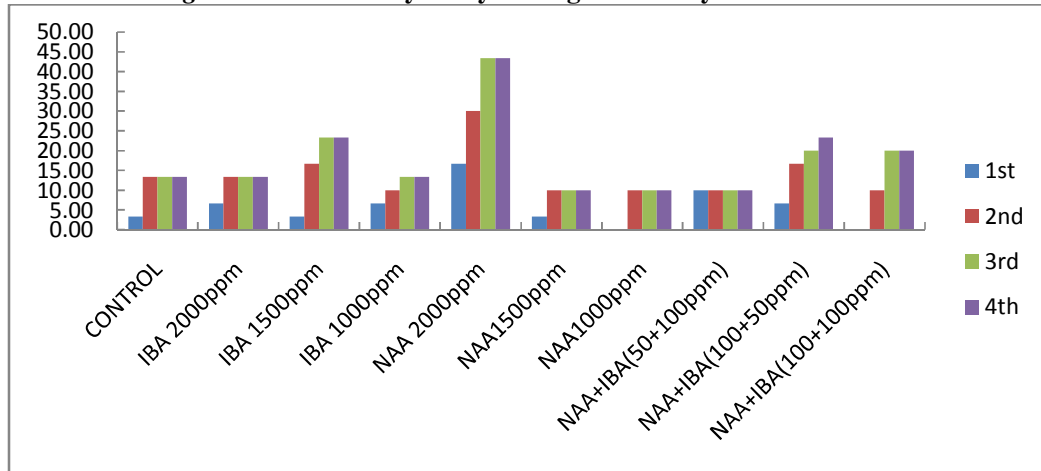


Fig. 3: Comparative effect of growth regulators treatments (<5sec) on shoot emergence in *Bougainvillea* var. Zakiriana at monthly intervals

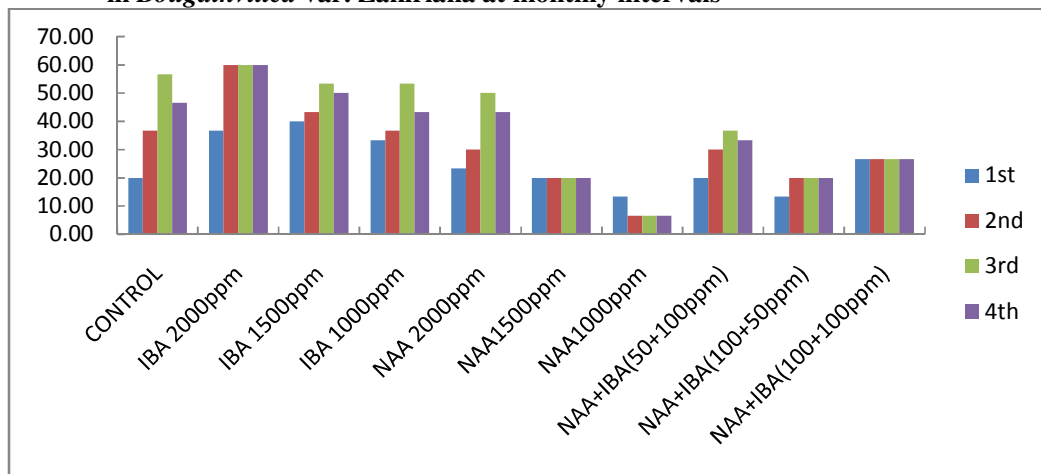


Table 1: Comparative effect of different growth regulator treatments (quick dip; <5s) on a percentage sprouting in Bougainvillea 4th month

Treatments (ppm)	Percent sprouting in different Bougainvillea varieties			
	Shubra	Lady Mary Baring	Zakiriana	Mean
NAA 1000	0.00	10.00	6.67	5.55
NAA 1500	6.67	10.00	20.00	12.22
NAA 2000	20.00	43.33	43.33	35.56
IBA 1000	20.00	13.33	43.33	25.56
IBA 1500	23.33	23.33	50.00	32.20
IBA 2000	13.33	13.33	60.00	28.89
NAA+IBA(500+100)	6.67	10.00	33.33	16.67
NAA+IBA(1000+500)	13.33	23.33	20.00	18.89
NAA+IBA (1000+1000)	10.00	20.00	26.67	18.89
Control	13.33	13.33	46.67	24.44
Mean	12.67	18.00	35.00	
C.D (5%)	Varieties (A)= 0.75; Growth regulators concentrations (B)= 1.38; Interaction (A×B)= NS			

4.1.2 Number of shoots

The treatment of cutting with growth regulators had non significant effect on number of shoots produced per cutting were recorded at monthly intervals (Fig. 4, 5, 6) (Table 2). The mean number of shoots per cutting was maximum in IBA 2000 ppm (1.64) and minimum in NAA 1500 ppm (0.69), irrespective of the varieties. The difference with respect to number of shoots was significant among the varieties and maximum in Zakiriana (1.30), followed by Lady Mary Baring (1.08) and Shubra (0.85), irrespective of growth regulator treatment. In Shubra, the maximum number of shoots was in IBA 2000 ppm (1.67) and treatment of cuttings with NAA 1000 ppm failed to exhibiting shoot formation. The maximum number of shoots was in IBA 2000 ppm (1.67) and minimum in NAA+IBA (50+100) ppm (0.67) in Lady Mary Baring. Likewise, in Shubra, the maximum number of shoots was in NAA 2000 ppm (1.68) and minimum in NAA 1500 ppm (0.92). The interaction with respect to number of shoot was non significant among the varieties.

The quick dip treatment increased number of shoots as observed earlier also. Memon *et al* (2013) observed in *Bougainvillea* that treatment of cuttings with NAA 6000 ppm results in maximum number of sprouts (3.13).

Fig. 4: Comparative effect of growth regulator treatments (<5sec) on number of shoots in *Bougainvillea* var. Shubra at monthly interval

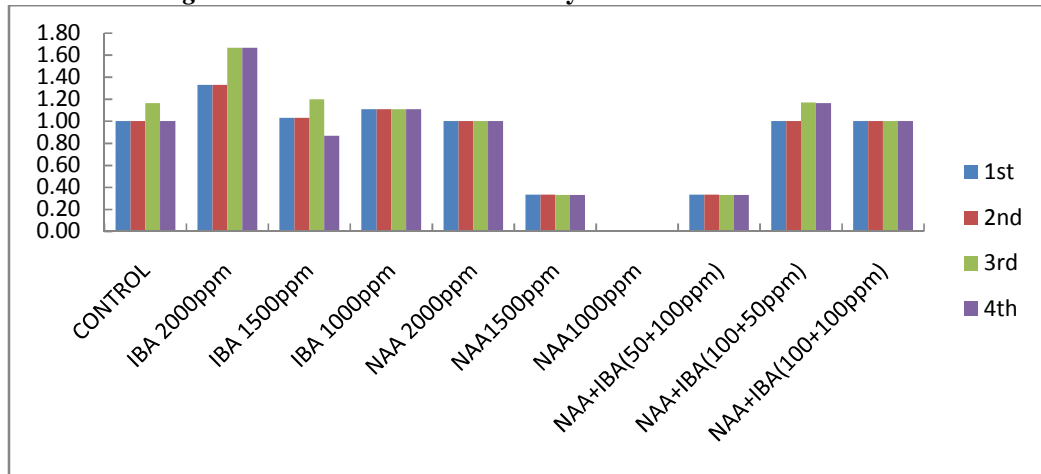


Fig. 5: Comparative effect of growth regulators treatments (<5sec) on number of shoots in *Bougainvillea* var. Lady Mary Baring at monthly intervals

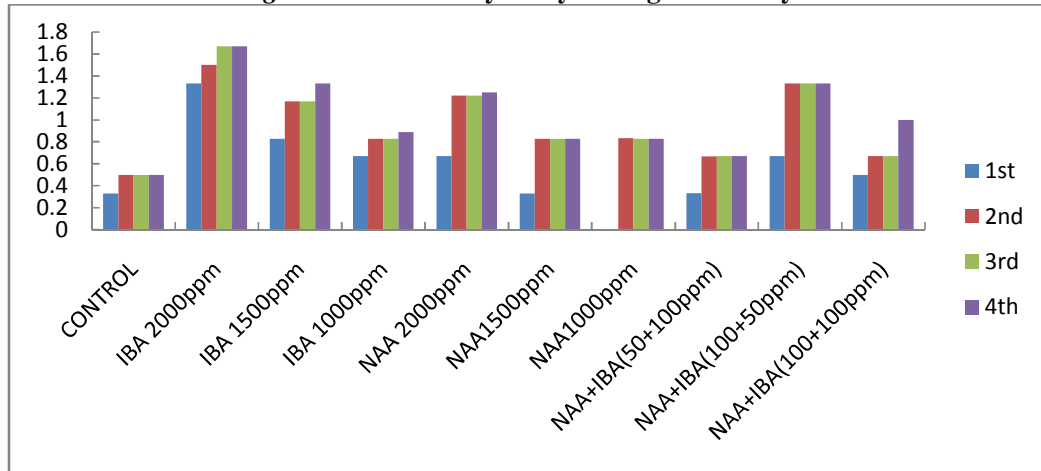


Fig. 6: Comparative effect of growth regulators treatments (<5sec) on number of shoots in *Bougainvillea* var. Zakiriana at monthly intervals

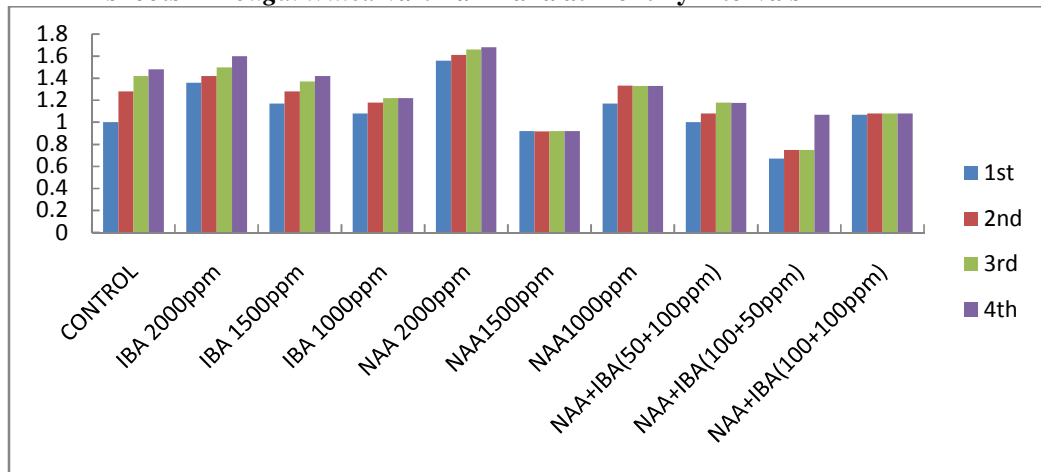


Table 2: Comparative effect of different growth regulator treatments (quick dip; <5s) on number of shoots in *Bougainvillea*

Treatments (ppm)	Shubra	Lady Mary Baring	Zakiriana	Mean
NAA 1000	0.00	0.83	1.33	0.72
NAA 1500	0.33	0.83	0.92	0.69
NAA 2000	1.00	1.25	1.68	1.31
IBA 1000	1.11	0.89	1.22	1.07
IBA 1500	0.86	1.33	1.42	1.21
IBA 2000	1.67	1.67	1.59	1.64
NAA+IBA(500+1000)	0.33	0.67	1.18	0.73
NAA+IBA(1000+500)	1.17	1.33	1.07	1.19
NAA+IBA(1000+1000)	1.00	1.00	1.08	1.03
Control	1.00	1.00	1.48	1.16
Mean	0.85	1.08	1.30	
C.D (5%)	Varieties (A)= 0.34; Growth regulators concentrations (B)= NS; Interaction (A×B)= NS			

4.1.3 Average shoot length

The treatment of cuttings with growth regulators had significant effect on average shoot length of cuttings as recorded at monthly intervals (Fig.7, 8, 9) (Table 3). The mean average shoot length was at par in IBA 2000 ppm (7.07 cm), NAA 2000 ppm (6.11 cm), IBA 1500 ppm (5.55 cm) and significantly better than all other treatments and minimum was observed in control (2.24 cm), irrespective of the varieties. The difference was significant among the varieties with maximum in Zakiriana (5.10 cm), followed by Lady Mary Baring (3.73 cm) and Shubra (3.24 cm), irrespective of growth regulator treatment. In Shubra, average shoot length was at par in NAA 2000 ppm (6.36 cm), IBA 2000ppm (5.82 cm), IBA 1500 ppm (4.64 cm), NAA+IBA (1000+500) ppm (3.97) significantly better than all other treatments and minimum was in NAA (50+100) ppm (1.53 cm). In Lady Mary Baring, average shoot length was at par in IBA 2000 ppm (6.35 cm), IBA 1500 ppm (5.75 cm), NAA 2000 ppm (4.95 cm), NAA+IBA (1000+500) ppm(4.55 cm), NAA+IBA (1000+1000) ppm (3.66 cm) and significantly better than all other treatments and was in control (0.85 cm).In Zakiriana, average shoot length was at par in IBA 2000 ppm (9.05 cm) and IBA 1500 ppm (6.58 cm) significantly better than all other treatments and minimum was in control (3.00 cm).

