# ROOTING OF MAGNOLIA AND BOUGAINVILLEA CUTTINGS UNDER OUTDOORS AND GLASSHOUSE CONDITIONS

By

Ahmad Khalighy

A Thesis Submitted to the Faculty
of Agricultural Sciences in Partial Fulfillment of
The Requirements for the Degree of

MASTER OF SCIENCE IN AGRICULTURE

Major: Horticulture - Plant Pathology
Minor: Entomology

Approved:

In Charge of Major Work

Chairman, Graduate Committee

American University of Beirut
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Rooting of Cuttings

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Ahmad Khalighy

ABSTRACT

Rooting of softwood and hardwood cuttings of Bougainvillea glabra and Magnolia grandiflora was examined at the American University of Beirut. Experiments were conducted under outdoor and glass house conditions during the year 1963-64. The effect of mist, root promoting substances, wounding and different types of cuttings and rooting media were studied. Mist, IBA and wounding produced a marked effect on callusing, rooting and survival of magnolia cuttings. The highest amount of callusing was produced when misting was applied together with IBA at 8000 ppm. Wounding with IBA increased rooting of magnolia cuttings.

Misting together with IBA at 3000 ppm. increased rooting of bougainvillea softwood cuttings. Hardwood bougainvillea cuttings produced higher rooting than softwood cuttings.

The results of this investigation have shown that, in order to obtain high rooting on magnolia cuttings, root promoting substances together with mist and wounding must be applied. The findings on bougainvillea indicate that in order to obtain high rooting, hardwood bougainvillea cuttings should be taken and treated with IBA at 4000 ppm. and planted in vermiculite.

Misting is recommended in the propagation of bougainvillea especially if softwood cuttings are to be used during Spring or Summer.

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# INTRODUCTION

Lebanon, having a moderate climate, is an ideal place for the cultivation of a variety of ornamental flowers and shrubs. With the tourist industry being one of the major contributing factors in the economy of the Lebanese, an attempt to improve the aesthetic quality of the country as a whole is amply justifiable. Planting of ornamental plants could be considered one of the effective means of accomplishing the above goal.

The climate of Lebanon is ideally suited to the multiplication of many of the most difficult ornamentals to propagate, such as, cyclamen, purple bougainvillea, nasturtiums and other flowers and shrubs which grow wild in many parts of the country. Unfortunately the Lebanese have not taken full advantage of this natural blessing.

Magnolia and bougainvillea are two of the most beautiful ornamentals grown outdoors in moderate climatic areas, demanding little attention and care once established. Nurserymen are interested in the propagation of these two flowering plants by cuttings because of the simplicity of the operation and the low unit cost of production. Of the ornamental species of bougainvillea the red species (B. glabra) in contrast to the purple species (B. spectabilis) seems to present more problems in propagation by cuttings, as it roots with

difficulty. Propagation of magnolia by cuttings also offers many problems. Layerage and grafting have been the standard methods of propagating this plant until recently (29). Attempts have been made during the past decades to improve its propagation by cuttings.

Since both magnolia and the red bougainvillea are highly priced in the market because of the difficulty of their multiplication, any improvement in their method of propagation is of great economical importance.

This study was undertaken to investigate the effect of mist, bottom heat, root promoting substances and different types of rooting media on rooting of magnolia and bougainvillea cuttings.

## REVIEW OF LITERATURE

### 1. Plant Condition and Time of Preparing the Cuttings as Influencing Root Formation.

The magnolia is a difficult tree to propagate vegetatively (29). It has been reported that root formation on cuttings taken from young actively growing magnolia trees was rapid and generally better than cuttings prepared from older trees.

When plants are grown from seed they go through what has been termed a juvenile phase during which no flower formation occurs (9). Cuttings collected from plants in this stage root readily; however, the ease of rooting decreases with increase in age of the tree and the onset of flowering.

Magnolia cuttings root best when taken from the current season's mature growth (29, 30). The rate of root formation decreases with age, to the extent that cuttings from branches one year old were found difficult to root.

Previous recommendations were to use old mature wood with large amounts of carbohydrate reserves to enable the plants to survive the period required for rooting (11). With propagation aids such as bottom heat and misting, faster root induction occurs without the drying out of the cuttings. These aids permit the use of young plant material with a high

root forming potential.

Bailey (1) wrote that bougainvillea hardwood cuttings can be taken any time during the year; the best time is in late spring or early summer after the vine is through with flowering which coincides with the time of heavy pruning.

Dore (5) reported that in many plants, cuttings could be made from shoots that are either in a flowering or vegetative condition. In species that root with ease, either of the above materials could be used. However, with the difficult-to-root species, the problem becomes more complication and cuttings have to be made either before or after, rather than during,the flowering period.

The time at which cuttings are to be taken is apparently related to the condition of the plant and the climate rather than the calendar (10). In England, with its temperate climate, hardwood cuttings are prepared and planted in September and October, whereas in parts of North America, they are collected in the autumn, stored during the winter and planted in the spring.

Hartman and Kester (12) reported that softwood cuttings of deciduous woody species taken during the spring or summer usually root more readily than hardwood cuttings made in the winter.

Enright (6) found that magnolia cuttings taken at weekly intervals during June produced from 82% to 88% rooting after 44 to 47 days. Free (8) reported that

magnolia cuttings taken in July did not produce roots. This was attributed to the influence of season on the rooting response of magnolia cuttings. In England, results showed that magnolia and in particular the Soulangiana group, responded favorably to the cutting propagation (14). Cuttings ranging from 10 to 30 cm. in length were recommended for propagation.

