

Rooting of *Bougainvillea spectabilis* Willd. stem cuttings using indolbutyric acid

Enraizamento de estacas de *Bougainvillea spectabilis* Willd. com o uso de ácido indolbutírico

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Abstract

The use of indolbutyric acid (IBA) as a stimulator of rooting in cuttings of *Bougainvillea spectabilis* Willd. can provide an increased root system for marketable seedlings. This study aimed to evaluate the rooting, shoot formation and survival of herbaceous, woody and semi-woody cuttings of *Bougainvillea* using IBA. The cuttings were collected and treated with IBA (1000 and 2000 mg/l). At 56 days the percentage of alive cuttings, rooted and with shoots, number of shoots and roots per cutting and the length of the longest root and highest bud were evaluated. The lowest rooting percentages were found in cuttings without the use of IBA. Major differences were found for woody cuttings. The use of IBA promotes rooting of *Bougainvillea*, with better performance for woody cuttings and using concentrations of 2000 mg/l IBA.

Key words: Rooting, synthetic auxin, cutting propagation.

Resumo

O uso de ácido indolbutírico (IBA) como estimulador do enraizamento em estacas de *Bougainvillea spectabilis* Willd. pode propiciar aumento de raízes para a formação de mudas comercializáveis. Objetivou-se avaliar o enraizamento, a formação de brotos e a sobrevivência de estacas herbáceas, lenhosas e semi-lenhosas de *Bougainvillea* com o uso de ácido indolbutírico (IBA). As estacas foram coletadas e tratadas com o IBA (1000 e 2000 mg/l). Aos 56 dias avaliaram-se a porcentagem de estacas vivas, enraizadas e com brotos; o número de brotos e de raízes por estaca e o comprimento da maior raiz e maior broto. As menores porcentagens de enraizamento foram verificadas nas estacas sem o uso de IBA. Maiores diferenças foram verificadas para as estacas lenhosas. O uso do IBA favorece o enraizamento de estacas de *Bougainvillea*, com melhor desempenho para as estacas lenhosas e na concentração de 2000 mg/l de IBA.

Palavras chave: Enraizamento, auxina sintética, estaquia.

Introduction

The use of ornamental plants has been disseminated in order to improve the population's quality of life, which increasingly invests in the landscaping of outdoor and indoor, generating growing interest in particular techniques of production of plants (Angelis-Neto and Angelis, 1999; Lorenzi and Souza, 2008; Ferriani *et al.*, 2006), among which the cuttings technique is highlighted (Loss *et al.*, 2008, 2009; Pereira *et al.*, 2012).

According to Monteguti *et al.* (2008) the successful use of propagation by cutting using woody cuttings of grapevine rootstocks, can also occur in ornamental plant cuttings, for example, bougainvillea (*Bougainvillea spectabilis*) (buganvília), depends on a set of external and internal factors. Among the internal factors are cited genetic variability, physiological conditions, the mother plant age, the type of cutting and the developmental stage in which they are harvested. As external factors are cited the environmental conditions to which the cutting are submitted and the substrate used.

From Brazil, the bougainvillea also known there as “primavera”, “ceboleiro”, “três-marias” or “flor-de-papel”, is a rustic, very cultivated and appreciated worldwide species. It is a climbing plant that has varied attractive colored flowers such as shades of white, orange, red and purple, the latter being the most prevalent. It has a stem protected by strong thorns branching every year in shoots, which grow in a disorganized way, reaching 9 m in height. The true flowers are small yellow and white tubes that are involved in three fused bracts, or modified leaves that are responsible for their colorful appearance (Lorenzi and Souza, 2005; 2008).

The bougainvillea can be used in walls and fences or window framing, especially in areas of Mediterranean architecture, enriching the decoration and letting stand out the light with their vivid colors. It is ideal to be placed on patios or even entries, being the pruning the mechanism to guide and control its shape and growth (Ribeiro, 1994).