Fig. 7: Comparative effect of growth regulators treatments (<5sec) on average length of shoot in *Bougainvillea* var. Shubra at monthly intervals

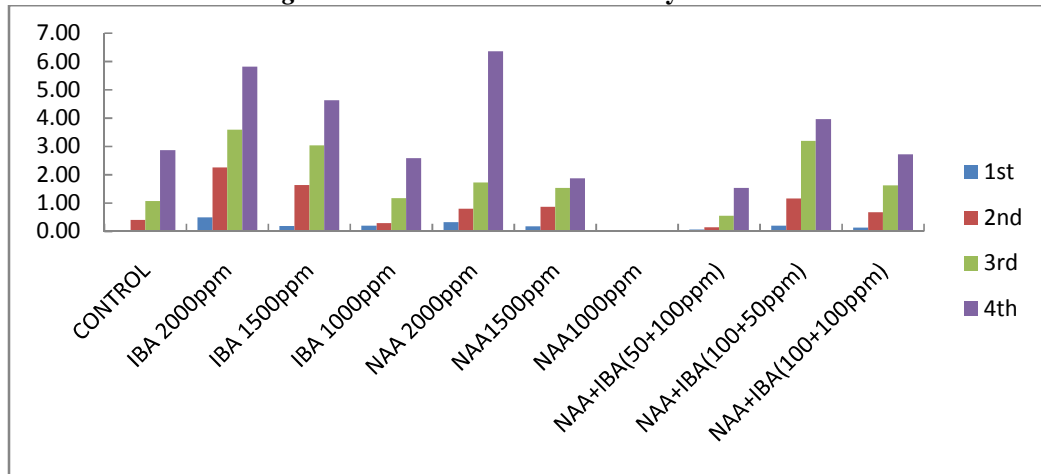


Fig. 8: Comparative effect of growth regulators treatments (<5sec) on average length of shoot in *Bougainvillea* var. Lady Mary Baring at monthly intervals

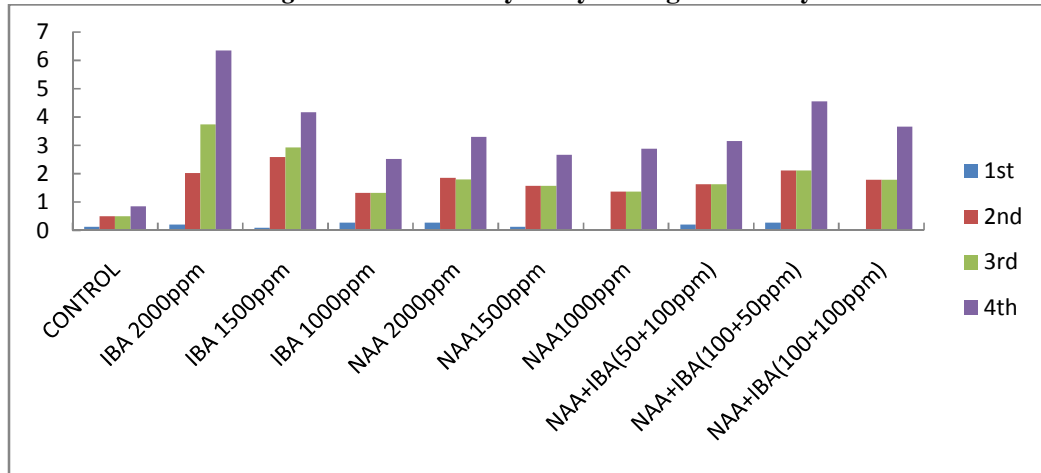


Fig. 9: Comparative effect of growth regulators treatments (<5sec) on average length of shoot in *Bougainvillea* var. Zakiriana at monthly intervals

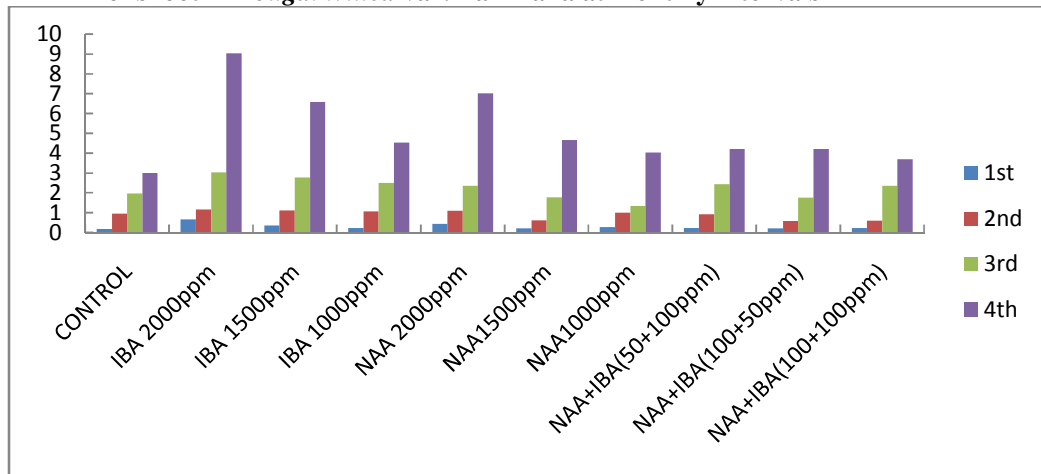


Table 3: Comparative effect of different growth regulator treatments (<5s) on average length of shoot (cm) in *Bougainvillea*

Treatments (ppm)	Shubra	Lady Mary Baring	Zakiriana	Mean
NAA 1000	0.00	2.88	4.03	2.31
NAA 1500	1.87	2.67	4.67	3.07
NAA 2000	6.36	4.95	7.03	6.11
IBA 1000	2.58	2.52	4.53	3.21
IBA 1500	4.64	5.75	6.58	5.66
IBA 2000	5.82	6.35	9.05	7.07
NAA+IBA(500+1000)	1.53	3.15	4.21	2.96
NAA+IBA(1000+500)	3.97	4.55	4.21	4.24
NAA+IBA(1000+1000)	2.72	3.66	3.69	3.36
Control	2.87	0.85	3.00	2.24
Mean	3.24	3.73	5.10	
C.D (5%)	Varieties (A)= 1.51 ; Growth regulators concentrations (B)= 2.76 ; Interaction (A×B)= NS			

The quick dip treatment increased average shoot length of the cuttings as reported earlier also. Singh *et al* (2011) observed in *Bougainvillea glabra* var. Torch Glory that IBA (3000 ppm) resulted in the maximum length of sprout/cutting (18.87 cm). Singh and Singh (2002) studied in *Bougainvillea peruviana* cv. Thimma that the hardwood cuttings and IBA (2000 ppm) significantly increased length of sprout.

4.1.4 Number of leaves

The treatment of cuttings with growth regulators had non significant effect on number of leaves per cutting as recorded at monthly intervals (Fig. 10, 11, 12) (Table 4). The mean number of leaves was maximum in IBA 2000 ppm (24.91) and minimum in control (10.10), irrespective of the varieties. The difference was significant among varieties with maximum in Zakiriana (25.02), followed by Lady Mary Baring (19.35) and Shubra (13.42), irrespective of growth regulator treatment. In Shubra, maximum number of leaves was in IBA 2000 ppm (20.67) and minimum was in control (9.00). Maximum number of leaves was in IBA 2000 ppm (25.00) and minimum was in control (6.17) in Lady Mary Baring. Likewise, in Zakiriana, maximum number of leaves was in IBA 2000 ppm (29.05) and minimum was in control (15.14).

Panwar *et al* (1999) studied in cuttings of *Bougainvillea* cv. Thimma that IBA (2000 ppm) was the best treatment to increase the sprouting of cuttings and number of leaves. Singh and Singh (2002) studied in *Bougainvillea peruviana* cv. Thimma that the hardwood cuttings

Fig. 10: Comparative effect of growth regulators treatments (<5sec) on number of leaves in *Bougainvillea* var. Shubra at monthly intervals

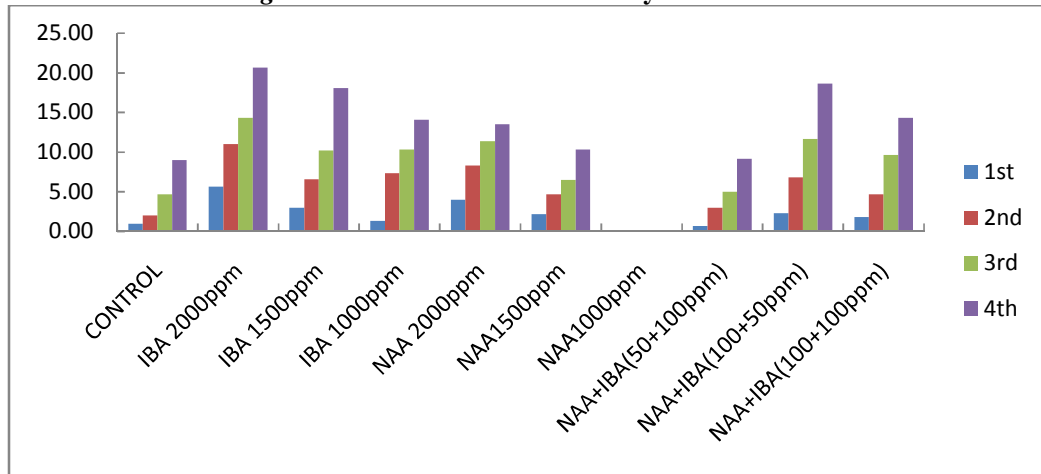


Fig. 11: Comparative effect of growth regulators treatments (<5sec) on number of leaves in *Bougainvillea* var. Lady Mary Baring at monthly intervals

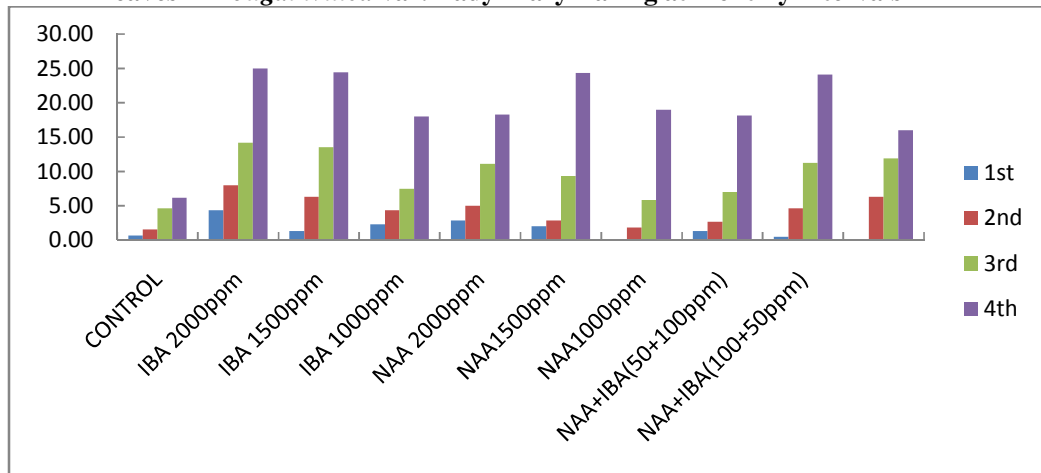


Fig. 12: Comparative effect of growth regulators treatments (<5sec) on number of leaves in *Bougainvillea* var. Zakiriana at monthly intervals

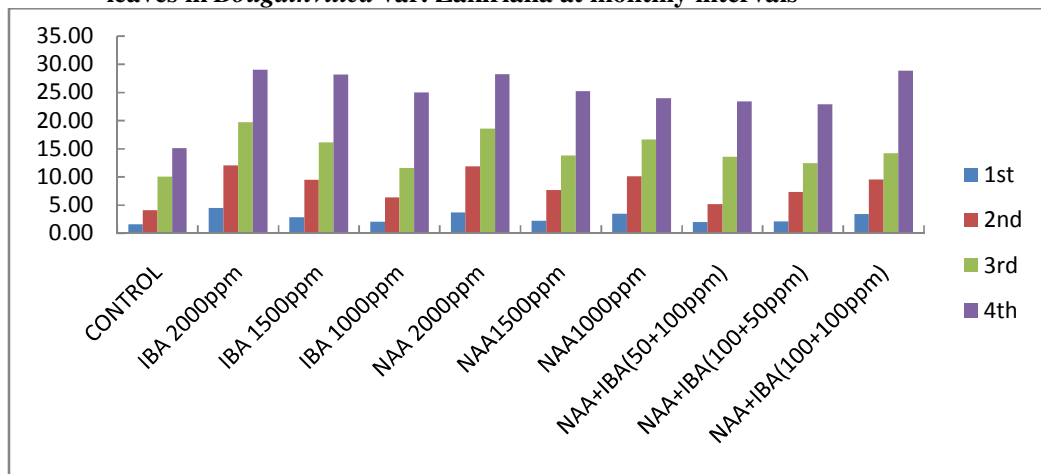


Table 4: Comparative effect of different growth regulator treatments (quick dip; <5s) on number of leaves in *Bougainvillea*

Treatments (ppm)	Shubra	Lady Mary Baring	Zakiriana	Mean
NAA 1000	0.00	19.00	24.00	14.33
NAA 1500	10.35	24.33	25.25	19.98
NAA 2000	13.53	18.27	28.28	20.03
IBA 1000	14.11	18.00	24.98	19.03
IBA 1500	18.07	24.44	28.18	23.56
IBA 2000	20.67	25.00	29.05	24.91
NAA+IBA(500+100)	9.17	18.17	23.44	16.93
NAA+IBA(100+50)	21.33	24.11	22.92	22.79
NAA+IBA(100+100)	14.33	16.00	28.92	19.75
Control	9.00	6.17	15.14	10.10
Mean	13.06	19.35	25.02	
C.D (5%)	Varieties (A)= 6.44 ; Growth regulators concentrations (B)= NS; Interaction (A×B)= NS			

and IBA (2000 ppm) significantly increased rooting and number of leaves/cuttings. El-Shazly and El-Sabrou (1994) reported in *Le conte* pear that maximum numbers of leaves/cutting (19.13) were observed in treatment with IBA (4000 ppm). Alshammary *et al* (2013) reported that in *Bougainvillea peruviana* cv. Shubra cuttings treated with IBA 2000 ppm resulted in greater number of leaves per cuttings (59.00).