2. Effect of Wounding on Rooting.

Stuart and Marth (28) reported that wounded cuttings have given better rooting than those not wounded. Longley (16) found that this was true for many of the greenhouse plants he studied. Garner (11) concluded that wounding the base of cuttings aids rooting specially when hardwood cuttings are employed.

Wells (29) reported that he produced a good effect on root formation by basal wounding of magnolia cuttings. He stated that large cuttings, such as used commercially in magnolia propagation , may be effectively wounded by removing a thin slice of bark, down each side of the cuttings, exposing the cambium without cutting deep into the wood.

Hartman and Kester (12) stated that good rooting could be obtained by treating cuttings with one of the root promoting substances immediately after wounding. Day (4) reported that wounded cuttings are able to absorb more water from the rooting medium than non-wounded cuttings. This practice would

also provide for a greater uptake of growth regulators by the tissues.

3. Effect of Media on Rooting.

Wells (30) recommended a plain sharp sand as a medium for rooting of most deciduous magnolia. Long (16), working with a large number of ornamental plants, reported that cuttings of many plants, when rooted in sand, produce coarse, brittle, separately branched roots, while those rooted in peat moss produce cylindrical, flexible, and usually well branched roots. Lerch (15) reported a favorable effect on rooting produced from a mixture of one part peat to three parts sand for rooting of magnolia cuttings.

Chadwich (2), studying the effect of certain media on the rooting of some evergreen plant cuttings, concluded that a number of plants root better in vermiculite with large size particles, whereas some do better in the finer grades of this material. Bailey (1) recorded that sand is a good planting medium for rooting of bougainvillea cuttings.

According to Garner (10), Knight found that a high water content of the medium favored callusing but reduced rooting in hardwood cuttings. He further quoted Hunter who reported indications that root formation, as distinct from callusing, took place under fairly wet condition. Hunter recommended increasing the water supply of the media after callusing.

4. Use of Root Promoting Substances in Rooting of Cuttings.

The disclosure that root promoting substances could be used as an aid in vegetative propagation resulted in numerous papers on this subject during the past 25 years (19, 29).

A number of synthetic growth regulators aid in rooting of cuttings (10, 21, 29). The two materials now in common use are Beta-indole-butyric acid (IBA) and Alpha-naphthalene-acetic acid (NAA) either in their acid form or as salts. These materials were found to be effective with a great number of plants and could be used in relatively high concentrations.

The chemical structure of root promoting substances has a marked influence on rooting (13). For every material and plant there is a critical level of effective concentration. Concentrations above the critical level not only inhibit root growth, but may cause morphological injury.

The method of application of root promoting substances used by Hitchcock and Zimmerman and described by Cooper (3) consisted of dipping the bases of the cuttings for a few seconds in a 50% alcohol solution containing 1 to 20 mg/ml. of the root promoting substances. This method was found particularly effective with such difficult-to-root species as apple and rhododendren. The large volume of alcohol used in these concentrated solutions made the method helpful in preparing solution of some of the relatively insoluble compounds such as naphthalene-acetamide.

Enright (7) wrote that dipping magnolia cuttings for 10 seconds in a wide range of IBA solutions increased rooting. His work did not reveal rooting on cuttings not receiving IBA, while those treated with 20,000 ppm. IBA produced from 84% to 88% rooted cuttings. All the cuttings were planted in coarse sand in a glass house bench under mist and provided with bottom heat. Root development was directly proportional to the concentration of IBA used. According to Pearse (25), Scholz reported that magnolia cuttings taken in July produced 67% rooting with the application of 200 ppm. IBA in a 24 hours soak, as compared with no root formation on the control. The rooting time for the treated cuttings was six weeks. Contrary to the above experiment, Samantaria (26) reported that stem cuttings of Magnolia grandiflora did not respond to IAA or IBA treatment or to aqueous solutions of NAA. Lerch (15) showed that magnolia cuttings made between mid-June and the end of July, produced 74% to 88% rooting after the immersion of the cuttings in a warm solution (20°C) of IAA or its sodium salt for 24 hours. The cuttings were potted in a mixture of 1 part of peat to 3 parts of sand and kept in a closed frame with bottom heat at 24° to 26°. Rooting took place in about 6-9 weeks.

Wells (29) found that a mixture (Hormodin No. 3) containing 0.8% IBA was the most successful root promoting substance for Magnolia grandiflora cuttings. Soukop (27) obtained a high percent rooting with magnolia cuttings by

applying IBA and IAA. He emphasized that high rooting is possible provided that cuttings were taken at the right stage.

Popenoe (23) found that some species of bougainvillea are more difficult to root than others. He emphasized that rooting hormones are very helpful for difficult to root species. Pearse (21) reported on the work of Maxon, Picket and Rickey, who found that cuttings of Bougainvillea glabra treated with IBA at 20 ppm. for 24 hours during November, produced 62% rooting after 7 weeks, as compared with 7% for the control. They further found that some of the cuttings that did not produce roots within 7 weeks did so if left in the rooting media for a longer time. Pillai (22) studied the effect of root promoting substances on bougainvillea cuttings. He soaked the cuttings in different solutions of IAA, NAA, IAA + NAA, IAA + IBA and NAA + IBA, each at two different concentrations of 0.005% and 0.0005%. His results showed that all the cuttings formed callus after 7 days, except for the cuttings receiving the 0.005% IBA. After callus formation the cuttings were transferred to water culture where root formation occurred on some, at the end of 14 days. The rooted cuttings were those treated with NAA, IAA + NAA, IAA + IBA and NAA + IBA. Shoots also appeared following treatments with all the root promoting substances except for those receiving IAA.

5. Effect of Mist and Humidification on Rooting of Cuttings.

Softwood and leafy cuttings were found to root satisfactorily if kept in a fresh turgid condition. It has long been recognized that mist and humidification techniques are very useful in propagating plants by cuttings (13, 12, 25).