Its propagation can be done by cuttings (Lorenzi and Souza, 2008), but low rooting percentages are obtained (Singh *et al.*, 2011; Cerveny and Gibson, 2006). Cuttings can be classified according to their position in the plant as apical, middle or basal and, according to their stage of development in woody, herbaceous or semi-woody or semi-herbaceous (Souza, 1977).

Woody cuttings would be those with strong tissue, hardened and resilient, while herbaceous are those with juicy aspect, less consistent. The semi-woody or semi-herbaceous are intermediate between the two extremes (Souza and Inforzato, 1959).

Regarding the low percentage of rooting present in the cuttings, to improve the rooting plant growth regulators are used, which aim to accelerate the root initiation, increase the number and quality of formed roots and standardize the rooting (Fachinello *et al.*, 1995).

Among the growth regulators used to induce rooting, is distinguished the indolebutyric acid (IBA). However it is difficult to make specific recommendations, since proper concentration varies, among other factors, according to the species or cultivar, type of cutting used and the time of its harvesting. The IBA has the advantages of low toxicity, more localized action than other products and greater chemical stability at the cutting body (Hartmann *et al.*, 2011). Because the concentrations of the plant regulators change in function to several factors, among them, the species, the maturity stages of the buds, means of application (Gupta *et al.*, 2002; Singh *et al.*, 2011; Loss *et al.*, 2009; Pereira *et al.*, 2012).

Few studies are made to improve the ways of spreading *Bougainvillea spectabilis* and optimize its production, reducing the time to use the seedlings. The method of propagation by cuttings, besides ensuring an offspring identical to the mother plant, can reduce the time to use seedlings of various ornamental plants. This research has as objectives to analyze the rooting, bud formation and survival of herbaceous, Woody and semi-woody cuttings of *Bougainvillea spectabilis* using indolebutyric acid (IBA).

Materials and methods

The experiment was conducted at the greenhouse of the horticultural area of the Institute of Agronomy, Department of Plant Protection of the Universidade Federal Rural do Rio de Janeiro, located at latitude 22° 45' S, longitude 43° 41' W and 33 MASL, being the climate type Aw according to Köppen.

The stems of bougainvillea were collected in early April 2011 from a mother plant of about 5 years old, located on the garden of the UFRRJ campus. Later, these stems (\pm 1m long) were cut (bevel) to obtain three cuttings of 0.20 m each

and at least three buds per cutting, the section was made according to its position in the branches, namely: herbaceous cutting (subapical, more tender, $\pm 0.50\text{-}0.80$ cm in diameter); hardwood cuttings (basal, ± 1 cm in diameter) and semi-hardwood cuttings (middle, with intermediate characteristics to the others, $\pm 0.80\text{-}1$ cm in diameter).

For all the cuttings, leaves were carefully removed to homogenize the samples and the injuries that could be caused in the cuttings were checked. The herbaceous cuttings were kept with two leaves, which were cut in half to avoid excessive water loss. However, the number of buds and size were the same for woody and semi-woody cuttings.

After preparation of the cuttings, these were subjected to the phytosanitary treatment with immersion in sodium hypochlorite solution 1% for 10 minutes and subsequently in the treatment solution, IBA solution at concentrations of 1000 and 2000 mg/l, and a control treated in distilled water. For the treatment of cuttings groups of ten cuttings were made and immersed in the treatment solution for 10 s. The cuttings were planted in a concrete bed inside the greenhouse, using washed sand as substrate. Then, the cuttings were planted at a depth of 1/3 its size, distributed in blocks with nine lines each containing 10 cuttings per line, and randomizing the treatments (spacing was ± 5 cm between cuttings and lines). The experimental design was a randomized block with three replications and each plot consisted of 10 cuttings. The experimental analysis was in a factorial 3 x 3 (three types of stems and three concentrations of IBA). Each treatment (0, 1000 and 2000 mg/l IBA) was composed of 30 cuttings (three lines with ten cuttings), being one line a replicate, for a total of 30 herbaceous cuttings, 30 woody and 30 semi-woody for each evaluated treatment.

