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BIOLOGY

Indolebutyric acid on the rooting of *Fuchsia* spp. cuttings

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ABSTRACT: *The princess earring is an ornamental plant native to the southern region of Brazil, much appreciated due to the beauty of its outstanding and colorful flowers. This study evaluated the effect of different doses of synthetic auxin indolebutyric acid (IBA) on the rooting of herbaceous cuttings of Fuchsia regia (Vell.) Munz, native species, and Fuchsia hybrida Hort. Ex Siebert & Voss commercial variety 'General Monk Red Blue'. The experiment was carried out in a greenhouse following a randomized block design with a 2x5 factorial arrangement (two genotypes of Fuchsia x five IBA doses). The IBA doses consisted in the concentrations of 0, 200, 400, 600 and 800 mg.L^{-1}. Evaluations were performed 20 days after staking. The parameters evaluated were length of the largest root, number of roots per cutting, fresh weight and dry weight of the aerial part and roots. The concentration of 800 mg.L^{-1} of indolebutyric acid resulted in greater rooting of the cuttings of both Fuchsia materials tested. Therefore, the use of IBA (800 mg.L^{-1}) provided better quality rooted cuttings, with greater length and number of roots.*
Key words: *princess earring, cutting, plant growth regulator, auxin, ornamental plant.*

Ácido indolbutírico no enraizamento de estacas de *Fuchsia* spp.

RESUMO: *O brinco-de-princesa é uma planta ornamental nativa da região Sul do Brasil, muito apreciada devido a beleza de suas flores pendentes e coloridas. O presente trabalho foi realizado com o objetivo de avaliar o efeito de diferentes doses de auxina sintética ácido indolbutírico (IBA) no enraizamento de estacas herbáceas de Fuchsia regia (Vell.) Munz, espécie nativa, e Fuchsia hybrida Hort. Ex Siebert & Voss variedade comercial 'General Monk Red Blue'. O experimento foi conduzido em casa-de-vegetação e o delineamento experimental foi em blocos ao acaso com arranjo fatorial 2x5 (dois genótipos de Fuchsia x cinco tratamentos). Os tratamentos consistiram em controle, e doses de IBA (mg.L^{-1}) (0, 200, 400, 600 e 800). As avaliações foram feitas 20 dias após o estaqueamento. Os parâmetros avaliados foram: comprimento da maior raiz, número de raízes formadas por estaca, massa fresca e massa seca da parte aérea e das raízes. A concentração de 800 mg.L^{-1} de ácido indolbutírico resultou em maior enraizamento das estacas de ambos os materiais de Fuchsia testados. Portanto, o uso de IBA (800 mg.L^{-1}) proporcionou a obtenção de mudas enraizadas de melhor qualidade, maior comprimento e número de raízes.*
Palavras-chave: *brinco de princesa, estaquia, regulador vegetal, auxina, planta ornamental.*

INTRODUCTION

The ornamental plant market drives the demands for new products and the search for information related to the cultivation and propagation of species. Thus, the creation of new varieties with morphological and/or physiological improvements such as flower pigmentation and disease resistance; respectively, is economically important to increase this market segment (ALCANTARA et al., 2008; CORADIN et al., 2011; NOMAN et al, 2017). The princess earring (*Fuchsia* spp.) is an ornamental plant native to South America and has about 8,000 hybrids and cultivars around the world (BRICKELL, 1996). Internationally, *Fuchsia* is widely appreciated and cultivated in the European Community, where there are associations of growers, such as Euro-Fuchsia, composed by members from Austria, Germany, Holland, France, Ireland, Switzerland, United Kingdom, Norway and Denmark (EURO-FUCHSIA, 2018).