Rowe-Dutton (20) has extensively covered the subject of the use of misting in her book, Mist Propagation of Cuttings. The book stresses the importance of good drainage of the rooting media and covers the subject of effectiveness of the root promoting substances under mist condition. She reported that hormone treated magnolia cuttings planted in coarse vermiculite under constant mist produced 41% rooting within 51 days. Wells (29), using mist and humidification, reported a high rooting percentage of Magnolia grandiflora cuttings.

Knight, Bean, and Hanger (14) reported that many ornamental trees and shrubs, which root with difficulty from semi-hardwood cuttings, will root freely and in a short period under mist from succulent cuttings. Such cuttings taken earlier in the year become well established plants by autumn.

6. Ranks Method for the Evaluation of the Rooting Response of Cuttings.

Mahlstede and Lana (18) reported that the method of Ranks (assignment of arbitrary index number) is a simple one which can be used accurately to determine differences in

rooting responses of cuttings. They quoted O'Rouke and Maxon, who examined and illustrated the said method by inserting 5 lots of 20 uniform cuttings in various media at one time. All cuttings were removed from the rooting bench at the same time, but only after one lot of cuttings had produced one adequate root system. Each lot was divided into three classes - heavy, medium and light, based on root development. An index number was then calculated for each treatment by assigning the arbitrary number of five for each cutting which was classified in the heavily rooted class, three for those in the medium class and one for those which were lightly rooted. The summation of the number of cuttings in each class multiplied by their assigned values resulted in the index value for each treatment. This figure could then be used to compare the effectiveness of each of the treatments.

## MATERIALS AND METHODS

Rooting of cuttings of Magnolia grandiflora, Linne variety "Gloriosa" hereafter referred to as magnolia and Bougainvillea glabra, Choisy variety "Sanderiana" hereafter referred to as bougainvillea was examined using softwood and hardwood cuttings taken at different times during the year 1963-64. The magnolia cuttings were taken from 3-year-old potted plants growing at the Model Nurseries in Jamhour. These plants were annually pruned, fertilized and watered regularly and appeared to be in a good growing condition. Bougainvillea cuttings were secured from 5 healthy vines growing on the campus of the American University of Beirut.

From current season branches of magnolia and bougainvillea, cuttings 10 cm. long were obtained. The bottom cut on each cutting was made about ½ cm. below its basal bud and the upper cut was about 2 cm. above its top bud. Cuttings that ranged from 5 to 8 mm. in diameter were considered as hardwood cuttings and those less than 5 mm. in diameter as softwood. The cuttings were wrapped in a moist towel during their handling to keep them from dessication.

Before planting all leaves from each cuttings, except the uppermost one for magnolia and the two top ones for bougainvillea, were removed. The cuttings to be wounded

were slit about 2 cm. upward from the base before planting; and those which were to be treated, received IBA in different concentrations. The treatments were applied using the concentrated-solution-dip method as described by Cooper (3). All operations were performed under shade inside the glass house.

Planting was carried out in flats containing vermiculite or sand. The cuttings were set about 5 cm. deep and 3 cm. from one another, in rows 4 cm. apart. The flats were placed either inside or outside the glass house. During the winter and spring months from the 18th of October, 1963 to the 10th of March, 1964, the flats inside the glass house were placed in a thermostatically controlled electric heated bed with a bottom temperature ranging from 20° to 24°C.

Plants to receive mist were placed under a continuous fine spray of water from 8:00 a.m. to 6:00 p.m. daily. The cuttings that did not receive a mist spray were sprinkled with water when required.

Cuttings were considered callused when callus formation occurred. Rooted cuttings were classified as high rooted, medium rooted or low rooted, according to the number of roots formed, and the length obtained by them. Cuttings that formed at least 4 roots 5 cm. long were classed as high rooted. Cuttings that formed 2-3 roots 5 cm. long were considered as medium rooted while those with only 1 root or 2 short roots were considered low rooted.

The experimental work for this study was divided into 2 parts. The first part dealt with the rooting of magnolia cuttings and was made of 2 experiments, while the second part dealt with the rooting of bougainvillea cuttings and consisted of 4 experiments.

I. Studies on magnolia.

A. In the first experiment the effect of IBA and mist on the rooting of magnolia cuttings was determined. The experiment was laid out on a randomized block design in which there were three treatments and four replications. The treatments were as follows:

1. No mist and no IBA
2. Mist and no IBA
3. Mist and IBA at 8000 ppm.

For each of the above treatments 100 softwood magnolia cuttings were planted in vermiculite on October 17, 1963. Cuttings were examined 30, 60 and 89 days after being placed in the rooting medium for callusing and rooting. After every observation the cuttings were replanted discarding the well rooted and the dead. The experiment was terminated on January 15. Rooting response of the cuttings was evaluated according to the method of Ranks as described by Mahlstede and Lana (18).

B. The second experiment started on February 15, 1964, when the effect of wounding and IBA on the rooting of mag-

nolia cuttings was determined. The treatments were as follows:

1. Control
2. Wounding
3. Wounding + IBA at 8000 ppm.
4. IBA at 8000 ppm.

For each of the above treatments 80 magnolia softwood cuttings were planted in flats containing vermiculite which were placed inside the glass house on the heated bed. The cuttings were divided into lots of 20 allowing four replications per treatment. After three days, the cuttings were transferred to the outside on account of the appearance of dark brown spots on the surface of the leaves, which were considered to be due to a non-suitable environmental condition. Cuttings were examined 27, 58 and 82 days after being placed in the rooting medium for callusing, rooting and survival.