4.1.5 Number of branches

The treatment of cuttings with growth regulators had significant effect on number of branches per cutting as recorded at monthly intervals (Fig 13, 14, 15) (Table 5). The mean number of branches was at par in IBA 2000 ppm (2.17), NAA 2000 ppm (1.55) and significantly better than all other growth regulator treatments and minimum was in control (0.62), irrespective of the varieties. The differences were non significant among varieties with maximum in Zakiriana (1.30), followed by Lady Mary Baring (1.23) and Shubra (1.03), irrespective of growth regulator treatment. In Shubra, number of branches was at par in IBA 2000 ppm (2.33) and NAA+ IBA (1000+1000) ppm (1.50) and significantly better than all other treatments, whereas, minimum number of branches was in NAA 1000 ppm (0.00). Likewise, in Lady Mary Baring, number of branches was at par in IBA 2000 ppm (2.00), IBA 1500 ppm (1.45), NAA 2000 ppm (1.45), NAA+IBA (500+1000) ppm (1.33), NAA+IBA (1000+1000) ppm (1.28), NAA 1500 ppm (1.17) significantly better than all other treatments, whereas, minimum number of branches was in control (0.42). In Zakiriana, number of branches was at par in IBA 2000 ppm (2.17), NAA 2000 ppm (2.00), IBA 1500

Fig.13: Comparative effect of growth regulators treatments (<5sec) on number of branches in *Bougainvillea* var. Shubra at monthly intervals

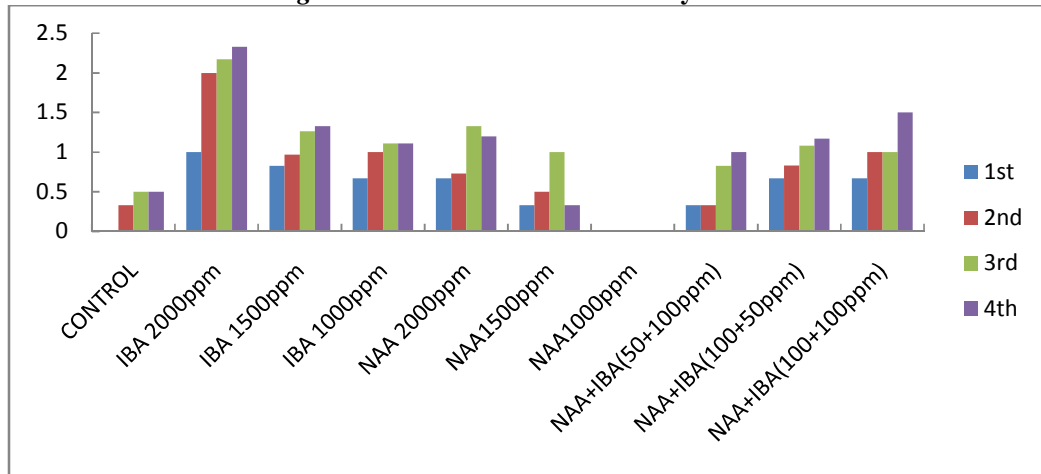


Fig.14: Comparative effect of growth regulators treatments (<5sec) on number of branches in *Bougainvillea* var. Lady Mary Baring at monthly intervals

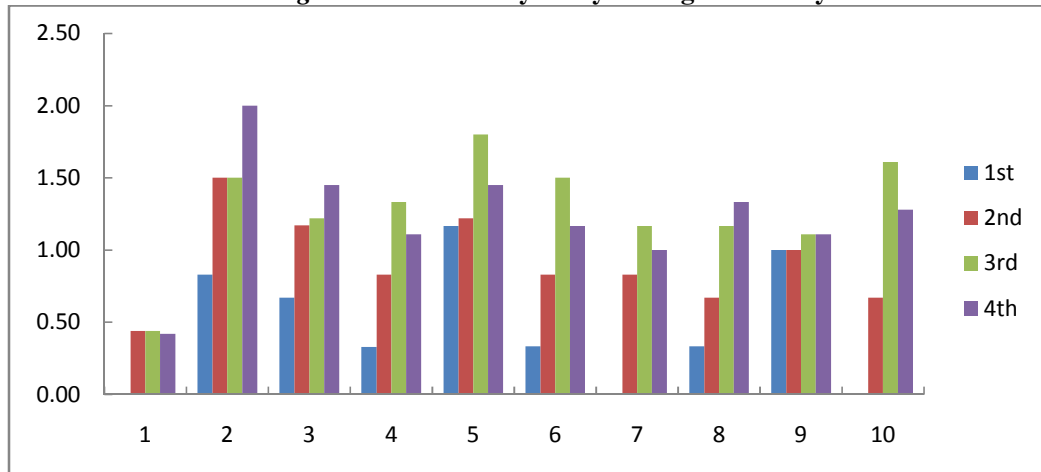


Fig.15: Comparative effect of growth regulators treatments (<5sec) on number of branches in *Bougainvillea* var. Zakiriana at monthly intervals

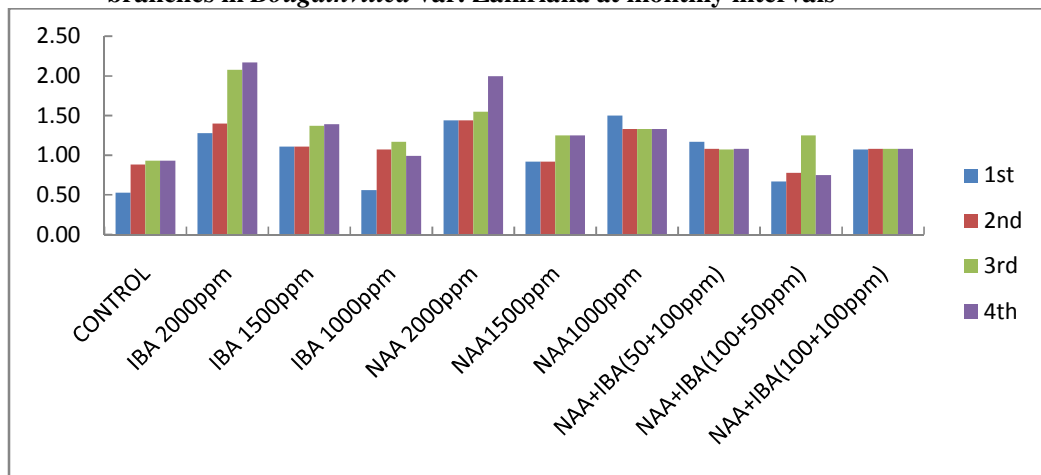


Table 5: Comparative effect of different growth regulator treatments (quick dip; <5s) on number of branches in *Bougainvillea*

Treatments (ppm)	Shubra	Lady Mary Baring	Zakiriana	Mean
NAA 1000	0.00	1.00	1.33	0.78
NAA 1500	0.33	1.17	1.25	0.92
NAA 2000	1.20	1.45	2.00	1.55
IBA 1000	1.11	1.11	0.99	1.07
IBA 1500	1.13	1.45	1.39	1.32
IBA 2000	2.33	2.00	2.17	2.17
NAA+IBA(500+1000)	1.00	1.33	1.08	1.14
NAA+IBA(1000+500)	1.17	1.11	0.75	1.01
NAA+IBA(1000+1000)	1.50	1.28	1.08	1.29
Control	0.50	0.42	0.93	0.62
Mean	1.03	1.23	1.30	
C.D (5%)	Varieties (A)= NS ; Growth regulators concentrations (B)= 0.84 ; Interaction (A×B)= NS			

ppm (1.39), NAA 1000 ppm (1.33) significantly better than all other treatments, whereas, was minimum in NAA+IBA (1000+500) ppm (0.75).

The quick dip treatment increased number of branches in the cuttings as reported earlier also. Alshammary *et al* (2013) reported in *Bougainvillea peruviana* cv. Shubra and *Hamelia patens* that IBA (2000 ppm) resulted in highest number of branches per cutting (3.6 and 5.4) respectively. Parvez *et al* (2007) studied in Peach cuttings that cuttings treated with 0, 500, 1000, 1500 and 2000 ppm IBA showed that maximum number of branches per plant (8.55) was observed in cuttings treated with 2000 ppm IBA. Rahdari (2014) studied in *Cordyline terminalis* that the highest the number of branches was in treatment of NAA (2000 mg/l) + IBA (1000 mg/l).

4.1.6 Number of cuttings exhibiting rooting

The treatment of cuttings with growth regulators had significant effect on number of cuttings exhibiting rooting (Table 6). The mean number of cuttings exhibiting rooting was at par in NAA 2000 ppm (3.56), IBA 1500 ppm (3.22), IBA 2000 ppm (2.89), IBA 1000 ppm (2.56), control (2.44) and significantly better than all other treatments, whereas, minimum in NAA 1000 ppm (0.56), irrespective of the varieties. The differences with respect to number of cuttings exhibiting rooting among varieties was also significant, the maximum was in Zakiriana (3.50), followed by Lady Mary Baring (1.80) and Shubra (1.27), irrespective of growth regulator treatment. In Shubra, number of cuttings exhibiting rooting was at par in

IBA

Table 6: Comparative effect of different growth regulator treatments (quick dip; <5s) on number of cuttings exhibiting rooting in *Bougainvillea* after 4 month

Treatments	Shubra	Lady Mary Baring	Zakiriana	Mean
NAA 1000	0.00	1.00	0.67	0.56
NAA 1500	0.67	1.00	2.00	1.22
NAA 2000	2.00	4.33	4.33	3.56
IBA 1000	2.00	1.33	4.33	2.56
IBA 1500	2.33	2.33	5.00	3.22
IBA 2000	1.33	1.33	6.00	2.89
NAA+IBA (500+1000)	0.67	1.00	3.33	1.66
NAA+IBA (1000+500)	1.33	2.33	2.00	1.89
NAA+IB (1000+1000)	1.00	2.00	2.67	1.89
Control	1.33	1.33	4.67	2.44
Mean	1.27	1.80	3.50	
C.D (5%)	Varieties (A)= 0.75; Growth regulators concentrations (B)= 1.38; Interaction (A×B)= NS			

1500 ppm (2.33), NAA 2000 ppm (2.00), IBA 1500 ppm (2.00), IBA 2000 ppm (1.33), NAA+IBA (1000+500) ppm (1.33), control (1.33), NAA+IBA (1000+1000) ppm (1.00) and significantly better than all other treatments and was minimum in NAA 1000 ppm (0.00). In Lady Mary Baring, maximum number of cuttings exhibiting rooting was in NAA 2000 ppm (4.33) and was minimum (1.00) was in NAA 1000 ppm, NAA 1500 ppm and NAA+IBA (500+1000) ppm. In Zakiriana, number of cuttings exhibiting rooting was at par in IBA 2000 ppm (6.00), IBA 1500 ppm (5.00), control (4.67) and significantly better than all other treatments and minimum in NAA 100 ppm (0.67).

The present investigation was in confirmation with earlier findings. Gupta (1995) studied the effect of intermittent mist and auxins on rooting in cuttings of *Buddlea asiatica* and concluded that IBA at 4000 ppm proved significantly effective in rooting, and survival of rooted cuttings of *Buddlea asiatica*. Mishra and Sharma (1995) studied the effect of plant growth regulators on rooting of stem cuttings of *Bougainvillea* and concluded that higher concentration of IBA (2000 ppm) significantly increased the rooting performance in *Bougainvillea* cvs. Dr. R. R. Pal and Mrs. H. C. Buck, which were difficult to root and cv. Dr. R. R. Pal performed better than Mrs. H. C. Buck. Sahariya *et al* (2013) studied the effect of IBA (0, 1000, 1500, 2000 ppm), on rooting of *Bougainvillea* var. Thimma and the treatment with IBA 2000 ppm resulted in the maximum number of rooted cuttings (6.33)

4.1.7 Per cent of cutting exhibiting rooting

The treatment of cuttings with growth regulator had significant effect on percentage of cuttings exhibiting rooting (Table 7). The mean per cent of cutting exhibiting rooting was significantly better in NAA 2000 ppm (35.60) than all other growth regulator treatments and minimum was in NAA 1000 ppm (5.60), irrespective of the varieties. The difference with respect to varieties was significant and was maximum in Zakiriana (3.50), followed by Lady Mary Baring (1.80) and Shubra (1.27), irrespective of growth regulator treatment. In Shubra, maximum per cent of cutting exhibiting rooting was in IBA 1500 ppm (23.33) and minimum was in NAA 1000 ppm (0.00). The maximum per cent of cutting exhibiting rooting was in NAA 2000 ppm (43.33) and minimum (10.00) was observed in NAA 1000 ppm, NAA 1500 ppm and NAA+IBA (500+1000) ppm in Lady Mary Baring. Likewise, in Zakiriana, the maximum per cent of cutting exhibiting rooting was in IBA 2000 ppm (60.00) and minimum was in NAA 1000 ppm (6.67).

Panwar *et al* (1999) studied the effect of growth regulator on cuttings of *Bougainvillea* cv. Thimma. It was observed that IBA (2000 ppm) was best treatment to increase per cent of rooting. Adiga *et al* (2004) reported that NAA (1000ppm) recorded the highest (85.42%) mean percent rooting in *Vernonia*. Hashemabadi and Sedaghatoor (2007) reported in *Camellia japonica* that the cuttings treated with IBA (4000 mg/l) recorded the highest rooting percentage. Sahariya *et al* (2013) studied the effect on rooting of *Bougainvillea* var. Thimma cuttings and the treatment with IBA 2000 ppm resulted in the maximum percentage of rooting (63.33%).

Table 7: Comparative effect of different growth regulator treatments (quick dip; <5s) on Per cent of cutting exhibiting rooting in *Bougainvillea* after 4 month

Treatments (ppm)	Shubra	Lady Mary Baring	Zakiriana	Mean
NAA 1000	0.00	10.00	6.67	5.60
NAA 1500	6.67	10.00	20.00	12.22
NAA 2000	20.00	43.33	43.33	35.60
IBA 1000	20.00	13.33	43.33	25.60
IBA 1500	23.33	23.33	50.00	32.20
IBA 2000	13.33	13.33	60.00	28.90
NAA+IBA(500+1000)	6.67	10.00	33.33	16.60
NAA+IBA(1000+500)	13.33	23.33	20.00	18.90
NAA+IBA(1000+1000)	10.00	20.00	26.70	18.90
Control	13.33	13.33	46.70	24.44
Mean	1.27	1.80	3.50	
C.D (5%)	Varieties (A)= 0.75 ; Growth regulators concentrations (B)= 1.38 ; Interaction (A×B)= NS			

4.1.8 Number of roots

The treatment of cutting with growth regulator had non significant effect on number of roots after growth regulator treatment (Table 8). The mean number of roots was the maximum in IBA 2000 ppm (1.64) and minimum in NAA 1500 ppm (0.69), irrespective of the varieties. The difference was non significant among the varieties, maximum was in Zakiriana (1.30), followed by Lady Mary Baring (1.08) and Shubra (0.85). In Shubra, maximum number of roots was in IBA 2000 ppm (1.67) and minimum was in NAA 1000 ppm (0.00). The maximum number of roots was in IBA 2000 ppm (1.67) and minimum in NAA+IBA (50+100) ppm (0.67) in Lady Mary Baring. In Zakiriana, maximum number of roots was in NAA 2000 ppm (1.68) and minimum in NAA 1500 ppm (0.92).

