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Effect of indole-3-butyric acid, putrescine and benzyladenine on rooting and lateral bud growth of *Ficus elastica* Roxb. ex Hornem leaf-bud cuttings

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ABSTRACT

An investigation was conducted to study the effects of indole-3-butyric acid (IBA), putrescine (Put) and benzyladenine (BA) on rooting and bud sprouting of leaf-bud cuttings of *Ficus elastica* Roxb. ex Hornem.. The highest number of roots per cutting (19.00) was obtained with Put 4000 ppm + IBA 4000 ppm and the lowest (4.17) was observed in control. Root length was increased with increasing Put concentrations and decreased with increasing IBA concentration. The highest length (12.17 cm) was observed with Put 4000 ppm and the lowest root length (7.1 cm) with Put 1000 + IBA 4000 ppm. The highest weight of roots (3.49 g) was obtained with Put 4000 + IBA 1000 ppm, and the lowest weight (1.2 g) was observed with control. In spite of the positive effects of IBA on rooting, higher concentrations produced thick and brittle roots, but application of Put improved the roots and led to more acceptable roots. The highest shoot length (30.5 cm) was obtained on cuttings treated with IBA 4000 + Put 4000 + BA 1000 ppm and the lowest shoot length (14.0 cm) was observed at BA 250 ppm treatment that was not significantly different compared to control. The highest number of leaves (6.0) was obtained with IBA 1000 + BA 4000 ppm and the lowest (3) obtained with control and BA 250 ppm. It was concluded that BA positively affected the number of leaves but IBA and Put had no significant effects on this parameter.

Key words: Bud sprouting, leaf-bud cuttings, polyamine, rubber tree, rooting.

INTRODUCTION

The growth hormones, regulate the growth of the plant species, which play an important role in root induction and growth of cuttings. Auxins, are the most effective in rooting in many plant species (Hartmann *et al*., 9). Polyamines (PAs), including diamine putrescine (Put), triamine spermidine (Spd) and tetramine spermine (Spm) are organic compounds with two or more primary amino groups that exist in plant cells. They play important roles in regulation of DNA replication and cell division, controlling of morphogenesis, senescence and resistance to environmental stresses (Kaur-Sawhney *et al*., 12; Couée *et al*., 2). It is documented that PAs have profound effects on plant growth and development (Farooq *et al*., 6). Cytokinins are important plant hormones that regulate various processes of plant growth and development including cell division and differentiation, enhancement of leaf expansion and nutrient mobilization (Hassan and El-Quesni, 10). The response of plants to cytokinins have been also discussed in more papers. For examples, Eraki (5) mentioned that application of BA on *Hibiscus sabdariffa* L. plants significantly increased plant height, number of branches, fresh and dry weights of leaves than the control.

Ficus elastica (rubber tree) is a broadleaf evergreen shrub or tree that widely grown in the tropics as an ornamental tree. In colder climates, this is an extremely popular houseplant. This plant is usually propagated by stem or leaf-bud cuttings (Hartmann *et al*., 9). One of the problems in propagation with leaf-bud cuttings is no growth or slow growth of lateral buds to produce shoots. The purpose of this study was to investigate the effects of putrescine, IBA and BA on rooting and growth of lateral buds in *F. elastica* leaf-bud cuttings.

MATERIALS AND METHODS

An experiment was conducted using *F. elastica* plants in the greenhouse of Horticultural Science Department of Shiraz University. Healthy and uniform leaf-bud cuttings including the lamina, petiole and a segment of stem length of 3 to 4 cm with the lateral buds were taken from the middle portion of one -year-old shoots in January. Cuttings were dipped in 2% benomyl fungicide for 5 min. and subsequently washed with double distilled water before application of hormonal treatments. Cuttings were divided into 16 groups of 30 cuttings each. Group 1 was treated with distilled water as a control. Others were treated with indole-3-butyric acid (IBA) (1000, 2000 and 4000 ppm), putrescine (1000, 2000 and 4000 ppm) and their combinations. Cuttings were treated by submersing the stem portion in each treatment solution for 10 sec. Thereafter, cuttings were planted on a bed of sand

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equipped with bottom heat facility and kept under intermittent mist system.