The data collected was subjected to the test of Lilliefors and Cochran-Bartlett, to verify the normality of the data and the homogeneity of variances, there was no need for data transformation. The results were subjected to analysis of variance with the use of the 'F' test and to compare means the Tukey's test was used at 5% probability.

The cuttings were subjected to sprinkler irrigation daily until the end of the experiment that was after 56 days of installation, analyzing the percentage of alive cuttings, rooting percentage, percentage of cuttings with shoots; the

number of shoots and roots per cutting and the length of the largest root and higher bud of each treatment. There were no callus formation, therefore they were not evaluated.

Results and discussion

For the percentage of live cutting differences were observed for all concentrations, being the woody cuttings the ones with higher percentages of alive cuttings, regardless of the concentration of IBA. With regard to different concentrations of IBA, in the semi-woody and woody cuttings no differences were observed, indicating that the survival of cuttings is not directly related to the dose of IBA, but with the cuttings. For herbaceous cutting, the concentration of 1000 mg/l of IBA proved to be more efficient in the percentage of alive cuttings when compared to control (Table 1).

Table 1. Effect of the interaction of the cutting type and the concentrations of indolebutyric acid (IBA) in relation to the percentage of root formation, budding and alive cuttings in *Bougainvillea spectabilis*, performed at UFRRJ, Seropédica, RJ.

Analyzed variables	Concentration (mg/l)	Cutting type		
		Herbaceous	Semi-woody	Woody
% of alive cuttings	0	16.8 Bb*	26.7 Ba	83.3 Aa
	1000	53.3 Ba	20.0 Ca	83.3 Aa
	2000	40.0 Bab	10.0 Ba	90.0 Aa
% of rooted cuttings	0	0.0 Aa	0.0 Ab	0.0 Ac
	1000	13.3 Ba	10.0 Bab	36.7 Ab
	2000	13.3 Ba	23.3 Ba	60.0 Aa
% of cuttings with buds	0	30.00 Ba	20.00 Ba	66.67 Ab
	1000	10.00 Cb	30.00 Ba	90.00 Aa
	2000	30.0 Ba	20.0 Ba	66.7 Ab
	2000	10.0 Cb	30.0 Ba	90.0 Aa

Averages followed by the same lower case letter in the row are not statistically different among the cutting type, for each concentration according to Tukey's test at 5%; followed by the same lower case letter in the column are not statistically different among concentrations, for each cutting type according to Tukey's test at 5%.

Paula *et al.* (2007) evaluated the effect of indole butyric acid (0, 500, 1000 and 2000 mg/l) at rates 0.5% (based on molybdenum and cobalt and 0.5% naphthalene acetic acid) on rooting of herbaceous and woody cuttings of *Spondias tuberosa* (imbu) and found that the woody cuttings showed the best results in relation to survival when compared to the herbaceous cuttings. This pattern is similar to what is found in this study.

Regarding the percentage of rooted cuttings, the control had zero, regardless of the cutting. However, when using the IBA was observed that woody cuttings presented the best answer to rooting at doses of 1000 and 2000 mg/l, which is corroborated by the percentage of alive cutting, except in the control. These results are due to the higher degree of lignification of woody cuttings, compared to herbaceous and semi-woody cuttings, which possibly leads to a greater capacity for establishment and survival (Paula *et al.*, 2007) of woody cuttings of *B. spectabilis*; this result is favored by the application of IBA. Similar results were observed by Oliveira *et al.* (2010) in a study using IBA in cuttings of *B. spectabilis*, where woody cuttings treated with 2000 mg/l IBA showed better results in relation to rooting when compared to other cuttings. Singh and Singh (2011) in a study with the use of IBA in cuttings of *B. glabra*, revealed higher percentage of rooting and sprouting in woody cuttings treated with 2,000 mg/l IBA.

