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HYDROPONIC SYSTEM FOR MASS PROPAGATION OF *Bougainvillea x buttiana* "MRS BUTT"

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ABSTRACT: Cuttings of *Bougainvillea x buttiana* "Mrs Butt" were cultured in peat moss [after treating with 1000 ppm indolebutric acid (IBA) or without] or hydroponic units contained: water, quarter Hoagland strength, half Hoagland strength, full Hoagland strength, 2.5 ppm, 5 ppm or 20 ppm IBA solutions. Results showed that treating cuttings with IBA at 1000 ppm before culturing was more effective than culturing without treating. Among the different hydroponic solution treatments, IBA solution at medium (5 ppm) or high concentration (10 ppm) had the best results, since they produced the highest values of rooting percentage, number of roots/cutting, number of shoots/cutting, shoot length, number of leaves/shoot and survival percentage. Also, using of 10 ppm IBA solution resulted in initiating the first root more rapidly than all other treatments.

Key words: *Bougainvillea x buttiana* "Mrs Butt", hydroponic, propagation, hoagland solution, indolebutyric acid (IBA).

INTRODUCTION

Bougainvillea, a member of the family Nyctaginaceae, and a native of South America, is one of the most charming and colorful garden plants. It is among the most floriferous shrubs of the tropics producing beautiful colour effects which can hardly be excelled by any other plant. As a result, it has become the most popular garden plant all over the world. The Bougainvillea can be grown as shrub, climber, hedge, standard and pot plant. Some of the varieties are relatively small in size, but others are extremely vigorous in growth and require plenty of room. The spines on stems help in climbing and rambling. They make admirable borders, live hedges and fences and when pruned to suitable dimensions they make perfect pot plant, a live arch or pergola. The bract colour ranges from magenta and purple to crimson, bricked, pale pink, salmon yellow and white (**Baraskar, 1987**).

Commercial propagation of *Bougainvillea x buttiana* "Mrs Butt" is carried out by semi-hard stem cuttings, but the percentage of rooted cuttings is low even under intermittent mist system in greenhouse (37.5 – 57.5%); moreover, cuttings produced a poor number of adventitious roots (**Hosni *et al.*, 2000**).

Efforts had been done to develop hydroponic and aeroponic systems for using in propagation by cutting (**Hershey and Merritt, 1986; Bertram, 1988; Soffer and Burger, 1989; Bertram, 1991; Tawfik, 200l; El-Shamy and Helal, 2008**). These techniques have many advantages *viz* availability of high oxygen concentration which stimulate root initiation and development; facilitating of water influx to the cutting; simplicity and low cost. Most of previous studies devoted particular attention to compare hydroponic and aeroponic systems with solid medium during propagation by cutting.

It has been repeatedly confirmed that auxin is required for initiation of adventitious roots on stems, and indeed, it has been shown that divisions of the first root initial cells are dependent upon either applied or endogenous auxin (**Hartmann *et al.*, 2006**).

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It has been difficult to quantify the effect of nutrient on root primordial initiation versus root primordial elongation (**Hartmann *et al.*, 2006**). The promotive effect of increasing nutrient salt concentration in rooting medium on number of initiated roots/cutting was previously demonstrated by **Bertram (1991)** on *Hibiscus rosa-sinensis* and **El-Shamy and Helal (2008)** on *Ficus elastica* var. decora cuttings. On the other side, the enhancing effect of decreasing nutrient salt level on root development has been reported in some micropropagation studies such as **Hasegawa (1980)** on rose, **Deshpande *et al.* (1998)** on *Ficus religiosa,* and **Kaur and Kant (2000)** on *Acacia catechu*. Also, El-**Shamy and Helal (2008)** on *Ficus elastica* var. decora in hydroponic system reported the same result.

The objectives of this study were, therefore, to investigate the effect of using different concentrations of IBA, different levels of nutrients in hydroponic solutions on root initiation and development as well as to compare hydroponic system (which comparable to nutrient film technique) with the common rooting medium (peat moss) in propagation of *Bougainvillea x buttiana* "Mrs Butt" by cuttings.

MATERIALS AND METHODS

This experiment was conducted at Horticulture Department, Faculty of Agriculture, Zagazig University during the two successive seasons, 2016 and 2017.

Plant Material

Uniform cuttings were collected and cultured on 15 March from 10 years old *Bougainvillea x buttiana* "Mrs Butt" plants grown in Faculty of Agriculture, Zagazig University Farm during both seasons. Cuttings were prepared with about 20 cm length and 1.2 cm diameter from the basal parts of shoots. Cuttings bases (5 cm) were dipped in fungicide solution (2 g l^{-1}) of Rizolex for 2 hr. before culturing.