Alshammary *et al* (2013) reported in *Bougainvillea peruviana* cv. Shubra and *Hamelia patens* that IBA (2000 ppm) resulted number of roots per cutting (15.5 and 24.8) respectively. Memon *et al* (2013) observed in *Bougainvillea* that the treatment of cuttings with NAA (6000 ppm) resulted in the maximum roots per cutting (27.833cm). Seyedi *et al* (2013) investigated different levels of IBA on the rooting of *Bougainvillea glabra* and the cuttings treated with IBA (4000 mg/l) showed the number and length of the root.

Table 8: Comparative effect of different growth regulator treatments (quick dip; <5s) on number of roots in *Bougainvillea* after 4th month

Treatments (ppm)	Shubra	Lady Mary Baring	Zakiriana	Mean
NAA 1000	0.00	2.50	2.33	1.61
NAA 1500	1.33	2.67	2.00	2.00
NAA 2000	2.07	2.68	3.00	2.58
IBA 1000	2.17	2.00	2.68	2.81
IBA 1500	2.60	2.89	2.67	2.17
IBA 2000	5.00	3.00	3.26	3.75
NAA+IBA(500+1000)	1.33	2.00	2.72	2.02
NAA+IBA(1000+500)	3.00	2.67	2.25	2.64
NAA+IBA(1000+1000)	2.00	2.50	2.83	2.44
Control	1.00	0.78	1.16	0.98
Mean	2.05	2.37	2.49	
C.D (5%)	Varieties (A)= NS ; Growth regulators concentrations (B)= NS; Interaction (A×B)= NS			

4.1.9 Average length (cm) of roots

The treatment of cutting with growth regulator had non significant effect on average length(cm) of roots (Table 9).The mean length of roots (cm) was maximum in NAA+IBA (1000+500) ppm (10.50 cm) and was minimum in NAA 1000 ppm (5.20 cm), irrespective of

Table 9: Comparative effect of different growth regulator treatments (quick dip; <5s) on average length of roots (cm) in *Bougainvillea* after 4 month

Treatments	Shubra	Lady Mary Baring	Zakiriana	Mean
NAA 1000	0.00	6.45	9.13	5.20
NAA 1500	4.00	5.68	6.43	5.44
NAA 2000	12.09	9.97	9.31	10.46
IBA 1000	5.84	6.33	9.88	7.53
IBA 1500	8.31	12.19	10.07	10.19
IBA 2000	7.18	12.68	11.15	8.15
NAA+IBA(500+1000)	3.47	7.22	10.11	6.93
NAA+IBA(1000+500)	12.56	10.36	8.57	10.50
NAA+IBA(1000+1000)	5.70	8.49	8.96	7.71
Control	5.52	2.07	6.56	6.47
Mean	6.47	8.14	9.04	
C.D (5%)	Varieties (A)= NS ; Growth regulators concentrations (B)= NS; Interaction (A×B)=NS			

the varieties. The difference among varieties was non significant, maximum was in Zakiriana (9.04), followed by Lady Mary Baring (8.14) and Shubra (6.47 cm), irrespective of growth regulator treatment. In Shubra, maximum average root length (cm) was in NAA+IBA (1000+500) ppm (12.56 cm) and minimum in NAA 1000 ppm (0.00). The maximum average root length (cm) was in IBA 2000 ppm (12.68 cm) and minimum was in control (2.07 cm) in Lady Mary Baring. Likewise, in Zakiriana, maximum average root length was in IBA 2000 ppm (11.15) and minimum was in NAA 1000 ppm (5.20 cm).

Singh *et al* (2014) studied effect of IBA and NAA on rooting of Stem cuttings of *Morus alba*. They were treated with 1000, 1500 and 2000 ppm IBA and NAA solutions by quick dip method. Among all the treatments, length of roots/cuttings was higher in IBA 2000 ppm. Alshammary *et al* (2013) reported in *Bougainvillea peruviana* cv. Shubra and *Hamelia patens* that IBA (2000 ppm) resulted in root length per cutting (31.6 mm and 27.2 mm). Susila and Reddy (2013) reported in *Adathoda vasica* that IBA (1500 ppm) resulted in the longest root length (22.18 cm).

4.1.10 Per cent Establishment

The treatment of cutting with growth regulator treatment had significant effect on per cent establishment after growth regulator treatments (Table 10). The mean per cent establishment was at par in NAA 2000 ppm (32.22%), IBA 1500 ppm (31.11%) and significantly better than all other growth regulator treatments and minimum in NAA 1000 ppm

Table 10: Comparative effect of different growth regulator treatments (quick dip; <5s) on Percent establishment in *Bougainvillea*

Treatments (ppm)	Shubra	Lady Mary Baring	Zakiriana	Mean
NAA 1000	0.00	6.67	6.67	4.44
NAA 1500	6.67	10.00	20.00	12.22
NAA 2000	16.67	43.33	36.67	32.22
IBA 1000	20.00	13.33	43.33	25.56
IBA 1500	20.00	23.33	50.00	31.11
IBA 2000	13.33	13.33	60.00	28.89
NAA+IBA(500+1000)	6.67	10.00	26.67	14.44
NAA+IBA(1000+500)	10.00	16.67	20.00	15.55
NAA+IBA(1000+1000)	10.00	16.67	26.67	17.78
Control	6.67	13.33	33.33	17.78
Mean	11.00	16.67	32.33	
C.D (5%)	Varieties (A)= 0.69 ; Growth regulators concentrations (B)= 1.26 ; Interaction (A×B)= NS			

(4.44%), irrespective of the varieties. The difference among varieties was significant, however, the maximum per cent establishment was in Zakiriana (60.00%), followed by Lady Mary Baring (16.67%) and then Shubra (11.00%). In Shubra, maximum per cent establishment (20.00%) was in IBA 1000 ppm and in IBA 1500 ppm and minimum was in NAA 1000 ppm (0.00%). The maximum per cent establishment was in NAA 2000 ppm (43.33%) and minimum in (6.67%) in Lady Mary Baring. Likewise, in Zakiriana, the maximum per cent establishment was in IBA 2000 ppm (60.00%) and minimum was in NAA 1000 ppm (6.67%) (Plate 3).

Alshammary *et al* (2013) reported in *Bougainvillea peruviana* cv. Shubra and *Hamelia patens* that IBA (2000ppm) resulted in maximum establishment percentage (60.3% and 42.3%) respectively. Shabha and Alshammary (2013) reported in *Bougainvillea* cv. Shubra that treatment of cuttings with IBA (500 ppm) resulted in the highest establishment percentage (68.3 and 53.3% after 12 and 24 hours, respectively).

4.2 Growth regulator treatment of hardwood cuttings of *Bougainvillea* by using long duration (12h) method

4.2.1 Shoot emergence of cuttings

The hardwood cuttings of all three varieties viz. Shubra, Lady Mary Baring and Zakiriana planted after growth regulator treatments (long duration; 12h) exhibiting sprouting

Fig. 16: Comparative effect of growth regulators treatments (12h) on shoot emergence in *Bougainvillea* var. Shubra at monthly intervals

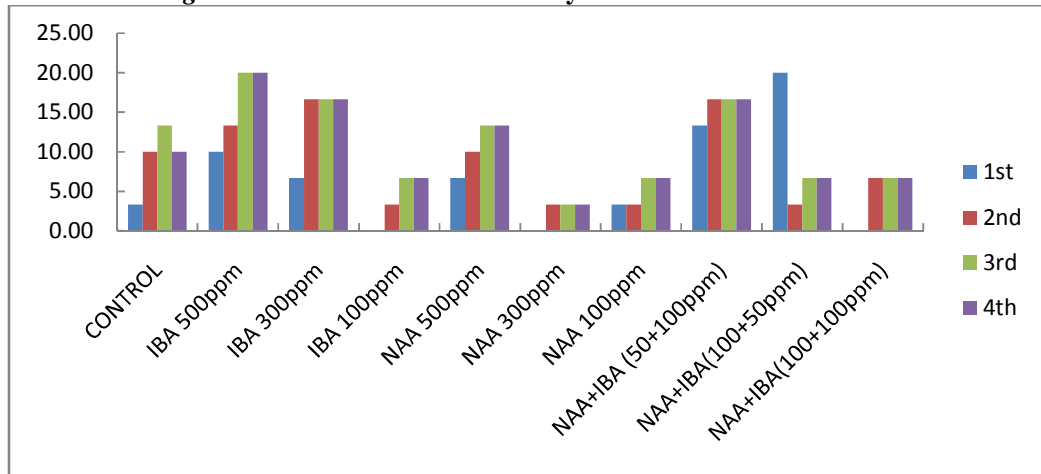


Fig. 17: Comparative effect of growth regulators treatments (12h) on shoot emergence in *Bougainvillea* var. Lady Mary Baring at monthly intervals

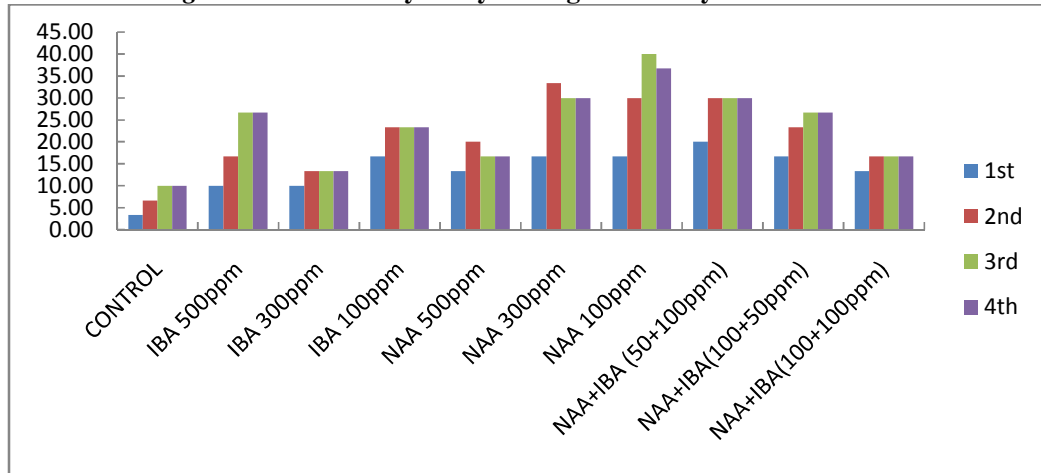


Fig. 18: Comparative effect of growth regulators treatments (12h) on shoot emergence in *Bougainvillea* var. Zakiriana at monthly intervals

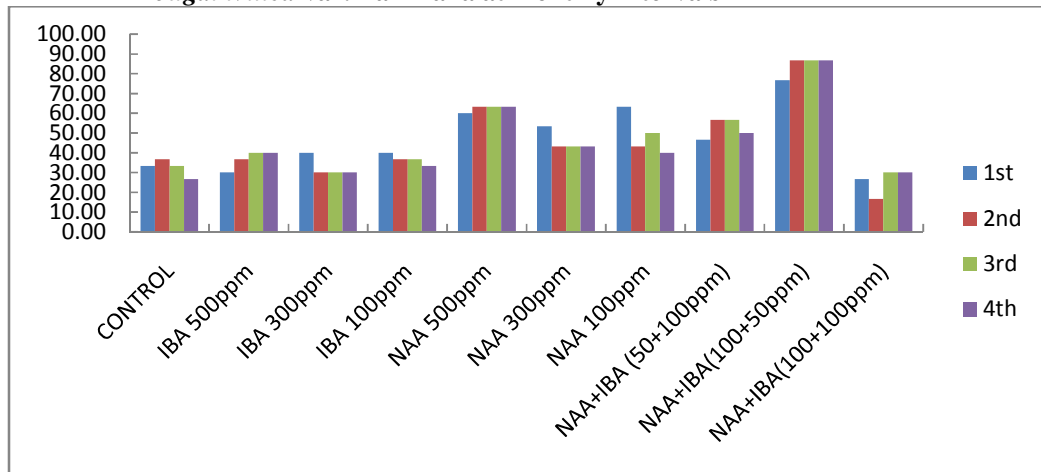




Plate 3: Showing establishment of plants *Bougainvillea* var. *Zakiriana*



(a)



(b)



(c)

Plate 4: Showing Shoot emergence of *Bougainvillea* var. (a) Lady Mary Bearing, (b) Zakiriana and (c) Shubra after 1 month

Table 11: Comparative effect of different growth regulator treatments (long duration; 12h) on a percentage sprouting in Bougainvillea 4th month

Treatments (ppm)	Percent sprouting in different Bougainvillea varieties			
	Shubra	Lady Mary Baring	Zakiriana	Mean
NAA 100	6.67	36.67	40.00	27.78
NAA 300	3.33	30.00	43.33	25.56
NAA 500	13.33	16.67	63.33	31.11
IBA 100	6.67	23.33	33.33	21.11
IBA 300	16.67	13.33	30.00	20.00
IBA 500	20.00	26.67	40.00	28.89
NAA+IBA(50+100)	16.67	30.00	50.00	32.22
NAA+IBA(100+50)	6.67	26.67	86.67	40.00
NAA+IBA(100+100)	6.67	16.67	30.00	17.77
Control	10.00	10.00	26.67	15.56
Mean	10.67	23.00	44.33	
C.D (5%)	Varieties (A)= 0.54 ; Growth regulators concentrations (B)= 0.98 ; Interaction (A×B)= 1.70			

and observations were recorded at monthly intervals (Fig. 16, 17, 18) (Table 11). It was observed that the treatment of cuttings with growth regulators had significant effect on shoot emergence. The mean shoot emergence was maximum in NAA+IBA (1000+1000) ppm (40.00%) and minimum in NAA 1000 ppm (15.56%), irrespective of the varieties. The difference had significant effect among varieties, was maximum in Zakiriana (44.33%) and followed by Lady Mary Baring (23.00%) and Shubra (10.67%), irrespective of growth regulator treatment. In Shubra, maximum shoot emergence (%) was in NAA 300 ppm (20.00%) and minimum was in IBA 500 ppm (3.33%). The maximum shoot emergence was in NAA+IBA (50+100) ppm (36.67%) and minimum was in NAA 100 ppm (10.00%) in Lady Mary Baring. Likewise, in Zakiriana, the maximum shoot emergence was in NAA+IBA (100+100) ppm (86.67%) and minimum was in NAA 100 ppm (26.67%) (Plate 4).