Fuchsias are highly appreciated due to the beauty of their flowers, which can be single, semi-

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double or double. They are often bicolored and have contrasting colors of their petals and sepals, which can be purple, magenta, pink or white (BRICKELL, 2011). *Fuchsias* are better adapted to cold climates, are frost-tolerant and can grow in full sun or partial shade (LORENZI & SOUZA, 2008). In Brazil, it is considered the symbol flower of the state of Rio Grande do Sul (Decreto nº 38.400 da Assembleia Legislativa do Rio Grande do Sul, 1998).

The princess earring has a broad range of uses in landscaping. Varieties can be found for planting in pots and in gardens, representing an expressive economic potential (BERRY, 1982, 1989; CORADIN et al., 2011). Establish practices of production for native plants with ornamental potential, like *Fuchsias,* can be a competitive advantage in a market increasingly inclined to products with reduced environmental impact (HEIDEN et al., 2006). Furthermore, princess earring production constitutes a suitable alternative for small and medium scale farmers, due to its profitability and the small land area required (TOMBOLATO, 2008; JUNQUEIRA & PEETZ, 2017).

These plants can be propagated by seeds or by stem cuttings (LORENZI & SOUZA, 2008). The cutting method has proved to be the most effective alternative for the propagation of ornamental plants on a commercial scale, as it provides the formation of cuttings quickly and easily, in large quantities and at low cost (HARTMANN et al., 2002; MAZZINI, 2012; EMER et al., 2016). In addition, this technique ensures the production of cuttings genetically identical to the parent plant (CAMPOS & PETRY, 2009).

There are a variety of exogenous and endogenous factors that influences the rooting process in cuttings. Among the endogenous factors, phytohormones are critical. Its functions include stimulation of adventitious roots growth, activation of cambial cells, inhibition of lateral buds emissions, abscission of leaves and fruits and promotion of plant growth (FACHINELLO et al, 2005).

In this context, the auxins can play key role on vegetative propagation (FACHINELLO et al, 2005). The application of synthetic auxins at the base of plant cuttings, such as indolebutyric acid (IBA), naphthaleneacetic acid (NAA) and indoleacetic acid (IAA) can promote the increased number of roots per cutting, an acceleration of root formation and a greater uniformity of the root system (HARTMANN, 2002; GRATIERI-SOSSELLA et al., 2008; MAZZINI, 2012; MENEGAES et al., 2017).

Currently, IBA is the synthetic auxin most frequently used in vegetative propagation through cuttings (HARTMANN et al., 2002; EMER et al., 2016), as it has greater solubility and stability compared to IAA and NAA (LIMA et al., 2017). In addition, it is photostable, less sensitive to biological degradation, non-toxic in a wide range of concentrations and applicable to a wide variety of plant species (HARTMANN, 2002; FACHINELLO et al., 2005; GRATIERI-SOSSELLA et al., 2008).

Considering that *Fuchsia* has a relevant importance in the ornamental plant market, and the lack of information about techniques to improve its propagation, the present research evaluated the effect of different doses of synthetic indolebutyric acid (IBA) in the rooting of cuttings from two genotypes of *Fuchsia*: *F. regia* (Vell.) Munz and *F. hybrida* Hort. Ex Siebert & Voss 'General Monk Red Blue' variety.

MATERIALS AND METHODS

The experiment was carried out in the Experimental sector of the Horticulture Pavilion of the Vegetable Production Department of the 'Luiz de Queiroz' College of Agriculture - University of Sao Paulo (ESALQ / USP) (22º 42 'S, 47º 38' W, altitude 546 m) in Piracicaba, state of Sao Paulo, Brazil.

For this study, cuttings of two *Fuchsia* genotypes were evaluated: *Fuchsia regia* (Vell.) Munz, 'native' species and *Fuchsia hybrida* Hort. Ex Siebert & Voss var. 'General Monk Red Blue'. According to LORENZI & SOUZA (2008), *F. regia* (Vell.) Munz is native to high-altitude regions of Brazil, characterized by being a hardy branched bush, with a height from 1.5 to 3 meters and hanging branches with simple and oval leaves in addition to the axillary flowers, with a purple-red tubular chalice and purple-violet petals, and are attractive to the local fauna. *F. hybrida* Hort. Ex Siebert & Voss var. 'General Monk Red Blue' is a commercial variety obtained through genetic crossing, and is characterized by its herbaceous size, erect branches and showy tubular chalice flowers, dark pink and dark violet corolla, double (LAZZERI, 2018), formed mainly in the spring summer period.