For concentrations of 1000 and 2000 mg/l, among the types of cuttings, woody ones showed a higher percentage of rooted cuttings over the others (Table 1). Among the IBA concentrations evaluated, the semi-woody and woody cuttings showed higher percentage of rooted cuttings at concentration of 2000 mg/l, differences were observed between 1000 and 2000 mg/l levels for the semi-woody cuttings (Table 1). The herbaceous cuttings showed no differences between the IBA concentrations used (Table 1). These results demonstrate the interaction of the type of cutting and the hormone, promoting the rooting of cuttings *B. spectabilis*, and highlighting that the woody cuttings showed the best results with 2000 mg/l of IBA. Similar results were observed by Oliveira *et al.* (2010) and Singh and Singh (2011), in woody cuttings of *Bougainvillea* sp. treated with 2000 mg/l de IBA which showed the best results for rooting. Silva *et al.* (2004), evaluated the rooting induction in woody cuttings of *Piper* sp. with IBA at 0, 1000, 2000, 3000, 4000 and 5000 mg/l concentrations, and observed that the woody cuttings were responsive to rooting at higher doses of IBA, being this result similar to the one of this study. According to Silva *et al.* (2004), *Piper* sp. has cofactors in the stem and the buds that favor the vegetative propagation by cuttings, with low amounts of substances that inhibit rooting and therefore, the rooting is more efficient when using promoting substances, in this case the IBA.

Comparing the results of the findings of the study by Silva *et al.* (2004) with the results of this study, it is corroborated that there is also an increase in rooting of *B. spectabilis* when treated with IBA. Therefore, the woody cuttings of *Bougainvillea*, in which the best results for rooting percentage were observed, demonstrate that to produce seedlings by cuttings in large numbers and with industrial standards, the woody cuttings are the recommended.

In relation to the cuttings with buds, it was observed that the woody cuttings also showed the highest percentage in all the concentrations. Among the cuttings, the woody ones had the highest percentage of cuttings with buds at 2000 mg/l concentration (Table 1). For the 0 and 1000 mg/l concentrations there were no differences among the herbaceous and semi-woody cuttings, being only differences among the three type of cuttings only at 2000 mg/l. A similar pattern was found by Singh and Singh (2011) when studying woody cuttings of *B. glabra*, 100% of the cuttings had buds at 2000 mg/l IBA concentration and, among the IBA doses, the woody cuttings also showed a higher bud percentage than the others.

According to Pacheco (2007) the ability to use the necessary carbohydrates for root and bud growth is higher in the woody cuttings than in the basal ones. Therefore, these cuttings have better conditions associated to the source of assimilable energy and maintenance of the metabolic activities of the plant, which are favored by the use of IBA, as can be observed for all the variables analyzed at higher IBA doses.

For the variable root length at a concentration of 1000 mg/l, herbaceous cuttings were observed with larger root lengths when compared with semi-woody cuttings. The concentration of 2000 mg/l, the cuttings with better performance for increased root length were the woody ones (Table 2). These results demonstrate, as seen in Table 1, a direct correlation between the concentration of the hormone and the type of cutting. According to the research of Oliveira *et al.* (2010) the woody cuttings of *B. spectabilis*, with or without leaves, that are treated with IBA at 1000 and 2000 mg/l concentrations, have a better performance (rooting) than the cuttings without leaves at 2000 mg/l concentration of IBA.

For variable bud length, in all concentrations, woody cuttings showed higher values (Table 2). Among the evaluated concentrations, for

Table 2. Effect of the interaction of the cutting type and the concentrations of indolebutyric acid (IBA) in relation to largest root length, largest bud, number of roots and buds per cutting of *Bougainvillea spectabilis*, performed at UFRRJ, Seropédica, RJ.