Renuka and Sekhar (2014) studied the effect of IBA and NAA at different concentrations on the rooting of carnation (*Dianthus caryophyllus* L.) cuttings of cv. Dona. The treatment with IBA 200 ppm and the treatment IBA 100 ppm + NAA 50 ppm recorded best results. Kumari *et al* (2013) reported in *Jatropha curcas* that IBA (200 ppm) resulted in early emergence of shoots (25.92 days) and sprouting (81.10%) and rooting (49.83%). Thorat *et al* (2006) observed in Nerium that the cuttings treated with IBA (100 ppm) for 24 h resulted in the highest sprouting, rooting and survival percentage of plants.

4.2.2 Number of shoots

The treatment of cutting with growth regulator had non significant effect on number of shoots per cutting as recorded at monthly intervals (Fig. 19, 20, 21) (Table 12). The mean number of shoots was maximum in IBA 500 ppm (1.86) and minimum in control (0.98), irrespective of the varieties. The difference among varieties was significant, however, the maximum was in Zakiriana (1.69), followed by Lady Mary Baring (1.66) and Shubra (1.00). In Shubra, the maximum number of shoots (1.67) was in IBA 500 ppm and NAA+IBA (50+100) ppm and minimum was in NAA 300 ppm (0.33). The maximum number of shoots was in NAA 500 ppm (2.50) and minimum in control (0.56) in Lady Mary Baring. Likewise, in Zakiriana, the maximum number of shoots was in IBA 500 ppm (1.92) and minimum (1.28) in NAA+IBA (100+100) ppm (Plate 5).

Table 12: Comparative effect of different growth regulator treatments (12h) on number of shoots in *Bougainvillea*

Treatments (ppm)	Shubra	Lady Mary Baring	Zakiriana	Mean
NAA 100	0.67	1.52	1.85	1.35
NAA 300	0.33	2.06	1.87	1.42
NAA 500	1.00	2.50	1.75	1.75
IBA 100	0.67	1.44	1.91	1.34
IBA 300	1.17	1.89	1.75	1.60
IBA 500	1.67	2.00	1.92	1.86
NAA+IBA(50+100)	1.67	1.28	1.40	1.45
NAA+IBA(100+50)	0.67	1.87	1.58	1.37
NAA+IBA(100+100)	1.33	1.50	1.28	1.37
Control	0.78	0.56	1.61	0.98
Mean	1.00	1.66	1.69	
C.D (5%)	Varieties (A)= 0.34 ; Growth regulators concentrations (B)= NS; Interaction (A×B)= NS			

The present findings are in confirmation with the earlier finding. Singh (2000) reported in *Bougainvillea peruviana* cv. Shubra, the treatment of cuttings with IBA (500 ppm) resulting in number of shoots per cutting (1.37).

4.2.3 Average shoot length

The treatment of cutting with growth regulators had significant effect on average shoot length as recorded at monthly intervals (Fig. 22, 23, 24) (Table 13). The mean shoot length was at par in IBA 500 ppm (7.11 cm), IBA 300 ppm (6.85 cm), NAA+IBA (50+100) ppm (6.43 cm), NAA+IBA (100+50) ppm (5.68 cm), IBA 100 ppm (5.53 cm), NAA 500 ppm

Fig. 19: Comparative effect of growth regulators treatments (12h) on number of shoots in *Bougainvillea* var. Shubra at monthly intervals

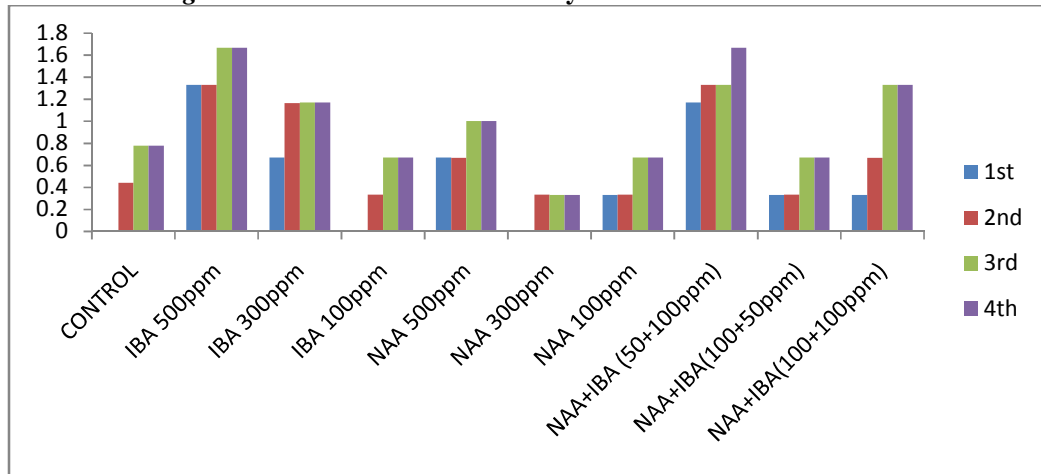


Fig. 20: Comparative effect of growth regulators treatments (12h) on number of shoots in *Bougainvillea* var. Lady Mary Baring at monthly intervals

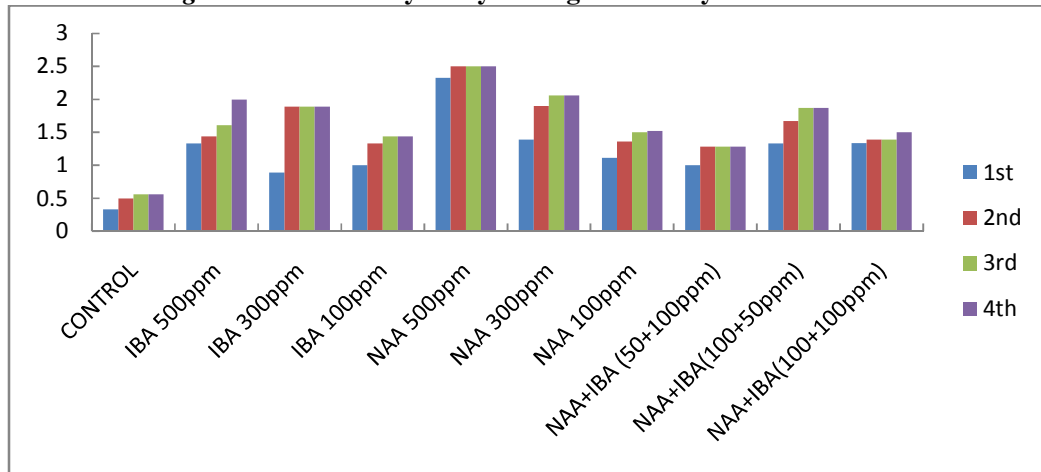


Fig. 21: Comparative effect of growth regulators treatments (12h) on number of shoots in *Bougainvillea* var. Zakiriana at monthly intervals

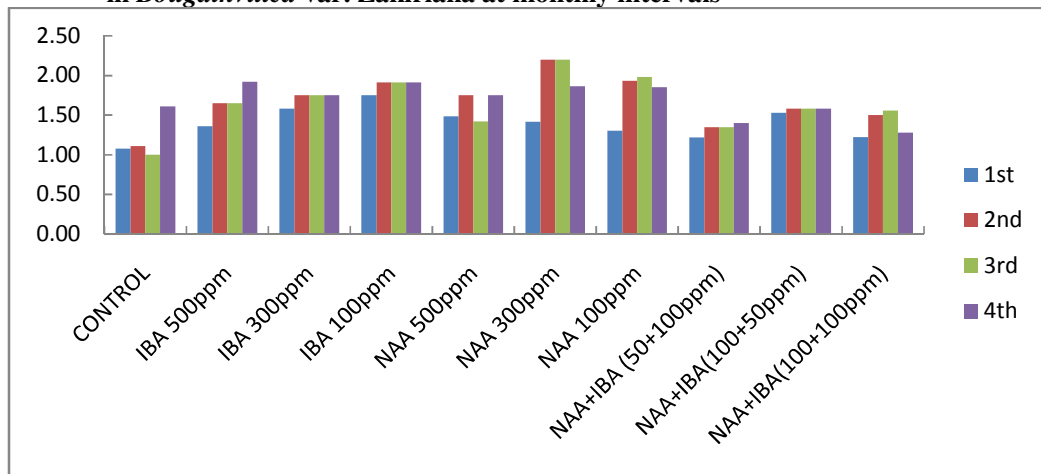


Fig.22: Comparative effect of growth regulators treatments (12h) on average length of shoot in *Bougainvillea* var. Shubra at monthly intervals

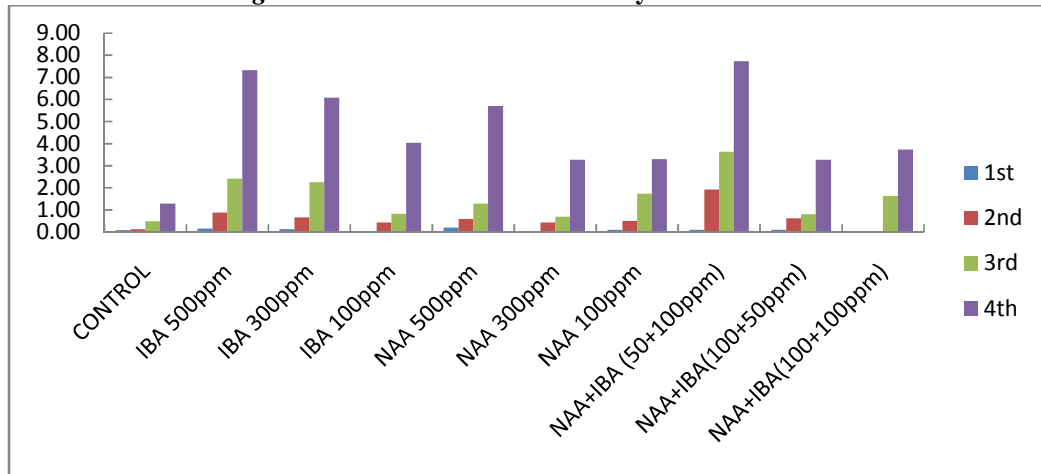


Fig.23: Comparative effect of growth regulators treatments (12h) on average length of shoot in *Bougainvillea* var. Lady Mary Baring at monthly intervals

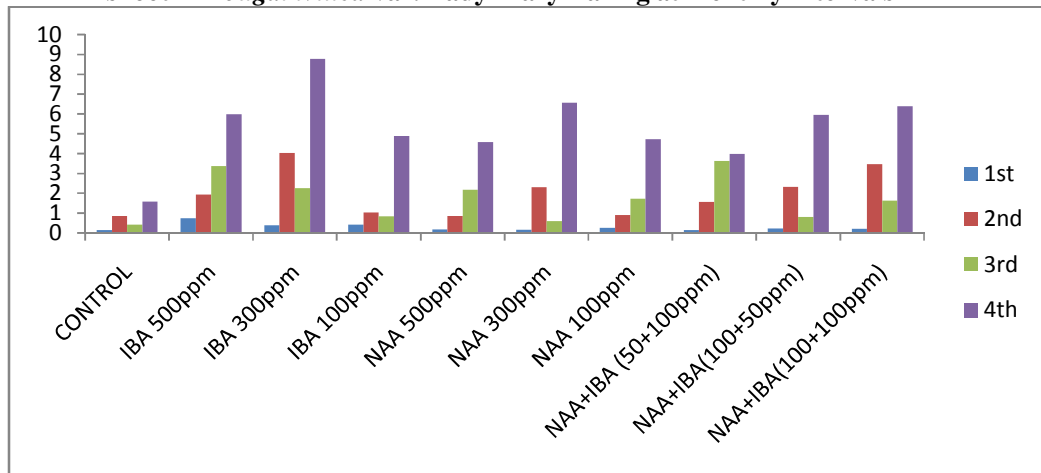
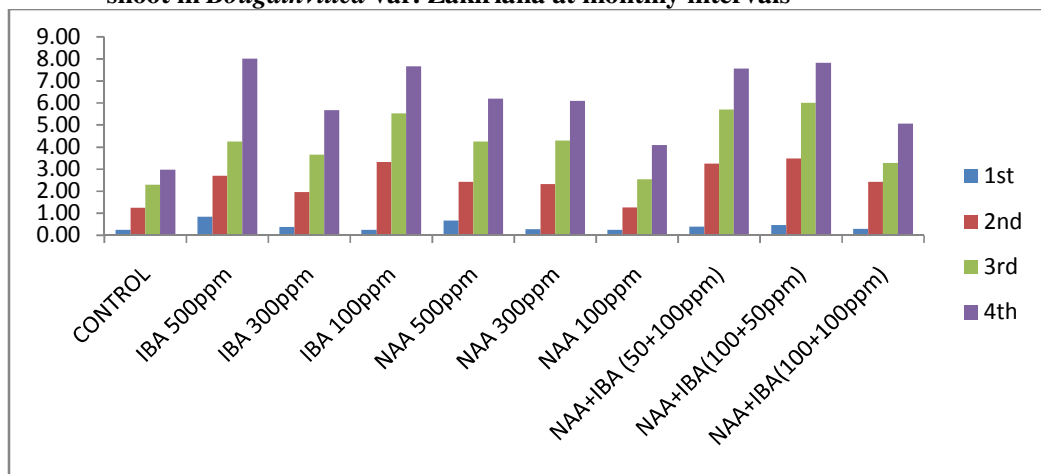