II. Studies on bougainvillea

A. The first experiment was started on October 17, 1963. Bougainvillea cuttings were treated with IBA at 3000 ppm. and planted in a sand medium, along with the control, inside the glass house in a heated bed. The treated cuttings were further divided into two lots, in order to examine the effect of retreating bougainvillea cuttings with IBA. The treatments were as follows:

1. Control
2. IBA at 3000 ppm. (one application)
3. IBA at 3000 ppm. (two applications)

For each of the above treatments 100 cuttings were employed. Dead and rooted cuttings of all the treatments were discarded and the non-rooted cuttings of only one lot were retreated with IBA at 3000 ppm. on December 25. All the non-rooted cuttings were replanted. Cuttings were lifted on January 10 when the rooting of the cuttings was evaluated according to the Ranks Method.

B. The second experiment was to study the effect of media and type of cuttings on the rooting of bougainvillea cuttings treated with IBA at 3000 ppm. The experiment was laid out in a split plot design using media as the main-plots and type of cuttings as the sub-plots. This made a total of 4 treatments each with 100 cuttings. The cuttings were divided into lots of 25, allowing 4 replications per treatment.

Cuttings were planted in flats filled either with sand or vermiculite and placed in the hot propagating frame. Planting was done on December 25, 1963. Cuttings were evaluated for the amount of root and shoot formation, 10 weeks after planting.

C. The third experiment was executed to study the effect of misting and IBA on the rooting of softwood bougainvillea cuttings. The treatments were as follows:

1. Control
2. Mist
3. Mist + 3000 IBA

For each of the above treatment 100 softwood cuttings were planted in vermiculite, outside the glass house, without bottom heat. Cuttings were planted on November 15, 1963. Later newly formed shoots on the cuttings were killed due to an unpredictable cold spell (2.6°C on January 16, 1963) and the experiment was discontinued. Temperature, rainfall and the relative humidity of the outdoor conditions during the winter 1963-64 are reported in table 14.

The above experiment was repeated on June 14, 1964 and rooting response of the cuttings was determined after 10 weeks

D. The last experiment dealt with the effect of different levels of IBA on the rooting of softwood bougainvillea cuttings. The treatments were as follows:

1. Control
2. IBA at 2000 ppm.
3. IBA at 4000 ppm.
4. IBA at 6000 ppm.
5. IBA at 8000 ppm.

For each of the above treatments 100 cuttings were taken, and planted in vermiculite under constant mist. Cuttings were planted on June 15 and lifted on August 17 and the rooting was evaluated according to the Ranks Method.

## EXPERIMENTAL RESULTS

Experiments were conducted during the years 1963-64 at the American University of Beirut to find effective means for the rooting of magnolia and bougainvillea cuttings under outdoors and glass house condition. The results obtained from this study are reported in tables 1 to 13. The analysis of variance for each character studied is given in the Appendix in tables 15 to 25. For convenience the findings are reported as follows:

I. The experimental findings for the rooting of magnolia cuttings are reported under three headings, namely callusing, rooting and mortality.

A. Callusing.

Each callusing was observed for all cuttings placed under mist. By studying table 1, it is seen that only those cuttings receiving mist showed callus formation one month after planting. However, after an interval of two months from the planting date, callusing was found on some of the cuttings under no mist. The percent callusing observed at that time differed among treatments, with the control showing the least amount, and the cuttings receiving the mist and IBA at 8000 ppm. producing the largest number of callused cuttings.

Three months after planting, and at the time of ter-

Table 1. Mortality, callusing and rooting of magnolia (M. grandiflora) cuttings as influenced by misting, IBA and period of rooting.

| Date of observation* | % Mortality of total | | | % Callusing of total | | | % Rooting of total | | |
|---|---|---|---|---|---|---|---|---|---|
| | Control | Mist | Mist + IBA | Control | Mist | Mist + IBA | Control | Mist | Mist + IBA |
| November 17 | 22 | 15 | 15 | 0 | 4 | 8 | 0 | 0 | 0 |
| December 17 | 20 | 12 | 8 | 10 | 18 | 25 | 7 | 7 | 13 |
| January 15 | 17 | 9 | 3 | 8 | 10 | 14 | 8 | 9 | 22 |
| Total % | 59 | 36 | 26 | 18 | 32 | 47 | 15 | 16 | 35 |

* Cuttings planted on October 17, 1963.

minating the experiment, it was revealed that there was a significant increase in the amount of callus formation on the cuttings under mist and IBA treatment as compared with the control. The above results are reported in table 2. There was no significant difference in the amount of callused cuttings between the control and those receiving mist alone, as well as the latter and those receiving mist and IBA. However it could be observed that there was an indication of increased number of callused cuttings among any two treatments.

By studying the data obtained in the second experiment, in which the effect of wounding and IBA were investigated as to their influence on rooting, it was revealed that wounding and wounding with IBA at 8000 ppm. produced a high amount of callus formation on cuttings treated as such (table 3). Furthermore, it was found that callusing occurred on a larger number of cuttings two months after planting, under all treatments, as compared to the amount of callusing occurring at one and three months after planting. The total amount of callused cuttings counted at the time of the termination of the experiment are reported in table 6. There was no significant difference as to number of callused cuttings among treatments. However, the cuttings that received wounding and IBA at 8000 ppm. showed a slightly larger number of callused cuttings as compared with the other treatments. However, the cuttings that received wounding and IBA

Table 2. Effect of misting and IBA on percentage callusing of magnolia (M. grandiflora) cuttings.

| Treatment | Percentage callused mean* of four replications |
|---|---|
| 1. Control | 18 |
| 2. Mist | 32 |
| 3. Mist + IBA | 47 |

* L.S.D. at 5% level = 17.92.