Analyzed variables	Concentration (mg/l)	Cutting type		
		Herbaceous	Semi-woody	Woody
Root length	0	0.0 Ac*	0.0 Ab	0.0 Ac
	1000	5.3 Aa	3.0 Ba	4.0 ABb
	2000	3.3 Bb	3.7 Ba	8.0 Aa
Bud length	0	1.0 Bb	1.7 Bb	15.0 Ab
	1000	3.3 Ba	4.3 Ba	14.3 Ab
	2000	1.0 Cb	4.0 Ba	21.3 Aa
Number of roots per cutting	0	0.0 Ab	0.0 Ab	0.0 Ab
	1000	4.0 Ba	0.00 Cb	9.7 Aa
	2000	4.0 Ba	4.0 Ba	11.0 Aa 11.00 Aa 11.00 Aa
Number of buds per cutting	0	0.0 Cb	2.3 Bb 2.33 Bb	3.7 Aa
	1000	3.0 Ba	2.3 Bb 2.33 Bb	5.0 Aa
	2000	0.0 Bb	4.0 Aa	4.7 Aa

* Averages followed by the same lower case letter in the row are not statistically different among the cutting type, for each concentration according to Tukey's test at 5%; followed by the same lower case letter in the column are not statistically different among concentrations, for each cutting type according to Tukey's test at 5%.

woody cuttings there was no statistical difference between the control treatment and concentration of 1000 mg/l, there were differences only at concentration of 2000 mg/l, which showed higher bud length (Table 2). Regarding the number of roots per cutting, as was seen, zero was the result for rooting percentage (Table 1) and also for the number of roots in the control treatment (Table 2). At a concentration of 1000 and 2000 mg/l, woody cuttings showed higher number of roots per cutting, with no differences between them.

For the variable number of buds per cutting, there were no statistical differences among the concentrations for the woody cuttings. However, among the types of cuttings, the woody ones showed higher values for number of buds at 0 at 1000 mg/l IBA concentrations; for 2000 mg/l IBA concentration there were differences among the woody and semi-woody cuttings. The semi-woody cuttings had higher values than the herbaceous ones for the control treatment and 2000 mg/l and there are no statistical differences for the 1000 mg/l concentration. Similar results were observed by Pio *et al.* (2005) in olive cuttings, led him to conclude that cuttings with-

out leaves promote higher budding of cuttings and that IBA only promotes the characteristics compromising the root system.

In general, the use of IBA at 1000 and 2000 mg/l favors the rooting percentage and number of roots per cutting of the different cuttings of *B. spectabilis*, variables that were absent in the treatment without IBA (Table 1 and 2, respectively) during a period of 56 days in the experimental conditions evaluated.

These results agree with the ones by Singh and Singh (2011) who evaluated the number of roots in woody cuttings of *B. glabra* with different IBA concentrations (0, 500, 1000, 1500, 2000, 2500, 3000, 3500, 4000, 4500 and 5000 mg/l), finding a larger number of roots per cutting (21) in the treatment with 3000 mg/l, however, the number of roots/cutting was 11.3 and 9.9 in the treatments with 2000 and 1000 mg/l, respectively.

In this study, the treatments with 2000 and 1000 mg/l of IBA for the woody cuttings, resulted in 11 and 9.7 roots per cutting (Table 2), being these results similar to the findings by Singh and Singh (2011). Similarly, cuttings with higher number of roots have better conditions for water and nutrient absorption, favoring a faster development of the plant which is desirable in commercial production of ornamental plants.

Conclusions

Woody cuttings, among the others, where the ones showing the better regenerative capacity in *B. spectabilis*, resulting in a maximum for rooting and budding, independently of the IBA concentration used.

To produce seedlings of *B. spectabilis*, the use of woody cuttings and doses of 2000 mg/l of IBA, turns into a faster production for its commercialization.

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