Cuttings with 5 cm in length were selected from the apical region of the branches, containing two axillary buds and keeping the leaves of the apical portion of the cutting. To avoid the loss of turgor of the plant material, the time period between cut off branches and make the cuttings was as short as possible.

A randomized block design with a 2x5 factorial arrangement was used for evaluate the response of five IBA doses in two genotypes of *Fuchsia*, totalizing ten treatments. They were evaluated in four replications with eight cuttings each. The doses of IBA evaluated were: 0 (control), 200, 400, 600 and 800 mg.L^{-1}. The basal end of the cuttings was soaked in different concentration of 50% hydroalcoholic IBA solution for 10 seconds (PRETI et al., 2012) and placed in cutting starter trays filled with Vida Verde® coconut fiber substrate. After staking, the trays were kept in a greenhouse with intermittent mist system, controlled by a relative humidity and temperature monitoring system, which was set to operate at 70% relative humidity. The average temperature in the greenhouse was 25,3º C.

The evaluation was performed 20 days after staking. The evaluated parameters were: length of the largest root (LLR), number of roots formed per cutting (NR), root fresh mass (RFM) and root dry mass (RDM), shoot fresh mass (SFM) and shoot dry mass (SDM). For the evaluation of roots and shoots fresh mass, the part of the roots was removed from the first adventitious root formed at the base of the cutting, in order to isolate them from the aerial part. Then, shoots and roots of the cuttings were weighted on a semi-analytical scale. To obtain the dry mass, the roots and shoots were placed in an oven for a period of approximately 5 hours and temperature of 65ºC, until constant weight. After that, the dry mass of roots and shoots were weighted.

The analysis of variance (ANOVA) and the Tukey test at 5% significance were performed using the "SAS Studio" statistical package (SAS INSTITUTE, 2018).

RESULTS

The ANOVA revealed that there were highly significant differences ($P \leq 0.01$) between genotypes and between IBA levels regarding the length of the largest root (LLR), number of roots (NR), roots fresh mass (RFM) and root dry mass (RDM) after the application of the treatments with IBA (Table 1). All of the parameters evaluated except SFM showed highly significant effect of, at least, one IBA dose. The interaction between genotypes and doses were significant for most of the parameters evaluated. These results indicated that there are differences in the potential of rooting between genotypes. The rooting response can be also due to different doses and their differential effect on each genotype.

Both materials showed 100% leaf retention throughout the experiment. The fresh mass of the aerial part of the 'native' species and the 'General Monk Red Blue' showed no statistical differences in any applied dose of IBA, including the control treatment (Table 2).

'General Monk Red Blue' cuttings showed no significant differences among doses for LLR, RMF and RDM except for the control treatment (Table 2). The number of roots (NR) showed differentiation in all doses of IBA, although the concentration of 800 mg.L^{-1} provided the greatest increase in the number of roots, with a value of 34.91 units (Table 2), differing statistically from the other treatments.

Table 1 - Summary of the analysis of variance, with degrees of freedom (DF), mean squares (MS), coefficients of variation (CV) and general average of length of the largest root (LLR), number of roots formed per cutting (NR),shoot fresh mass (SFM), root fresh mass (RFM), root dry mass (RDM)) and shoot dry mass (SDM) for genotypes of *Fuchsia* spp., submitted to different doses of indolebutyric acid (IBA)(ESALQ/USP, Piracicaba, SP, 2018).