Table 3. Callusing, rooting and mortality of magnolia (M. grandiflora) cuttings as influenced by wounding, wounding with IBA and IBA.

| Date of observation* | % Mortality of total | | | | % Callusing of total | | | | % Rooting of total | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Control | Wounding | Wounding + IBA | IBA | Control | Wounding | Wounding + IBA | IBA | Control | Wounding | Wounding + IBA | IBA |
| March 15 | 23.75 | 15 | 22.5 | 23.75 | 3.75 | 7.5 | 12.5 | 3.75 | 0 | 0 | 0 | 0 |
| April 15 | 12.5 | 12.5 | 7.5 | 15 | 15 | 21.25 | 17.5 | 16.25 | 6.25 | 6.25 | 10 | 3.75 |
| May 9 | 6.25 | 5 | 2.5 | 7.5 | 10 | 5 | 7.5 | 6.25 | 17.5 | 22.5 | 17.5 | 18.75 |
| Total % | 42.50 | 32.50 | 32.50 | 46.25 | 28.75 | 33.75 | 37.50 | 26.25 | 23.75 | 28.75 | 27.5 | 22.50 |

* Cuttings planted on February 15, 1964.

Table 4. Effect of wounding, wounding with IBA and IBA on percentage callusing of magnolia (M. grandiflora) cuttings.

| Treatment | Percentage callused mean of four replications |
|---|---|
| 1. Control | 28.75 |
| 2. Wounding | 33.75 |
| 3. Wounding + IBA | 37.50 |
| 4. IBA | 26.25 |

Calculated F = 1.28 (N.S).

at 8000 ppm. showed a slightly larger number of callused cuttings as compared with the other treatments.

B. Rooting.

As seen in table 1 and 3, there was no rooting during the first 30 days after planting the cuttings, irrespective of the treatments received by the cuttings. However the amount of rooted cuttings increased under all treatments as time advanced.

At the end of the first experiment on magnolia, it was seen that cuttings receiving IBA with mist had 35% rooting which was significantly higher than cuttings under mist condition with 16% and the control with 15% rooting (tables 1 and 5).

In the second experiment on magnolia, wounding together with IBA increased rooting of the cuttings significantly as compared with the other treatments and the control (table 6). Wounding with no IBA treatment increased rooting of the cuttings significantly over the control, but the difference in rooting of the cuttings under this treatment and that of cuttings which received only IBA was not statistically significant. By comparing the rooting percentage of cuttings under the control with those receiving IBA at 8000 ppm. it was found that although IBA increased the rooting slightly the increase was not statistically significant.

Table 5. Effect of misting and IBA on percentage rooting of magnolia (M. grandiflora) cuttings evaluated by the Ranks Method.

| Treatment | High (5) | Medium (3) | Low (1) | 0 (0) | Index total | Mean* of Index |
|---|---|---|---|---|---|---|
| 1. Control | 4 | 5 | 6 | 85 | 41 | 10.25 |
| 2. Mist | 6 | 4 | 6 | 84 | 48 | 12.00 |
| 3. Mist and IBA at 8000 ppm | 22 | 11 | 2 | 65 | 145 | 36.25 |

* L.S.D. at 5% level = 13.73.

Table 6. Effect of wounding, wounding with IBA and IBA on percentage rooting of magnolia (M. grandiflora) cuttings.

| Treatment | High (5) | Medium (3) | Low (1) | 0 (0) | Index total | Mean* of Index |
|---|---|---|---|---|---|---|
| 1. Control | 5 | 5 | 9 | 81 | 49 | 9.8 |
| 2. Wounding | 9 | 6 | 8 | 77 | 71 | 14.2 |
| 3. Wounding + IBA 8000 ppm | 15 | 5 | 2 | 78 | 92 | 18.4 |
| 4. IBA 8000 ppm | 9 | 6 | 3 | 82 | 66 | 13.2 |

* L.S.D. at 5% level = 4.07.

C. Mortality.

High mortality was observed during the first 30 days after planting, as seen in tables 1 and 3. Mortality however decreased as time advanced. The percentage mortality of the cuttings was significantly higher under the control treatments, as compared with those under misting (table 7). Under the mist condition, the mortality was higher in untreated cuttings, as compared with those treated with IBA at 8000 ppm.

At the end of the second experiment on magnolia, it was found that there was no significant difference between the percentage mortality of the wounded cuttings and those kept as a control (table 8).

II. The results of the experiments on the rooting of bougainvillea cuttings were as the following:

A. Results of the effect on root formation of retreating bougainvillea cuttings with IBA are reported on table 9. It was found that cuttings retreated with IBA at 3000 ppm. produced similar rooting when compared with those treated only at planting time.

However, IBA at 3000 ppm., when used either once or twice increased rooting of bougainvillea cuttings significantly over the control.

B. The results of the experiment in which hardwood and softwood bougainvillea cuttings were planted in both sand

Table 7. Effect of mist and IBA on percentage mortality of magnolia (M. grandiflora) cuttings.

| Treatment | Percentage mortality mean* of four replications |
|---|---|
| 1. Control | 59 |
| 2. Mist | 36 |
| 3. Mist + IBA | 26 |

* L.S.D. at 5% level = 8.64.

Table 8. Effect of wounding and IBA on percentage mortality of magnolia (M. grandiflora) cuttings.

| Treatment | Percentage mortality mean of four replications |
|---|---|
| 1. Control | 42.50 |
| 2. Wounding | 32.50 |
| 3. Wounding + IBA 8000 ppm | 32.50 |
| 4. IBA 8000 ppm | 46.25 |

Calculated F = 3.015 (N.S.).