After 1 month of treatment, six cuttings of each treatments were removed from the medium and rooting percentage, root fresh weight, root length (length of the longest root) and root number were measured. To determine the quality of the roots, rooting index was calculated (Criley, 3). The cuttings in each category were given the following scores for their rootings: 5 for heavy rooting, 4 for medium rooting and 3 for light rooting. Alive, but not rooted cuttings and dead cuttings receive a score of 2 and 1, respectively.

When the cuttings were rooted, they were transplanted, and two cuttings were planted in a plastic pot 30 cm in diameter that were filled with a medium containing disinfected soil, leaf mold and sand (1:1:1) by volume. After the establishment of the plants in February, different concentrations of BA (0, 250, 500 and 1000 ppm) applied on each six cuttings (in three pots) of previous treatment as foliar sprays. Treatments were arranged as a factorial experiment in a completely randomized design with three replications for each treatment. After 5 months, growth indices of bud growth percentage, developed shoots (branch length), internode length and leaf number were measured.

Statistical analysis of data was performed using SAS software and the means were compared at 5% level using Duncan's multiple range test.

RESULTS AND DISCUSSION

The results showed that the all cuttings were rooted, but the best rooting index obtained from IBA 2000 ppm + Put 4000 ppm treatment (data not shown). High concentrations of auxin led to thick and brittle roots, but putrescine application improved the roots quality and increased the number of secondary thin roots. The highest number of roots per cutting (19.00) was obtained with Put 4000 ppm + IBA 4000 ppm that did not significantly differ with other concentrations of putrescine. The lowest root number (4.17) were obtained in control. Roots increased with increasing concentration of auxin and putrescine. Root length increased with increasing putrescine concentrations and decreased with increasing auxin concentration. The maximum length (12.17 cm) obtained with Put 4000 ppm and the lowest root length (7.1 cm) was related to Put 4000 ppm + IBA 4000 ppm. Root fresh weight increased with increasing auxin and putrescine concentrations. Maximum weight of roots per cutting (3.49 g) was obtained with Put 4000 ppm + IBA 1000 ppm, which was not significantly different with IBA 4000 ppm (3.44 g). Minimum root fresh weight (1.2 g) was recorded in control (Table 1).

Overall, the results indicated that although auxin had the positive effects on root formation, higher concentrations produced thick and brittle roots, but

Table 1. Interaction between IBA and putrescine on No., length and fresh weight of roots of *Ficus* cuttings.

Put (ppm)	IBA (ppm)				Mean
	Control	1000	2000	4000	
Root No.					
Control	4.16 h*	9.83 d-f	10.83 d-f	17.67 ab	10.62 B
1000	6.00 gh	10.83 d-f	11.68 c-e	17.17 ab	11.42 B
2000	8.00 fg	10.33 d-f	13.33 cd	17.17 ab	12.21 B
4000	9.50 ef	13.00 c-e	14.83 bc	19.00 a	14.08 A
Mean	6.92 D	11.00 C	12.67 B	17.75 A	
Root length (cm)					
Control	9.72 ac	8.20 bc	8.52 bc	8.58 bc	8.75 AB
1000	10.42 ab	8.17 bc	8.53 bc	7.12 c	8.56 B
2000	10.58 ab	8.85 bc	9.58 a-c	10.58 ab	9.90 A
4000	12.16 a	10.42 ab	8.75 bc	7.50 c	9.71 AB
Mean	10.72 A	8.91 B	8.85 B	8.45 B	
Root fresh wt. (g)					
Control	1.20 e	3.14 a-c	2.90 a-d	3.44 ab	2.67 AB
1000	2.06 d	2.36 cd	2.90 a-d	2.55 b-d	2.35 B
2000	2.34 cd	2.67 a-d	2.46 cd	3.23 a-c	2.79 A
4000	2.95 a-d	3.49 a	2.43 cd	3.12 a-c	3.00 A
Mean	2.13 C	2.91 AB	2.67 B	3.09 A	

*Means in each row or column with the same letter(s) are not significantly different at 5% level using Duncan’s test.

use of putrescine improved the roots and led to more acceptable roots. It may be concluded that the use of putrescine with auxin can improve the quality of roots.