Source of variation	DF	---MS---					
		LLR (cm)	NR	RFM (g)	SFM (g)	RDM (g)	SDM (g)
Genotypes (G)	1	1.66**	701.99**	18.95**	0.62$^{n.s}$	0.06**	1.79$^{n.s}$
IBA doses (D)	4	1.45**	176.43**	3.79**	1.17$^{n.s}$	0.02**	0.02**
G x D	4	0.45**	73.22**	0.51*	0,46$^{n.s}$	0.002$^{n.s}$	0.02**
Residuals	30	0.09	3.67	0.19	0.69	0.002	0.69
Total	39	-	-	-	-	-	-
CV (%)		9.04	9.54	15.23	13.68	15.51	15.11
Average (g)		3.49	20.06	2,84	6.09	0.25	1.08

F test: $_{n.s.}$ = non-significative; ** = significative ($P \leq 0{,}01$); *= ($P < 0{,}05$).

Table 2 - Length of the largest root (LLR), number of roots formed per cutting (NR), root fresh mass (RFM), shoot fresh mass (SFM), root dry mass (RDM)) and shoot dry mass (SDM) of cuttings with different doses of IBA in *F. regia* (Vell.) Munz ('native') and *F. hybrida* Hort. Ex Siebert & Voss variety 'General Monk Red Blue' ('General Monk') (ESALQ/USP, Piracicaba, SP, 2018).

Genotypes	IBA	LLR (cm)	NR	RFM (g)	SFM (g)	RDM (g)	SDM (g)
	0	2.80^{b}	13.47^{c}	2.00^{b}	5.36^{a}	0.19^{b}	0.85^{a}
	200	3.87^{a}	22.24^{b}	3.48^{a}	5.75^{a}	0.29^{a}	0.82^{a}
'General Monk'	400	3.62^{a}	25.06^{b}	3.97^{a}	6.31^{a}	0.32^{a}	0.89^{a}
	600	4.16^{a}	25.58^{b}	3.83^{a}	6.30^{a}	0.31^{a}	0.92^{a}
	800	4.01^{a}	34.91^{a}	4.35^{a}	6.12^{a}	0.33^{a}	0.85^{a}
	0	2.84^{c}	13.69^{b}	1.51^{c}	6.02^{a}	0.16^{c}	1.30^{a}
	200	2.93^{bc}	14.31^{ab}	1.79^{bc}	5.65^{a}	0.18^{bc}	1.19^{a}
'native'	400	3.48^{ab}	16.44^{ab}	2.52^{ab}	6.20^{a}	0.25^{ab}	1.26^{a}
	600	3.26^{ab}	16.88^{ab}	2.20^{ab}	6.21^{a}	0.21^{abc}	1.24^{a}
	800	3.91^{a}	18.06^{a}	2.72^{a}	7.00^{a}	0.27^{a}	1.45^{a}

Means followed by the same letter in the column per genotype do not differ statistically from each other by Tukey test (α=0.05).

In the 'native' species, the highest concentrations (400, 600 and 800 mg.L^{-1}) had greater effect on LLR, NR, RFM, and RDM. Regarding the number of roots (NR), the highest concentration applied (800 mg.L^{-1}) differed significantly from the control treatment but did not differ from the other doses (Table 2). These results suggested a positive effect on the parameters evaluated due to the application of IBA in any dose tested, especially higher concentrations.

F.regia and *F. hybrida* 'General Monk Red Blue' responded differently to the different doses of IBA concentrations applied. Besides the similar response between the two genotypes for LLR, NR, RFM and RDM were similar under the control treatment, 'General Monk Red Blue' responded statistically better to treatments with IBA in all concentrations for most of the parameters evaluated (Table3).

DISCUSSION

Cuttings rooting is a genetically controlled phenomenon and requires the presence of auxin, which induces the formation of the root primordium. There is often an imbalance in the natural levels of this hormone, requiring the use of plant growth regulators exogenous to the plant, such as indolebutyric acid (IBA) and naphthaleneacetic acid (ANA) (PAIVA et al., 2005).