Table 9. Effect on root formation of re-treating bougainvillea (B. glabra) hardwood cuttings with IBA.

| Treatment | High (5) | Medium (3) | Low (1) | 0 (0) | Index total | Mean* of Index |
|---|---|---|---|---|---|---|
| 1. Control | 9 | 3 | 11 | 77 | 65 | 16.25 |
| 2. IBA 3000 ppm (1 application) | 25 | 9 | 7 | 59 | 159 | 39.75 |
| 3. IBA 3000 ppm (2 applications) | 28 | 3 | 7 | 62 | 156 | 39 |

*' L.S.D. at 5% level = 14.98.

Cuttings were planted inside the glass house on October 17, and lifted on January 10, 1963.

and vermiculite are reported in table 10. There was a significant increase in the rooting of hardwood cuttings as compared with softwood cuttings, in both sand and vermiculite. Interaction between media and types of cuttings, and also the variations between the four replications were not found to be statistically different.

The cuttings rooted in sand had a very long brittle root system that made uprooting without breakage practically impossible. Only results on number and length of roots, as well as the height of shoots, for the cuttings planted in vermiculite are reported in table 11. At the end of this experiment it was found that there was no difference in number and length of roots formed on either hardwood or softwood cuttings. The height of new shoots however, was found to be significantly greater on hardwood cuttings, as compared with those on the softwood. It was further observed that no callus formation occurred on bougainvillea cuttings throughout the trials.

C. By studying the data presented in table 12 it was revealed that IBA at 3000 ppm. together with mist, significantly increased rooting of softwood bougainvillea cuttings as compared with mist alone and the control. There was no significant difference in rooting of cuttings receiving the misting treatment without IBA and the control.

Table 10. Effect of media and type of cuttings on the percentage rooting of bougainvillea (B. glabra) cuttings.

| Media | Type of cuttings | Percentage rooting mean* of four replications |
|---|---|---|
| Sand | Hardwood | 51 |
| | Softwood | 31 |
| Vermiculite | Hardwood | 49 |
| | Softwood | 18 |

* L.S.D. at 5% level = 15.05, for the types of cuttings.

Cuttings were planted inside the glass house on December 25, 1963 and lifted on March 10, 1964.

Table 11. Effect of type of cuttings on root number and length, and on height of newly formed shoots in bougainvillea (B. glabra) cuttings.

| Types of cuttings | Mean of number of roots | Mean of length of roots (cm) | Mean of height of shoots (cm) |
|---|---|---|---|
| 1. Hardwood | 4 | 14.13 | 4.87 |
| 2. Softwood | 3.22 | 12.88 | 1.33 |
| Difference between the means | Observed "t" = 1.33<br>Theoretical "t" at 5% level = 2 | Observed "t" = 0.504<br>Theoretical "t" at 5% level = 2 | Observed "t" = 5.472<br>Theoretical "t" at 1% level = 2.66 |

Table 12. Effect of misting and IBA on percentage rooting of softwood bougainvillea (B. glabra) cuttings.

| Treatment | percentage rooting mean* of four replications |
|---|---|
| 1. Control | 3 |
| 2. Mist | 8 |
| 3. Mist + IBA 3000 ppm | 30 |

* L.S.D. at 5% level = 6.09.

Cuttings were planted outside the glass house on June 14 and lifted on August 28, 1964.

D. IBA at different concentrations did not show any significant effect on the rooting of bougainvillea cuttings (table 13). However, it was observed that there was an indication of increased rooting of the cuttings under different treatments of IBA, as compared with the control. It seemed that IBA at 4000 ppm. was a slightly more effective dose than others employed.

Table 13. Effect of different concentrations of IBA on percentage rooting of bougainvillea (B. glabra) hardwood cuttings evaluated by the Ranks Method.

| Treatment | High (5) | Medium (3) | Low (1) | 0 (0) | Index total | Mean of Index |
|---|---|---|---|---|---|---|
| 1. Control | 7 | 10 | 15 | 68 | 80 | 20.00 |
| 2. IBA 2000 ppm | 8 | 13 | 21 | 58 | 100 | 25.00 |
| 3. IBA 4000 ppm | 10 | 22 | 24 | 44 | 140 | 35.00 |
| 4. IBA 6000 ppm | 11 | 18 | 16 | 55 | 125 | 31.25 |
| 5. IBA 8000 ppm | 10 | 18 | 20 | 52 | 124 | 31.00 |

Calculated F = 1.549(N.S.).

Cuttings were planted under constant mist outside the glass house on June 15, and lifted on August 17, 1964.

## DISCUSSION OF RESULTS

Mist, IBA and wounding produced a marked effect on callusing, rooting and survival of magnolia cuttings. It was observed that cuttings kept under mist, irrespective of their rooting condition, remained in a turgid state. This state of turgidity and lack of wilting enhanced better callusing, rooting and low mortality, especially when IBA was used as a root promoting substance. This finding is in agreement with the work of Rowe-Dutton (20) who obtained 41% rooting with the application of mist to the hormone treated magnolia cuttings. The results with IBA are in agreement with the works of Enright (7), Wells (29) and Soukop (27) who used IBA as a root promoting substance for rooting of magnolia cuttings and obtained a high percentage rooting. Samantaria (26) reported that stem cuttings of magnolia did not respond to IAA or IBA, which does not agree with the findings of this investigation.

Cuttings treated with IBA and kept under mist produced a maximum of 35% rooting in this study, which was considerably lower than 88% or 74% to 88% rooting, as reported by Enright (7) and Lerch (15) respectively. However this low rooting response of magnolia cuttings is believed to be due to the low temperature prevailing during rooting as these experiments were carried on outside the glass house

during the winter of 1963-64. On the other hand, magnolia cuttings which were placed inside the glass house lost their turgidity within a few days. This was believed to be due to the fast rate of transpiration by the leaves as the glass house temperature was relatively high. Misting was found to be a good means for reducing the rate of transpiration of the leaves as previously discussed by Rowe-Dutton (20).