Fig. 24: Comparative effect of growth regulators treatments (12h) on average length of shoot in *Bougainvillea* var. Zakiriana at monthly intervals





(a)



(b)



(c)

Plate 5: Showing Shoot development of established plant of *Bougainvillea* var. (a) Lady Mary Bearing, (b) Zakiriana and (c) Shubra after 4 months

Table 13: Comparative effect of different growth regulator treatments (12h) on average length of shoots (cm) in *Bougainvillea*

Treatments (ppm)	Shubra	Lady Mary Baring	Zakiriana	Mean
NAA 100	3.30	4.73	4.09	4.04
NAA 300	3.27	6.56	6.10	5.31
NAA 500	5.70	4.58	6.20	5.49
IBA 100	4.03	4.89	7.67	5.53
IBA 300	6.08	8.79	5.68	6.85
IBA 500	7.32	5.99	8.01	7.11
NAA+IBA(50+100)	7.73	3.98	7.57	6.43
NAA+IBA(100+50)	3.27	5.95	7.82	5.68
NAA+IBA(100+100)	3.73	6.38	5.06	5.06
Control	1.30	1.58	2.97	1.95
Mean	4.57	5.34	6.12	
C.D (5%)	Varieties (A)= NS ; Growth regulators concentrations (B)= 2.90; Interaction (A×B)= NS			

(5.49 cm), NAA 100 ppm (5.31 cm), NAA+IBA (100+100) ppm (5.06 cm) and significantly better than all other treatments, however, minimum was in control (1.95 cm), irrespective of the varieties. The difference among varieties was non significant and maximum shoot length was obtained in Zakiriana (6.12 cm), followed by Lady Mary Baring (8.14 cm) and Shubra (6.47 cm), irrespective of growth regulator treatment. In Shubra, the average shoot length was at par in NAA+IBA (50+100) ppm (7.73 cm), IBA 500 ppm (7.32 cm), IBA 300 ppm (6.08 cm), NAA 500 ppm (5.70 cm) and significantly better than all other treatments and minimum was in NAA 100 ppm (1.30 cm). In Lady Mary Baring, average shoot length was at par in IBA 300 ppm (8.79 cm), NAA 300 ppm (6.56 cm), NAA+IBA (100+100) ppm (6.38 cm), IBA 500 ppm (5.99 cm), NAA+IBA (100+50) ppm (5.95 cm) and significantly better than all other treatments, however, minimum was in control (1.58 cm). Likewise, in Zakiriana, was at par in IBA 500 ppm (8.01 cm), NAA+IBA (100+50) ppm (7.82 cm), IBA 100 ppm (7.67 cm), NAA+IBA (50+100) ppm (7.57 cm), NAA 500 ppm (6.20 cm), NAA 300 ppm (6.10 cm), IBA 300 ppm (5.68 cm) significantly better than all other treatments, however, minimum was in control (2.97 cm).

The treatment of growth regulator improved average length of shoot as observed earlier also. Akhtar *et al* (2015) in *Rosa centifolia* is propagated through cuttings, IBA (450 ppm) concentration produced maximum shoot length (10.67 cm). Kumari *et al* (2013) reported in *Jatropha curcas* that IBA (200ppm) resulted in the maximum shoot length (10.57

cm). Singh (2000) reported in *Bougainvillea peruviana* cv. Shubra that the treatment of cuttings with IBA (500 ppm) resulted in significantly more sprouting (71.67%) and average shoot length (128.86 cm).

4.2.4 Number of leaves

The treatment of cuttings with growth regulators had significant effect on number of leaves as recorded at monthly intervals (Fig. 25, 26, 27) (Table 14). The mean number of leaves were at par in treatment with NAA+IBA (28.81), IBA 300 ppm (27.30), IBA 500 ppm (25.32), NAA 500 ppm (25.13), IBA 100 ppm (24.93), NAA 300 ppm (24.16), NAA+IBA (100+100) ppm (22.80), NAA+IBA (100+50) ppm (22.65), NAA 100 ppm (21.71) significantly better than the control (10.96), irrespective of the varieties. The difference had significant effect among the varieties, however, maximum was in Zakiriana (30.80), followed by Lady Mary Baring (25.70) and Shubra (13.68), irrespective of growth regulator treatment. In Shubra, the number of leaves was at par in NAA+IBA (50+100) ppm (25.67), IBA 500 ppm (19.83), IBA 300 ppm (18.50) significantly better than all other treatments and minimum in NAA 300 ppm (4.67). In Lady Mary Baring, number of leaves was at par in NAA 300 ppm (31.86), IBA 100 ppm (29.28), IBA 500 ppm (28.45), NAA+IBA (50+100) ppm (28.00), NAA 500 ppm (27.33), IBA 300 ppm (26.89), NAA 100 ppm (26.12), NAA+IBA (100+50) ppm (26.03), NAA+IBA (100+100) ppm (24.61) and significantly better than in all the treatments, however, minimum was in control (8.44). In

Table 14: Comparative effect of different growth regulator treatments (long duration; 12h) on number of leaves in *Bougainvillea*

Treatments (ppm)	Shubra	Lady Mary Baring	Zakiriana	Mean
NAA 100	9.67	26.12	29.37	21.71
NAA 300	4.67	31.86	35.95	24.16
NAA 500	16.17	27.33	32.44	25.13
IBA 100	10.67	29.28	34.83	24.93
IBA 300	18.50	26.89	36.50	27.30
IBA 500	19.83	28.45	27.66	25.32
NAA+IBA(50+100)	25.67	28.00	32.77	28.81
NAA+IBA(100+50)	9.67	26.03	32.26	22.65
NAA+IBA(100+100)	14.00	24.61	29.78	22.80
Control	8.00	8.44	16.44	10.96
Mean	13.68	25.70	30.80	
C.D (5%)	Varieties (A)= 4.50 ; Growth regulators concentrations (B)= 8.21 ; Interaction (A×B)= NS			

Fig.25: Comparative effect of growth regulators treatments (12h) on number of leaves in *Bougainvillea* var. Shubra at monthly intervals

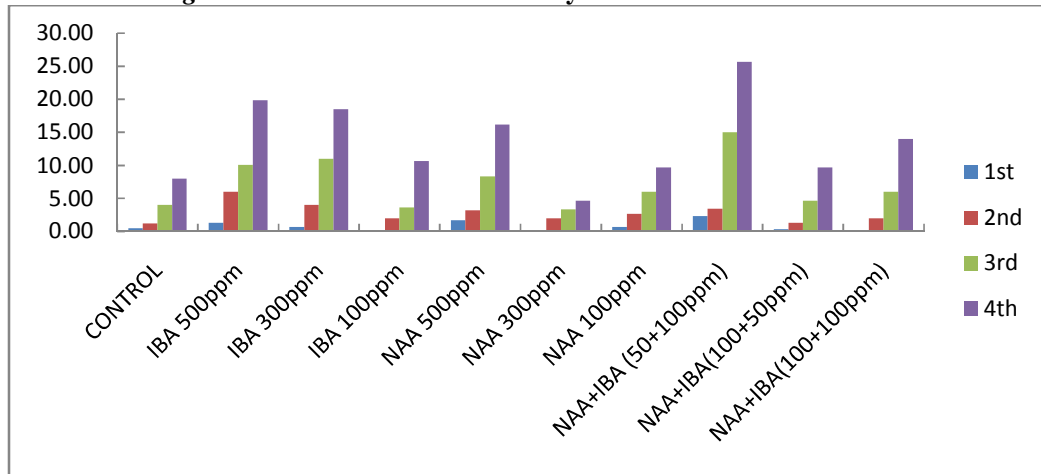


Fig.26: Comparative effect of growth regulators treatments (12h) on number of leaves in *Bougainvillea* var. Lady Mary Baring at monthly intervals

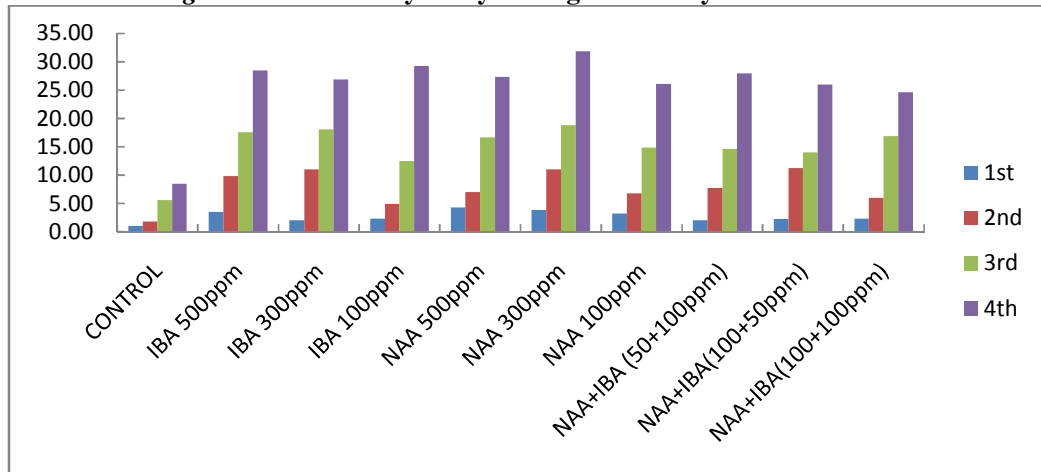
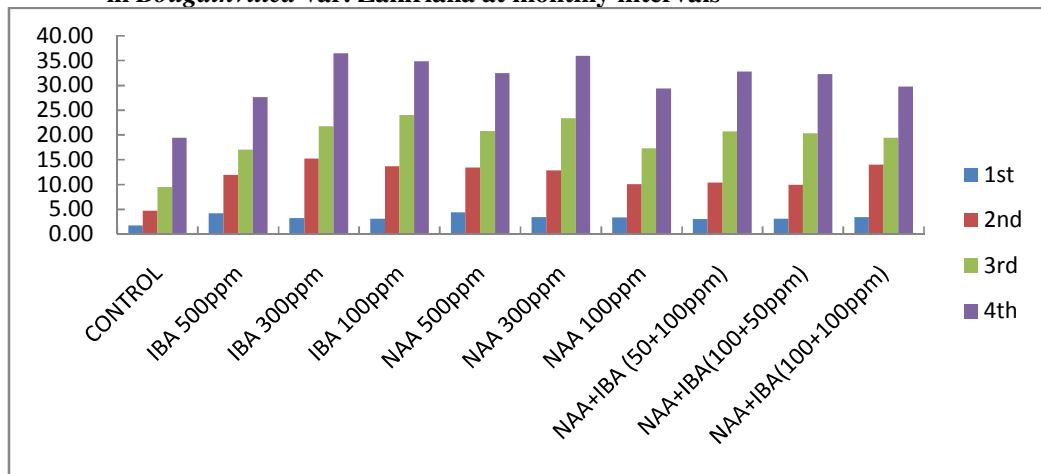


Fig.27: Comparative effect of growth regulators treatments (12h) on number of leaves in *Bougainvillea* var. Zakiriana at monthly intervals



Zakiriana, the number of leaves was at par in IBA 300 ppm(36.50), NAA 300 ppm (35.95), IBA 100 ppm (34.83), NAA+IBA (50+100) ppm (32.77), NAA 500 ppm (32.44), NAA+IBA (100+50) ppm (32.26), NAA+IBA (100+100) ppm (29.78), NAA 100 ppm (29.37) and all the treatments were significantly better, however, minimum was in control (16.44).

The treatment of growth regulator improved number of leaves as observed earlier also. Ullah *et al* (2013) conducted the experiment for regeneration of marigold. The maximum leaves per plant (44.00) were observed at 100 ppm IBA concentration while 200 ppm showed minimum leaves per plant (6.0). Singh (2000) reported in *Bougainvillea peruviana* cv. Shubra that the treatment of cuttings with IBA (500 ppm) resulted in maximum number of leaves per cutting (41.4).