Many studies have hypothesized a role for polyamines in the rooting process, and their relationship with auxins and peroxidases. According to Gaspar *et al*. (8) IAA and Putrescine, an important polyamine, might be required to initiate cell division at the end of the root induction phase. Polyamines induced rooting in olive (Rugini *et al*., 17), possibly at the very early stages of rooting. It has also been suggested that polyamines might be considered precocious markers of rooting.

The results also showed that putrescine can be a useful substance in increasing *Ficus elastica* qualitity of roots. In fact, it has been demonstrated that polyamines played an important role in primary, lateral, and adventitious root development (Pastur *et al*., 16; Naija *et al*., 15). The results obtained in this study are in agreement with those obtained by Rugini *et al*. (17) in olive, Cristofori *et al.* (4) in hazelnut, Wu *et al*. (2010) in trifoliate orange and Zikah *et al*. (22) in the cuttings of GF-677 (a hybrid of peach and almond). Cristofori *et al*. (4) found that, young cuttings collected from hazelnut 'Tonda Gentile Romana' in early September rooted poorly when treated with IBA alone, but showed the best rooting (80%) after the application of a combination of 1000 ppm IBA and 1600 ppm putrescine. Friedman *et al*. (7) suggested a possible regulatory role for PAs in combination with auxins in the early phase of adventitious root formation.

The highest lateral bud growth percentage (82%) was obtained on cuttings treated with 250 ppm BA, that was significantly different from other treatments and the lowest (74%) observed at control (Table 2). The highest shoot length (30.5 cm) was obtained on cuttings treated with IBA 4000 + Put 4000 + BA 1000 ppm and the lowest shoot length (14 cm) was observed at BA 250 ppm treatment that was not significantly different compared to control (Table 3).

Means showed that BA had a positive effect on the number of leaves, but showed no significant effect of IBA and Put (data not shown). The highest number of leaves (6.6) was obtained with IBA 1000 + BA 4000

Table 2. Effect of BA on bud growth of *Ficus* cuttings.

BA (ppm)	Bud growth (%)
Control	0.74 d*
250	0.82 a
500	0.76 c
1000	0.79 b

*Means in each row or column with the same letter(s) are not significantly different at 5% level using Duncan's test.

Table 3. Effect of IBA, putresine and BA concentrations on shoot length (cm) of *Ficus* cuttings.

IBA (ppm)	Put (ppm)	BA (ppm)				Mean	Put Mean
		Control	250	500	1000		
Control	Control	16.5 eg*	14.0 g	18.0 d-g	21.3 a-f	24.66 A	21.07 C
	1000	24.8 a-e	23.3 a-g	24.1 a-f	24.7 a-e		24.43 B
	2000	26.3 a-e	25.2 a-e	25.2 a-e	28.2 a-c		25.89 B
	4000	27.8 a-d	27.9 a-d	28.2 a-c	29.1 a		28.14 A
1000	Control	14.5 fg	16.5 e-g	18.3 b-g	24.9 a-e	24.59 A	
	1000	24.5 a-e	22.3 a-g	24.0 a-f	29.2 a		
	2000	27.2 a-d	27.0 a-d	25.3 a-e	26.8 a-d		
	4000	26.8 a-d	27.8 a-d	28.0 a-d	27.8 a-d		
2000	Control	18.2 c-f	21.8 a-g	23.2 a-g	26.6 a-d	25.25 A	
	1000	23.5 a-g	24.5 a-e	25.6 a-e	25.1 a-e		
	2000	23.0 a-g	22.5 a-g	23.3 a-g	29.1 a		
	4000	27.2 a-d	28.8 a	29.3 a	29.0 a		
4000	Control	23.2 a-f	25.6 a-e	26.3 a-e	27.4 a-d	26.19 A	
	1000	23.0 a-g	23.3 a-g	23.8 a-f	23.8 a-f		
	2000	23.9 a-f	25.2 a-e	28.4 ab	26.8 a-d		
	4000	27.8 a-d	26.2 a-e	28.2 a-c	30.5 a		
BA Mean		21.01 B	24.35 B	25.19 B	27.19 A		