The significant interaction presented that the genotypes of *Fuchsia* studied in this research showed favorable responses to the use of indolebutyric acid in all concentrations used. This positive response may be related to several endogenous factors, such as hormonal balance, the physiological condition of the stock plant and the state of youth (MILANI et al, 2015).

Similar results were reported in other ornamental plants (*Alternanthera brasiliana* (L.) Kuntze var. *brasiliana*, *Alternanthera dentada* (Moench) Scheygr., *Pileia cadierei* Ganep. & Guillaumin, *Pileia microphylla* (L.) Liebm. e *Sphagneticola trilobata* (L.) Pruski), whose highest concentration of IBA (2,000 mg.L^{-1}) generated a greater number of roots, as obtained in *Fuchsia* (MENEGAES et al., 2017).

The 'General Monk Red Blue' and 'native' *Fuchsias* showed a different development in response to the plant growth regulator IBA (Table 2).The interaction between IBA doses and genotypes demonstrate that 'General Monk Red Blue' responded statistically better to IBA doses than 'native', despite being of the same genus. The

Table 3 - Effect of different doses of IBA (0,200,400, 600 e 800 mg.L^{-1}) in *F. regia* (Vell.) Munz (‘native’) and *F. hybrida* Hort. Ex Siebert & Voss var. ‘General Monk Red Blue’ (General Monk’) for the evaluation of length of the largest root (LLR), number of roots formed per cutting (NR), root fresh mass (RFM), shoot fresh mass (SFM), root dry mass (RDM)) and shoot dry mass (SDM) (ESALQ/USP, Piracicaba, SP, 2018).

Parameters	Genotypes	----------IBA doses (mg.L^{-1})----------				
		0	200	400	600	800
LLR (cm)	GM	2.80 A	3.88 A	3.61 A	4.16 A	4.01 A
	N	2.84 A	2.93 B	3.49 A	3.27 B	3.27 B
NR	GM	13.47 A	22.24 A	25.58 A	25.06 A	34.91 A
	N	13.69 A	14.31 B	16.43 B	16.87 B	18.06 B
RFM (g)	GM	2.00 A	3.48 A	3.97 A	3.83 A	4.35 A
	N	1.52 A	1.79 B	2.52 B	2.21 B	2.72 B
SFM (g)	GM	5.36 A	5.75 A	6.31 A	6.30 A	6.13 A
	N	6.03 A	5.65 A	6.20 A	6.21 A	7.00 A
RDM (g)	GM	0.19 A	0.29 A	0.33 A	0.31 A	0.33 A
	N	0.16 A	0.18 B	0.25 B	0.21 B	0.27 B
SDM (g)	GM	0.85 B	0.83 B	0.89 B	0.92 B	1.46 A
	N	1.30 A	1.19 A	1.26 A	1.24 A	0.85 B

Means followed by the same letter in the column per parameter and dose do not differ statistically from each other by Tukey test (α=0.05).

variation in the response to plant growth regulators is dependent on environmental conditions, genetic characteristics, and the concentration of endogenous auxin in the plant (FACHINELLO et al., 2005; GRATIERI-SOSSELLA et al., 2008). For this reason, rooting capacity may be different even between species of the same genus (PAULUS et al, 2016). LIMA et al. (2006) reported different rooting results for two species of *Calliandra*, *C. tweediei* and *C. selloi*, when using exogenous auxin to obtain cuttings. This same behavior was observed in cuttings of the genus *Ficus* (*F. ovata*, *F. polita* and *F. platyphylla*) (DANTHU et al., 2002) and of the genus *Baccharis* (*B. articulata*, *B. stenicephala* and *B. trimera*) (BONA et al., 2004).