4.2.5 Number of branches

The treatment of cuttings with growth regulator treatment had non significant effect on number of branches as recorded at monthly intervals (Fig. 28, 29, 30) (Table 15). The mean number of branches was the maximum (1.84) in NAA 500 ppm and IBA 500 ppm and minimum in control (0.86), irrespective of the varieties. The difference with respect to number of branches was significant among the varieties, however, the maximum was in Zakiriana (1.72), followed by Lady Mary Baring (1.60) and Shubra (0.97), irrespective of growth regulator treatment. In Shubra, maximum number of branches was in IBA 500 ppm (1.89) and minimum in NAA 300 ppm (0.33). The maximum number of branches was in NAA 500 ppm (2.50) and minimum in control (0.44) in Lady Mary Baring. Likewise, in

Table 15: Comparative effect of different growth regulator treatments (long duration; 12h) on number of branches in *Bougainvillea*

Treatments (ppm)	Shubra	Lady Mary Baring	Zakiriana	Mean
NAA 100	1.00	1.33	1.85	1.40
NAA 300	0.33	2.06	2.20	1.53
NAA 500	1.17	2.50	1.85	1.84
IBA 100	0.67	1.44	1.86	1.32
IBA 300	1.17	1.89	1.78	1.61
IBA 500	1.89	1.72	1.92	1.84
NAA+IBA(50+100)	1.33	1.44	1.40	1.39
NAA+IBA(100+500)	0.67	1.87	1.58	1.37
NAA+IBA(100+100)	0.67	1.28	1.44	1.13
Control	0.83	0.44	1.31	0.86
Mean	0.97	1.60	1.72	
C.D (5%)	Varieties (A)= 0.35 ; Growth regulators concentrations (B)= NS ; Interaction (A×B)= NS			

Fig. 28: Comparative effect of growth regulators treatments (12h) on number of branches in *Bougainvillea* var. Shubra at monthly intervals

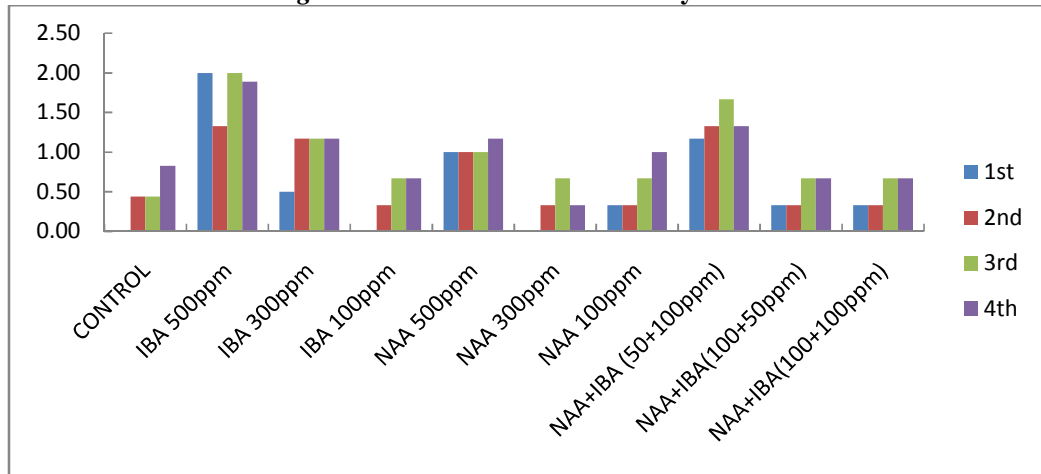


Fig. 29: Comparative effect of growth regulators treatments (12h) on number of branches in *Bougainvillea* var. Lady Mary Baring at monthly intervals

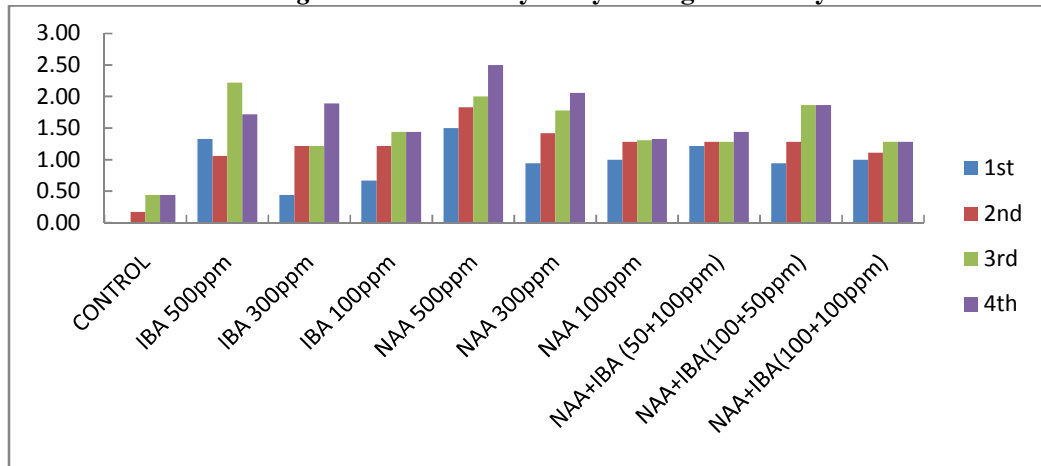
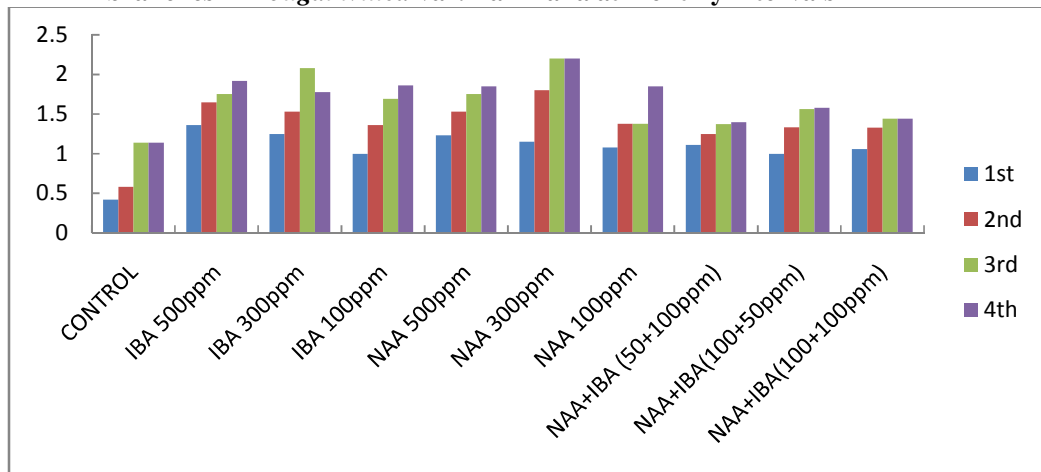


Fig. 30: Comparative effect of growth regulators treatments (12h) on number of branches in *Bougainvillea* var. Zakiriana at monthly intervals



Zakiriana, the maximum was in NAA 300 ppm (2.20) and minimum was in control (1.31).

The present findings are in confirmation with the earlier findings. Ullah *et al* (2013) conducted for regeneration of marigold. The maximum branches per plant (6.8) were observed at 400 ppm IBA.

4.2.6 Number of cuttings exhibiting rooting and per cent of cutting exhibiting rooting

The treatment of cuttings with growth regulator had significant effect on number of cuttings exhibiting rooting (Table 16). The mean number of cuttings exhibiting rooting was at par in NAA+IBA (100+50) ppm (4.00), NAA+IBA (50+100) ppm (3.22), NAA 500 ppm (3.11) and significantly better than all other treatments and minimum was in control (1.56), irrespective of the varieties. The difference among varieties was significant, and maximum was in Zakiriana (4.34), followed by Lady Mary Baring (2.30) and Shubra (1.07), irrespective of growth regulator treatment. In Shubra, the number of cuttings exhibiting rooting was at par in IBA 500 ppm (2.00), IBA 300 ppm (1.67), NAA+IBA (50+100) ppm (1.67), NAA 500 ppm (1.33) and significantly better than all other treatments and minimum in NAA 300 ppm (0.33). In Lady Mary Baring, number of cuttings exhibiting rooting were at par in NAA 100 ppm (3.67) and NAA 300 ppm (3.00), NAA+IBA (50+100) ppm (3.00) and significantly better than all other treatments and minimum in control (1.00). Likewise, in Zakiriana, the maximum number of cuttings exhibiting rooting was in NAA+IBA (100+50) ppm (8.67) and minimum in control (2.67) (Plate 6).

Table 16: Comparative effect of different growth regulator treatments (long duration; 12h) on number of cuttings exhibiting rooting in *Bougainvillea*

Treatments (ppm)	Shubra	Lady Mary Baring	Zakiriana	Mean
NAA 1000	0.67	3.67	4.00	2.78
NAA 1500	0.33	3.00	4.33	2.56
NAA 2000	1.33	1.67	6.33	3.11
IBA 1000	0.67	2.33	3.33	2.11
IBA 1500	1.67	1.33	3.00	2.00
IBA 2000	2.00	2.67	4.00	2.89
NAA+IBA(500+1000)	1.67	3.00	5.00	3.22
NAA+IBA(1000+500)	0.67	2.67	8.67	4.00
NAA+IBA(1000+1000)	0.67	1.67	3.00	1.78
Control	1.00	1.00	2.67	1.56
Mean	1.07	2.30	4.34	
C.D (5%)	Varieties (A)= 0.54 ; Growth regulators concentrations (B)= 0.98 ; Interaction (A×B)= 1.70			



(a)



(b)



(c)

Plate 6: Showing Root Development of *Bougainvillea* var. (a) Lady Mary Bearing, (b) Zakiriana and (c) Shubra after 4 months

The treatment of cuttings with growth regulator on percentage of cutting had significant effect on per cent of cutting exhibiting rooting (Table 17). The mean per cent of cutting exhibiting rooting was maximum in NAA+IBA (100+50) ppm (40.00%) and minimum in control (15.60%), irrespective of growth regulator treatment. The difference among the varieties had significant effect and the maximum was in Zakiriana (43.40%), followed by Lady Mary Baring (23.00%) and Shubra (20.00%), irrespective of growth regulator treatment. In Shubra, the maximum per cent of cutting exhibiting rooting was IBA 500 ppm (20.00%) and minimum in NAA 300 ppm (3.33%). The maximum per cent of cutting exhibiting rooting was NAA 100 ppm (36.70%) and minimum in control (10.00%) in Lady Mary Baring. In Zakiriana, maximum per cent of cutting exhibiting rooting was in NAA+IBA (100+50) ppm (86.70%) and control (26.70%).

Table 17: Comparative effect of different growth regulator treatments (12h) on Per cent of cutting exhibiting rooting in *Bougainvillea*

Treatments (ppm)	Shubra	Lady Mary Baring	Zakiriana	Mean
NAA 100	6.67	36.70	40.00	27.88
NAA 300	3.33	30.00	43.33	25.66
NAA 500	13.33	16.77	63.33	31.11
IBA 100	6.67	23.33	33.33	21.11
IBA 300	16.70	13.33	30.00	20.00
IBA 500	20.00	26.70	40.00	28.90
NAA+IBA(50+100)	16.70	30.00	50.00	32.22
NAA+IBA(100+50)	6.67	26.70	86.70	40.00
NAA+IBA(100+100)	6.67	16.70	30.00	17.80
Control	10.00	10.00	26.70	15.60
Mean	10.70	23.00	43.40	
C.D (5%)	Varieties (A)= 0.54 ; Growth regulators concentrations (B)= 0.98 ; Interaction (A×B)= 1.70			

The treatment of growth regulator improved number and per cent of cutting exhibiting rooting as observed earlier also. Shabha and Alshammary (2013) reported in *Bougainvillea* cv. Shubra that treatment of cuttings with IBA (500 ppm) resulted in the highest rooting percentage (55.6% after 12 hours and 59.4% after 24hours of treatment). Bhatt *et al* (2008) observed in *Lavendula officinalis* that the cuttings treated with IBA resulted in maximum rooting percentage (86.66). Thorat *et al* (2006) observed in Nerium that the cuttings treated with IBA (100 ppm) for 24 h resulted in the highest sprouting and rooting of plants. Khan *et al* (2005) studied in Damask rose cuttings that the highest rooting percentage

(94.17%) was recorded in the cuttings treated with NAA (50 mg/l). Singh (2000) reported in *Bougainvillea peruviana* cv. Shubra, the treatment of cuttings with IBA (500 ppm) resulted in significantly more rooting (57.5%). Harris and Singh (1991) reported that the cuttings of *Bougainvillea* cvs. Shubra, Refulgense, Formosa, Mangnifica, dipped in IBA (100 ppm) for 12 h and placed under mist chamber, resulted in highest mean percentage rooting in all the cultivars. Mukhopadhaya and Bose (1996) reported in *Bougainvillea* cv. Mary Palmer that the cuttings treated with NAA (400 ppm) produced 12.5 percent rooting, whereas, the cutting treated with NAA (100 ppm) and in the control failed to exhibiting rooting. Lal *et al* (1971) reported that the cuttings of *Bougainvillea* spp. Thimma when treated with NAA (500 ppm) for one minute gave more rooting percentage (81 per cent) than NAA (100 and 1000 ppm) (30 and 48 per cent respectively).

4.2.7 Number of roots

The treatment of cutting with growth regulator had significant effect on number of roots (Table 19). The mean number of roots was at par in IBA 500 ppm (3.07), IBA 300 ppm (2.93), NAA 500 ppm (2.76), NAA 100 ppm (2.52), NAA+IBA (50+100) ppm (2.51), IBA 100 ppm (2.48), NAA+IBA (100+100) ppm (2.26), NAA+IBA (100+50) ppm (2.16), control (2.15) and significantly better than all other treatments, however, minimum was in NAA 300 ppm (2.09), irrespective of the varieties. The difference among varieties was non significant, maximum was in Zakiriana (2.64), followed by Lady Mary Baring (2.34) and Shubra (2.15), irrespective of the varieties. In Shubra, number of roots was at par in IBA 500 ppm (3.50), IBA 300 ppm (3.00), NAA+IBA (50+100) ppm (3.00), NAA 500 ppm (2.83) and significantly better than all other treatments and minimum in control (0.83). In Lady Mary Baring, number of roots was at par in NAA 500 ppm (3.00), IBA 500 ppm (2.78), NAA 300 ppm (2.75), IBA 300 ppm (2.56), IBA 100 ppm (2.56), NAA+IBA (100+50) ppm (2.53), NAA 100 ppm (2.48), NAA+IBA (50+100) ppm (2.14) and all the treatments were significantly better than control (0.67). Likewise, in Zakiriana, number of roots was at par in IBA 300 ppm (3.25), NAA+IBA (100+100) ppm (3.16), IBA 500 ppm (2.91), IBA 100 ppm (2.89), NAA 100 ppm (2.74), NAA+IBA (100+50) ppm (2.60), NAA 300 ppm (2.52), NAA 500 ppm (2.44), NAA+IBA (50+100) ppm (2.40) and significantly better in all treatments than in control (1.50).

The present findings are in confirmation with earlier findings. Akhtar *et al* (2015) *Rosa centifolia* is propagated through cuttings which are difficult to root. In this study rooting percentage was increased by applying plant growth regulators with different levels. Among three levels of IBA, 450 ppm concentration produced maximum number of roots (14.00). Renuka and Sekhar (2014) studied the effect of IBA and NAA at different concentrations on the rooting of carnation (*Dianthus caryophyllus* L.) cuttings of cv. Dona. The treatment with IBA 200 ppm recorded maximum number of roots followed by the treatment IBA 100 ppm +

NAA 50 ppm. Shabha and Alshammary (2013) reported in *Bougainvillea* cv. Shubra that treatment of cuttings with IBA (500 ppm) resulted in more number of roots per cutting (20.5 and 19.8 at 12 and 24 hours). Ullah *et al* (2013) conducted the experiment for regeneration of marigold and investigated that IBA 400 ppm had maximum effect on roots per plant (84.4). Khan *et al* (2005) studied in Damask rose cuttings that average number of roots and rooting percentage gradually increased with the increase in the hormone concentration and the highest number of roots (15.72) was recorded in the cuttings treated with NAA (50 mg/l). Harris and Singh (1991) reported that the cuttings of *Bougainvillea* cvs. Shubra, Refulgense, Formosa, Magnifica, dipped in IBA (100 ppm) for 12 h resulted in maximum number of roots per cuttings in all the cultivars.