At the termination of the first experiment on magnolia a large number of cuttings was callused but not rooted (table 1). From the percentage rooting and callusing occurring on January 17 as compared with those on December 17, it could be assumed that if the experiment was extended further a higher percentage of the cuttings, both under the mist and control, could have rooted. However, toward the end of the experiment, cuttings under mist started to turn yellow, presumably due to excessive leaching of the media and prolonged wilting of the leaves. Further it was felt that three months was a good arbitrary period for commercial magnolia rooting and as such it was decided to uproot the cuttings.

The increase in rooting and callusing of magnolia cuttings due to wounding, as reported in this study, is in agreement with the work of Stuart and Marth (28), Longley (17), Garner (10) and Wells (30). Wounding and IBA at 8000 ppm. produced high rooting which is in agreement with the work of Hartman and Kester (12) who stated that the

best rooting could be obtained by treating the cuttings with one of the root promoting substances immediately after wounding.

The results of this investigation have shown that, in order to obtain high rooting on magnolia cuttings, root promoting substances together with mist and wounding must be applied. Further work with bottom heat is suggested to determine if such an aid together with the above treatments might further increase the rooting of the cuttings.

The results obtained from the rooting of bougainvillea cuttings revealed that treating the same cuttings at two intervals with IBA at 3000 ppm. did not produce higher rooting as compared with those treated only once. This finding is not in agreement with the results obtained by Went and Cooper as reported by Pearse (21). The latter investigators were able to increase rooting with two treatments of IBA. The finding that 1 treatment and 2 treatments applied to bougainvillea cuttings increased rooting equally, is in agreement with the findings of Popenoe (23). This result is also partly in agreement with the work of Maxon, Picket and Rickey, as reported by Pearse (21).

Upon examining the rooting response of bougainvillea cuttings, as influenced by different rooting media, it was revealed that cuttings root equally well in both sand and vermiculite. However, the media was found to exert an influence on the type of root formed. Cuttings planted in

sand produced a very long and brittle root system which made uprooting difficult, without the loss of roots. Sand was found to produce brittle and long roots by Long (16). From the results obtained it could be concluded that vermiculite is a preferable medium for rooting of bougainvillea cuttings as it produced a well branched and strong root system and the uprooting operation was found to be practical.

From the rooting results reported in table 10,and the amount of shoots reported in table 11, it is seen that hardwood bougainvillea cuttings are better propagating material than softwood. This seems to be due to the facts that hardwood cuttings contain more carbohydrate reserve and have a lower rate of transpiration as compared with the softwood cuttings. The type of cuttings may not be considered important if misting is used, as this will cut down on the rate of transpiration and maintain the cuttings in a turgid state. The latter suggestion is further supported by the finding that softwood bougainvillea cuttings produce high rooting under mist condition. The above results are in agreement with the work of Knight, Bean and Hanger (14).

Upon studying the effect of a range of IBA concentrations on the rooting of softwood bougainvillea cuttings it was found that the increase in concentration had no correlation with the percentage rooting of the cuttings. However there was an indication that IBA at 4000 ppm. produced slightly higher rooting as compared with the other

concentrations and the control.

The above findings indicate that in order to obtain high rooting, hardwood bougainvillea cuttings should be taken, treated with IBA at 4000 ppm. and planted in a medium of vermiculite or similar materials if available. Misting is recommended in the propagation of bougainvillea especially if softwood cuttings are to be used during spring or summer.

## SUMMARY AND CONCLUSION

The study reported in this thesis was undertaken during the years 1963-64, to evaluate the effect of some propagation aids and other factors namely misting, misting + IBA, wounding, planting media and type of cuttings on the rooting of magnolia (M. grandiflora) and bougainvillea (B. glabra) cuttings.

From current season branches of magnolia and bougainvillea, cuttings 10 cm. long were obtained. The cuttings were wrapped in a moist towel during their handling to keep them from desiccation. The cuttings to be wounded were slit about 2 cm. upward from the base before planting and those which were to be treated received IBA in different concentrations. The treatments were applied using the concentrated-solution-dip method. Planting was carried out in flats filled with sand or vermiculite inside and outside the glass house. Planting under mist condition received a continuous fine spray of water during daytime.

The experimental work of this study was in two parts. The first part dealt with the rooting of magnolia cuttings and was made of 2 experiments, while the second part dealt with the rooting of bougainvillea cuttings and consisted of 4 experiments.

Mist, IBA and wounding produced a marked effect on

callusing, rooting and survival of magnolia cuttings. Misting applied together with IBA produced the maximum callusing. Wounding treatments showed no significant increase in total callusing. Wounding, together with IBA, increased rooting of magnolia cuttings. High mortality was observed during the first 30 days after planting in magnolia cuttings.

Bougainvillea cuttings which were retreated with IBA at 3000 ppm. two months after planting produced similar rooting to the cuttings which were treated only at planting time. IBA at 3000 ppm., when used once or twice, increased rooting of bougainvillea cuttings. Hardwood cuttings of bougainvillea produced higher rooting than softwood cuttings. The height of the new shoots was found to be significantly longer on hardwood cuttings as compared with those on softwood. It was found that vermiculite was a better rooting medium for bougainvillea cuttings.

The results of this investigation has shown that, in order to obtain high rooting on magnolia cuttings, root promoting substances together with mist and wounding must be applied. The findings from the work on propagation of bougainvillea indicate that in order to obtain high rooting hardwood bougainvillea cuttings should be taken, treated with IBA at 4000 ppm. and planted in vermiculite. Misting is recommended in the propagation of bougainvillea especially if softwood cuttings are to be used during spring or summer.