*Means in each row or column with the same letter(s) are not significantly different at 5% level using Duncan's test.

ppm which was significantly different compared to the other treatments. The lowest number of leaves (3.0) obtained with control and BA 250 ppm (Table 4). Overall, means showed that BA positively affected the number of leaves but IBA and Put had no significant effects on this parameter. Interaction of different treatments had no significant effect on internode length (data not shown).

In general, all three growth regulators had positive effect on aerial plant growth. Putrescine and BA had a positive effect on shoots length and BA significantly increased number of leaves. The increase of vegetative growth due to IBA treatments is in agreement with the findings of Singh (20) on *Bougainvillea peruviana*, Sharma *et al*. (19) on *Gardenia lucida* and Hussein (11) on *Thunbergia grandiflora*. They reported that IBA improved the plant vegetative growth. The promotive effect of IBA on the vegetative growth may be due to the enhancement of rooting percentage and root growth on the treated cuttings, which leads to more uptake of water and nutrients from the growing medium, resulting in an increase in vegetative growth.

Although auxins are required for axillary meristem initiation (McSteen, 14). Outgrowth of axillary buds is well correlated with the cytokinin level in the buds (Bangerth, 1). This increment in plant height in our study may be due to the role of cytokinin (BA) in increasing cell division in apical meristems and cambium. Our results are comparable with those obtained by Mazrou *et al*. (13) on sage plant and Eraki (5) on *Hibiscus sabdartffa* L. Significant effects of putrescine on shoot growth in our study are in agreement with the findings of Rugini *et al.* (18). They showed that putrescine increase the number of stem and leaf blade expansion in the pear. Further, application time of auxin and putrescine on cuttings, their effects on shoot growth is more related to the rooting of cuttings so that cuttings with stronger root system have better absorbance of water and nutrients and consequently higher cytokinin production, that increases shoot growth.

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Table 4. Effect IBA, Put and BA concentrations on No. of leaves per cutting in *Ficus*.

IBA (ppm)	Put (ppm)	BA (ppm)				Mean	Put Mean
		Control	250	500	1000		
Control	Control	3.0 d*	3.0 d	4.0 b-d	5.3 a-d	4.8 A	4.86 A
	1000	4.5 a-d	4.5 a-d	4.8 a-d	5.0 a-d		4.71 A
	2000	4.4 a-d	5.0 a-d	5.0 a-d	5.8 ab		5.06 A
	4000	5.0 a-d	5.4 a-d	5.2 a-d	5.5 a-c		5.18 A
1000	Control	3.3 cd	5.0 a-d	4.8 a-d	6.6 a	5.05 A	
	1000	4.5 a-d	4.5 a-d	4.8 a-d	4.8 a-d		
	2000	5.0 a-d	5.2 a-d	5.0 a-d	5.8 ab		
	4000	5.2 a-d	5.3 a-d	5.2 a-d	6.0 ab		
2000	Control	4.2 a-d	5.8 ab	6.0 ab	6.3 ab	5.09 A	
	1000	4.5 a-d	4.5 a-d	5.0 a-d	5.3 a-d		
	2000	4.3 a-d	4.5 a-d	4.4 a-d	5.3 a-d		
	4000	5.0 a-d	5.8 ab	5.0 a-d	5.0 a-d		
4000	Control	4.3 a-d	4.4 a-d	4.5 a-d	4.8 a-d	4.91 A	
	1000	4.0 b-d	5.0 a-d	5.0 a-d	5.0 a-d		
	2000	4.5 a-d	5.5 a-c	5.4 a-d	6.0 ab		
	4000	4.3 a-d	4.8 a-d	5.2 a-d	5.2 a-d		
Mean		4.39 C	4.97 B	4.98 B	5.47 A		

*Means in each row or column with the same letter(s) are not significantly different at 5% level using Duncan's test.

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