It was observed that the all doses of IBA favored the rooting of both materials, that is, there was an interaction between genotypes and doses, and the concentration of 800 mg.L^{-1} of IBA was the most effective for NR and LLR (Table 3). Both materials showed a better visual appearance of the roots, with greater root thickness and better quality of the root ball.

RAMOS et al. (2003) and NICOLA et al. (2005) obtained a better development of the number, length, and dry mass of the roots in cuttings of *Prunus cerasifera* and *Salvia officinalis*, respectively, due to the application of indolebutyric acid. However, when *Prunus cerasifera* was subjected to high amounts of exogenous auxin, there was a decrease in the development of the roots and causing an inhibitory effect. Excessive doses of phytohormone can promote an effect contrary to the expected, being able to be considered phytotoxic (FACHINELLO et al., 2005; PRETI et al., 2012; TAIZ & ZEIGER, 2013).

Some species require higher concentrations of exogenous auxin, such as *P. cerasifera*, which showed a peak in the development of length, number and dry mass of the roots between 2000 and 3000 mg.L^{-1}. Conversely, CAMPOS & PETRY (2009) obtained excellent results for rooting cuttings of *Glandularia marrubioides* (Cham.) Tronc. cf. with the application of 600 mg.L^{-1} of IBA. Root development closely related to IBA doses, as reported by ULLAH et al. (2013) who observed a significant increase in the number of roots (100 mg.L^{-1}) and root length (400 mg.L^{-1}) of the species *Tagetes erecta*. PAULUS et al. (2016) observed that rosemary cuttings treated with IBA at a concentration of 2,500 mg.L^{-1} showed the best results for fresh and dry mass of roots, and length of the largest root.

In the assessment of fresh and dry root mass (Tables 2 and 3), it was observed that the interaction of the treatments with IBA caused significant differences in both species of *Fuchsia.* The cuttings of 'General Monk Red Blue' and 'native' produced with a concentration of 800 mg.L^{-1} of IBA obtained, respectively, fresh mass of 2.35g and 1.20g and dry mass of 0.14g and 0.11g more than the control treatment.

BONA et al. (2010) observed that the increase in dry mass of roots proportionally accompanied the increase in the concentration of IBA (0; 500; 1000; 2000; 3000 mg.L^{-1}) applied in lavender cuttings (*Lavandula dentata*). The lavender cuttings showed denser and branched roots, with better quality compared to those produced in the lowest doses of the hormone, similar to the results obtained with 'General Monk Red Blue' and 'native' princess earring genotypes.

The propagation of cuttings of *F. regia* and *F. hybrida* 'General Monk Red Blue' with IBA in the concentration of 800 mg.L^{-1} contributed to the success of rooting; because it favored the emission of a greater number of roots, formed the main root with greater length and promoted greater fresh and dry mass. Therefore, the use of IBA provided development of cuttings of princess earrings with better quality.

In addition, the use of exogenous auxin can contribute to the conservation of *F. regia* (Vell.) Munz "native", since extraction can be minimized with the dissemination of technologies that promote an efficient propagation method for commercialization.

CONCLUSION

The rooting of princess earring cuttings *F. regia* and *F. hybrida* 'General Monk Red Blue' was favored by the use of IBA in the concentration of 800 mg.L^{-1}, as it promoted the production of better quality cuttings.

Fuchsia 'General Monk Red Blue' responded statistically better to the treatments with IBA in all concentrations, for most of the parameters evaluated; therefore, being the best genotype for rooting cuttings with the use of indolebutyric acid plant growth regulator.

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DECLARATION OF CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

AUTHORS' CONTRIBUTIONS

Planning and design: Tamura, M.M.N.; Ueno, S.; Mattiuz, C.F.M. Implantation of experiment and evaluation: Tamura, M.M.N.; Ueno, S.; Toledo, J.A.M.; Ambrosano, M. Statistical evaluation: Piedade, S. M. S. Writing and correction: Tamura, M.M.N.; Mattiuz, C.F.M.; Ueno, S.; Toledo, J.A.M.

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