Further work with bottom heat is suggested to determine if such an aid together with the above employed factors might increase the rooting of magnolia cuttings.

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# A P P E N D I X

Table 14. Monthly mean maximum and minimum temperature, total rainfall and relative humidity at the Campus of the American University of Beirut*

| Month | Mean maximum (°C) | Mean minimum (°C) | Monthly total rainfall (mm) | Mean relative humidity (%) |
|---|---|---|---|---|
| October 1963 | 26.83 | 20.93 | 24.65 | 70.6 |
| November 1963 | 22.58 | 17.36 | 136.80 | 70.6 |
| December 1963 | 18.34 | 12.58 | 137.05 | 66.6 |
| January 1964 | 15.16 | 10.02 | 96.30 | 62.2 |
| February 1964 | 10.94 | 10.79 | 319.90 | 73.4 |
| March 1964 | 19.40 | 13.80 | 91.10 | 75.7 |
| April 1964 | 21.50 | 15.20 | 21.10 | 67.9 |
| May 1964 | 23.00 | 17.00 | 53.70 | 72.3 |

* Data acquired from the Observatory, American University of Beirut, Beirut, Lebanon.

Table 15. Analysis of variance for the percentage callusing of magnolia as reported in table 2.

| Source | D.F. | M.S. | F. |
|---|---|---|---|
| Replications | 3 | 97.33 | 6.64* |
| Treatments | 2 | 841.38 | 57.43** |
| Error | 6 | 14.65 | |

* Significant at the 5 percent level.
** Significant at the 1 percent level.

Table 16. Analysis of variance for the percentage rooting of magnolia cuttings as reported in table 5.

| Source | D.F. | M.S. | F. |
|---|---|---|---|
| Replications | 3 | 147.66 | 2.29 |
| Treatments | 2 | 854 | 13.27** |
| Error | 6 | 64.33 | |

** Significant at the 1 percent level.

Table 17. Analysis of variance for the percentage mortality of magnolia cuttings, as reported in table 7.

| Source | D.F. | M.S. | F |
|---|---|---|---|
| Replications | 3 | 12 | 0.064 |
| Treatments | 2 | 1145.5 | 54.1** |
| Error | 6 | 21.16 | |

** Significant at the 1 percent level.

Table 18. Analysis of variance for the percentage callusing of magnolia cuttings, as reported in table 4.

| Source | D.F. | M.S. | F |
|---|---|---|---|
| Replications | 3 | 22.38 | 0.28 |
| Treatments | 3 | 101.55 | 1.28 |
| Error | 9 | 79.34 | |

Table 19. Analysis of variance for the percentage rooting of magnolia cuttings, as reported in table 6.

| Source | D.F. | M.S. | F |
|---|---|---|---|
| Replications | 3 | 7.5 | 1.15 |
| Treatments | 3 | 89.17 | 13.71** |
| Error | 9 | 6.5 | |

** Significant at the 1 percent level.

Table 20. Analysis of variance for the percentage mortality of magnolia cuttings, as reported in table 8.

| Source | D.F. | M.S. | F |
|---|---|---|---|
| Replications | 3 | 68.23 | 1.042 |
| Treatments | 3 | 197.39 | 3.015 |
| Error | 9 | 65.45 | |

Table 21. Analysis of variance for percentage rooting of bougainvillea cuttings, as reported in table 9.

| Source | D.F. | M.S. | F |
|---|---|---|---|
| Replications | 3 | 301.33 | 3.93 |
| Treatments | 2 | 713.60 | 9.31* |
| Error | 6 | 76.58 | |

* Significant at the 5 percent level.

Table 22. Analysis of variance for percentage rooting of two types of bougainvillea cuttings planted in two different media, as reported in table 10.

| Source | D.F. | M.S. | F |
|---|---|---|---|
| Replications | 3 | 19.66 | 0.173 |
| Media | 1 | 225 | 1.99 |
| Error (a) | 3 | 113 | |
| Types of cuttings | 1 | 2601 | 34.27** |
| Media x Types of cuttings | 1 | 121 | 1.59 |
| Error (b) | 6 | 75.66 | |

** Significant at the 1 percent level.

Table 23. "t"*test for determining the effect of type of cuttings on root number and length, and on height of newly formed shoots in bougainvillea cuttings as reported in table 11.

| | Hardwood cuttings | Softwood cuttings |
|---|---|---|
| 1. Number of rooted cuttings | 48 | 18 |
| 2. Mean of number of roots | 4 | 3.22 |
| 3. Mean of length of roots | 14.13 | 12.88 |
| 4. Mean of height of shoots | 4.85 | 1.33 |

* The following formulas were used in "t" calculation:

1. $$S^2 = \frac{S(x_i - \bar{x})^2 + S(x_2 - \bar{x})^2}{(n_1 - 1)(n_2 - 1)}$$

2. $$t = \frac{\bar{x}_i - \bar{x}_2}{S} \sqrt{\frac{n_1 x\, n_2}{n_1 + n_2}}$$

Table 24. Analysis of variance for rooting percentage of bougainvillea cuttings, as reported in table 12.

| Source | D.F. | M.S. | F |
|---|---|---|---|
| Replications | 3 | 12 | 0.6 |
| Treatments | 2 | 825.33 | 41.27** |
| Error | 6 | 22 | |

** Significant at the 1 percent level.

Table 25. Analysis of variance for rooting percentage of bougainvillea cuttings, as reported in table 13.

| Source | D.F. | M.S. | F |
|---|---|---|---|
| Replications | 3 | 10.31 | 0.113 |
| Treatments | 4 | 140.61 | 1.549 |
| Error | 12 | 90.75 | |