Table 18: Comparative effect of different growth regulator treatments (long duration; 12h) on number of roots in *Bougainvillea* after 4th month

Treatments (ppm)	Shubra	Lady Mary Baring	Zakiriana	Mean
NAA 100	2.33	2.48	2.74	2.52
NAA 300	1.00	2.75	2.52	2.09
NAA 500	2.83	3.00	2.44	2.76
IBA 100	2.00	2.56	2.89	2.48
IBA 300	3.00	2.56	3.25	2.93
IBA 500	3.50	2.78	2.91	3.07
NAA+IBA(50+100)	3.00	2.14	2.40	2.51
NAA+IBA(100+50)	1.33	2.53	2.60	2.16
NAA+IBA(100+100)	1.67	1.94	3.16	2.26
Control	0.83	0.67	1.50	2.15
Mean	2.15	2.34	2.64	
C.D (5%)	Varieties (A)= NS ; Growth regulators concentrations (B)= 0.99 ; Interaction (A×B)= NS			

4.2.8 Average length of root

The treatment of cutting with growth regulator had non significant effect on average length of root (Table 19). The mean shoot length of root (cm) was the maximum in IBA 300 ppm (12.76 cm) and minimum was in control (4.96 cm), irrespective of the varieties. The difference among the varieties was significant with respect to shoot length, however, the maximum shoot length was in Zakiriana (13.25 cm), followed by Lady Mary Baring (11.70 cm) and Shubra (6.50 cm), irrespective of the growth regulator treatment. In Shubra, the maximum average shoot length was in NAA+IBA (50+100) ppm (11.82 cm) and minimum in control (2.79 cm). The maximum average shoot length was in IBA 300 ppm (16.54 cm) and

Table 19: Comparative effect of different growth regulator treatments (12h) on average length of roots (cm) in *Bougainvillea* after 4th month

Treatments (ppm)	Shubra	Lady Mary Baring	Zakiriana	Mean
NAA 100	6.03	10.60	9.08	8.57
NAA 300	3.40	15.29	13.65	10.78
NAA 500	7.48	10.88	13.98	10.78
IBA 100	4.90	11.73	17.19	11.27
IBA 300	9.00	16.54	12.75	12.76
IBA 500	10.33	12.12	13.36	11.70
NAA+IBA(50+100)	11.82	9.47	16.02	12.43
NAA+IBA(100+50)	3.90	13.51	16.61	11.34
NAA+IBA(100+100)	5.37	13.59	11.07	10.01
Control	2.79	3.30	8.79	4.96
Mean	6.50	11.70	13.25	
C.D (5%)	Varieties (A)= 2.70 ; Growth regulators concentrations (B)= NS ; Interaction (A×B)= NS			

minimum was in control (3.30 cm) in Lady Mary Baring. In Zakiriana, the maximum average shoot length was in IBA 100 ppm (17.19 cm) and minimum was in control (4.96 cm).

Akhtar *et al* (2015) in *Rosa centifolia*, among three levels of IBA, 450 ppm concentration produced maximum root length (11.90 cm). Renuka and Sekhar (2014) studied the effect of IBA and NAA at different concentrations on the rooting of carnation (*Dianthus caryophyllus* L.) cuttings of cv. Dona. . The treatment with IBA 200 ppm recorded cumulative length of roots per cutting followed by the treatment IBA 100 ppm + NAA 50 ppm.

4.2.9 Per cent establishment of plants

The treatment of cutting with growth regulator had significant effect on per cent establishment of the cutting (Table 20). The mean per cent establishment was maximum in NAA+IBA (100+50) ppm (35.56%) and minimum in control (10.00%), irrespective of the varieties. The difference among varieties had significant effect and the maximum was in Zakiriana (39.67%), followed by Lady Mary Baring (20.67%) and Shubra (10.00%), irrespective of growth regulator treatment. In Shubra, the maximum per cent establishment was in IBA 500 ppm (20.00%) and minimum was in NAA 300 ppm (3.33%). In Lady Mary Baring, the maximum per cent establishment was in NAA 100 ppm (33.33%) and minimum was in control (6.67%). Likewise in Zakiriana, the maximum per cent establishment was in NAA+IBA (100+50) ppm (76.67%) and minimum was in control (16.67%) (Plate 6).

Table 20: Comparative effect of different growth regulator treatments (long duration; 12h) on establishment (%) in *Bougainvillea* after 4 month

Treatments (ppm)	Shubra	Lady Mary Baring	Zakiriana	Mean
NAA 100	6.67	33.33	33.33	24.44
NAA 300	3.33	26.67	43.33	24.44
NAA 500	13.33	16.67	63.33	31.11
IBA 100	6.67	20.00	26.67	17.78
IBA 300	16.67	13.33	30.00	20.00
IBA 500	20.00	20.00	40.00	26.67
NAA+IBA(50+100)	13.33	30.00	40.00	27.78
NAA+IBA(100+50)	6.67	23.33	76.67	35.56
NAA+IBA(100+100)	6.67	16.67	26.67	16.67
Control	6.67	6.67	16.67	10.00
Mean	10.00	20.67	39.67	
C.D (5%)	Varieties (A)= 0.47 ; Growth regulators concentrations (B)=0.85 ; Interaction (A×B)= 1.48			

Renuka and Sekhar (2014) studied the effect of IBA and NAA on the rooting of carnation (*Dianthus caryophyllus* L.) cuttings of cv. Dona. The treatment with IBA 200 ppm recorded highest percentage of establishment of cuttings followed by the treatment IBA 100 ppm + NAA 50 ppm. Shabha and Alshammary (2013) reported in *Bougainvillea* cv. Shubra that treatment of cuttings with IBA (500 ppm) resulted in the highest establishment percentage (68.3 and 53.3% after 12 and 24 hours, respectively). Singh (2000) reported in *Bougainvillea peruviana* cv. Shubra, the treatment of cuttings with IBA (500ppm) resulted in significantly more establishment of plant (51.67%) than all other treatment, irrespective of duration (12,24 h) of treatment and method of planting.

CHAPTER-V

SUMMARY

The present investigations were conducted on the “Effect of different growth regulators on rooting of stem cuttings in *Bougainvillea*”. The hardwood cuttings of all three varieties viz. Shubra, Lady Mary Baring and Zakiriana were treated with different growth regulator concentrations and combination for quick dip (<5s) and long duration (12h) and planted in polybags. The observations were recorded with respect to shoot emergence (%), number of shoots, average shoot length (cm), number of leaves, number of branches, number of cutting exhibiting rooting, per cent of cutting exhibiting rooting (%), number of roots, average length of roots (cm) and per cent establishment of plants (%). The findings of the studies are summarized in this chapter as follows:

5.1 Growth regulator treatment of hardwood cuttings of *Bougainvillea* by using quick dip (<5s) method

Among all the growth regulator treatments, IBA 2000 ppm resulted in the maximum mean number of shoots (1.64), mean shoot length (7.07 cm), mean number of leaves (24.91), mean number of branches (2.17) and mean number of roots (3.75) of cuttings. NAA 2000 ppm resulted in the maximum mean shoot emergence (35.56%), mean number (3.56) and per cent (35.60%) of cuttings exhibiting rooting and per cent establishment (32.22%) of plants. NAA+IBA (100+500) ppm resulted in the maximum mean length of root (10.50 cm) of cuttings. Among all the three varieties, Zakiriana was the best with maximum shoot emergence (35.00%), number of shoots (1.30), average shoot length (5.10 cm), number of leaves (25.02), number of branches (1.30), number of cutting exhibiting rooting (3.50), per cent of cutting exhibiting rooting (35.00%), number of roots (2.49), average length of roots (9.04 cm) and per cent establishment of plants (32.33%).

In Shubra, IBA 1500 ppm resulted in maximum shoot emergence (23.33%), number of roots (2.33) and per cent (23.33%) of cutting exhibiting rooting and per cent establishment of plants (20.00%). Also IBA 1000 ppm resulted in maximum per cent establishment of plants (20.00%). IBA 2000 ppm resulted in maximum number of shoots (1.67), number of branches (2.33), number of leaves (24.33) and number of roots (5.00). NAA +IBA (1000+500) ppm resulted in maximum average length of roots (12.56 cm). NAA 2000 ppm resulted in maximum average shoot length (6.36 cm).

In Lady Mary Baring, NAA 2000 ppm resulted in maximum shoot emergence (43.33%), number (4.33) and per cent (43.33%) of cuttings exhibiting rooting and per cent establishment (43.33%). IBA 2000 ppm resulted in the maximum number of shoots (1.67), average shoot length (6.35 cm), number of leaves (25.00), number of branches (2.00), number of roots (3.00) and average length of root (12.68 cm).

In Zakiriana, IBA 2000 ppm resulted in maximum shoot emergence (60.00%), average shoot length (9.05 cm), number of leaves (29.05), number of branches (2.17), number of cuttings exhibiting rooting (6.00), per cent of cuttings exhibiting rooting (60.00%), number of roots(3.26), average length of roots (11.15 cm) and per cent establishment (60.00%) of plants . NAA 2000 ppm resulted in the maximum number of shoots (1.68).

5.2 Growth regulator treatment of hardwood cuttings of *Bougainvillea* by using long duration (12h) method

Among all the growth regulator treatments, NAA+IBA (100+100 ppm) resulted in the maximum mean shoot emergence (40.00%). IBA 500 ppm resulted in the maximum mean number of shoots (1.86), mean length of shoots (7.11 cm), mean number of branches (1.84), mean number of roots (3.07). NAA 500 ppm also resulted in maximum mean number of branches (1.84). NAA+IBA (50+100 ppm) resulted in maximum mean number of leaves (28.81). NAA+IBA (100+50 ppm) resulted in the maximum mean number (4.00) and per cent (40.00%) of cuttings exhibiting rooting, mean per cent establishment of plants (35.56%). Among all the three varieties, Zakiriana was best with the maximum shoot emergence (44.33%), number of shoots(1.69), average shoot length (6.12 cm), number of leaves (30.80), number of branches (1.72), number of cuttings exhibiting rooting (43.4), per cent of cuttings exhibiting rooting (43.40%), number of roots (2.64), average length of roots (13.25 cm) and per cent establishment of plants (39.67%).

In Shubra, NAA 300 ppm resulted in maximum shoot emergence (20.00%). NAA+IBA (50+100 ppm) resulted in maximum number of shoots (1.67), average length of shoot (7.73 cm), number of leaves (25.67) and average length of root (11.82 cm). IBA 500 ppm resulted in maximum number of shoots (1.67), number of branches (1.89), number of roots (3.50), number (2.00) and per cent (20.00%) of cutting exhibiting rooting and per cent establishment of plants (20.00%).

In Lady Mary Baring, NAA+IBA (50+100 ppm) resulted in maximum shoot emergence (36.67%). NAA 500 ppm resulted in maximum number of shoots (2.50), number of branches (2.50) and number of roots (3.00). IBA 300 ppm resulted in maximum average shoot length (8.79 cm) and average length of root (16.54 cm). NAA 300 ppm resulted in maximum number of leaves (31.86).

In Zakiriana, NAA+IBA (100+100 ppm) resulted in maximum shoot emergence (86.67%). IBA 500 ppm resulted in maximum number of shoots (1.92), average shoot length (8.01 cm). IBA 300 ppm resulted in maximum number of leaves (36.50) and number of roots (3.25). NAA 300 ppm resulted in maximum number of branches (2.20). IBA 100 ppm resulted in maximum average length of root (17.19 cm). NAA+IBA (100+50) ppm was maximum in number (8.67) and per cent (86.67%) of cutting exhibiting rooting and per cent establishment (76.67%) of plants.

It was concluded that growth regulator treatment of hardwood cuttings of *Bougainvillea* by using quick dip (<5sec) method had significant effect and per cent shoot emergence (%), average shoot length (cm), percent rooting and establishment of plants (%) were the maximum in NAA 2000 ppm treatment, however, number of shoot was maximum in IBA 2000ppm treatment. Further, growth regulator treatment of hardwood cuttings of *Bougainvillea* by using long duration (12h) method also had significant effect and shoot emergence (%) was the best in treatment- NAA+IBA (100+100 ppm), number of shoot and average shoot length (cm) was maximum in IBA 500 ppm, percent rooting was the maximum in- NAA+IBA (50+100 ppm) and establishment of plants (%) was maximum in NAA+IBA (100+50 ppm). Among long duration (12h) and quick dip (<5s) method, long duration performed better as establishment (%) of plants was better in this method.

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APPENDIX I**Meteorological data during the year 2015**

Months	Air Temperature (°C)		Relative Humidity (%)		Sunshine hours	Rainfall (mm)	Evaporation (mm)
	Maximum	Minimum	Morning	Evening			
January	15.6	7.1	96	73	3.2	24.6	31.9
February	22.2	10.5	92.9	64.8	5.6	38.6	61.4
March	25.5	13.1	93	60	7.7	84.6	102.9
April	32.6	19.5	74.7	44.9	8.5	29.4	198.5
May	39.6	23.7	52	23	9.3	17.0	284.5
June	37.5	26.0	61	38	8.6	17.9	256.1
July	33.5	27.2	82	67	5.9	256.1	152.9
August	33.3	26.4	86	67	6.1	165.6	130.1
September	33.2	24.2	87.5	58.2	8.0	85.4	135.5
October	31.3	19.2	90	46	7.6	16.4	109.5
November	26.9	12.6	91.2	37.4	4.6	0.0	70.5
December	21.3	7.4	94	42	5.4	1.7	50.1

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