Hydroponic Unit Preparation

Hydroponic units were designed as described by **El-Shamy and Helal (2008)** by using plastic pipes (4.0 inches diameter and 4.0 m. length) with upper holes every 20 cm with 12 cm diameter each. Pipes were fixed with a gentle slope 1:100, so that solution could be flowed under the influence of gravity. Solution was accumulated in plastic tank contained 20 liters of solution. Solution was pumped in PVC hose (0.5 inch diameter) from the tank to higher end of pipe by using electrical pump (120 l $hr.^{-1}$). Solution was flowed to lower end of pipe and accumulated in the tank with continuous recirculation. Lower end of pipe was closed particularly (4 cm) from the bottom to allow solution to rise and reach to cuttings bases (about 2 cm).

Culture of Cuttings

Cutting bases were dipped in 1000 ppm IBA solution for five minutes before placed in pots (20 cm diameter) contained peat moss (one cutting each) or placed directly (without IBA treatment) in peat moss or plastic pipe containing one of the following solutions; tap water, full Hoagland strength (prepared according to **Hoagland and Amron, 1950**), half Hoagland strength, quarter Hoagland strength, and 2.5, 5.0 or 10 ppm IBA. Cuttings were fastened in plastic pipes by using adhesive tape. Sixteen cuttings were cultured in each treatment. Two cuttings were placed in each hole. Cuttings were incubated in greenhouse at about 25°C.

Recorded Data

Cuttings in each treatment were checked for root appearance every two days to determine number of days to first root appearance on each cutting. Cuttings which initiated root in peat moss were marked and did not check again to prevent interruption of root growth. After 60 days from culturing the cuttings, the following data were recorded: rooting (%), No. of main roots/cutting, root length (cm), No. of shoots/ cutting, shoot length (cm) and No. of leaves/ shoot. Also survival (%) was recorded after 30 days from transplanting rooted cuttings to pots (20 cm diameter, each pot contained one rooted cutting) contained peat moss medium.

Layout and Analysis of Experiment

The statistical layout of this experiment was completely randomized design. All collected data were analyzed with analysis of variance (ANOVA) procedure using the MSTAT-C Statistical Software Package (**Michigan State University, 1983**). Differences between means were compared by using Duncan multiple range test (**Gomez and Gomez, 1984**).

RESULTS

Effect on Rooting Characters of *Bougainvillea x buttiana* "Mrs Butt" Cutting

Results in Table 1 illustrate that treating cuttings with 1000 ppm IBA before culturing in peat moss increased the rooting percentage. Also, using any of hydroponic tested solutions improved rooting percentage compared with culturing in peat moss. Generally, increasing of Hogland solution strength or IBA concentration enhanced rooting percentage. Moreover, the most efficient treatment in this regard was using of 10 ppm IBA solution.

Dipping cutting bases in 1000 ppm IBA before culturing or culturing cuttings in any applied hydroponic solutions significantly accelerated root initiation. It is clear that increasing of either Hogland solution strength or IBA concentration resulted in more rapid appearance of roots, although the differences among some treatments did not reach to the significant level in some cases. Hydroponic solution of 10 ppm IBA was the most effective treatment in this respect.

Number of roots was significantly enhanced by treating cuttings with 1000 ppm IBA before culturing in peat moss. In additionally**,** culturing the cuttings in any investigated hydroponic solutions significantly increased root number. In most cases, there were no significant differences among different Hogland solution strengths in this respect. However, there was a linear positive relationship between IBA concentration and number of initiated roots. Again, it is evident that 10 ppm IBA produced the maximum number of roots.

Using of 1000 ppm IBA for treating cuttings significantly increased root length compared with untreated cuttings. Also, all investigated solutions produced longer roots compared with peat moss medium. It is obvious that increasing of Hogland solution strength resulted in suppression of root growth. On the other side, increasing of IBA concentration up to 5 ppm lead to significant increase in root length, while higher concentration (10 ppm) had nigative effect on root elongation. Treatment of 5 ppm IBA produced the longest roots.

Effect on Shoot Characters and Survival (%) of *Bougainvillea x buttiana* "Mrs Butt" Cutting

As shown in Table 2, No. of shoots/cutting was increased when cuttings were treated with 1000 ppm IBA before culturing in peat moss, but this increase reached to the significant level in second season only. Culturing the cuttings in any of tested hydroponic solutions enhanced the shoot number/cutting compared with cuttings planted in peat moss without treating with IBA. Generally, increasing of Hogland solution strength was concomitant with improving in this parameter, but sometimes the differences among different strengths did not reach to the significant level. Also, inoculation the cuttings in any IBA concentration solution significantly raised this character value. This parameter reached its maximum value with the highest IBA concentration (10 ppm).

Shoot length (cm) was significantly elevated by treating the cuttings with 1000 ppm IBA before culturing. On the other side, there were no significant differences between peat moss, water and quarter Hogland strength solution in this regard. While, increasing of Hogland strength above qurter strength was concomitant with significant increase in shoot length, since the highest strength (full) produced the tallest shoot. Additionally, using of IBA solution at any investigated concentration significantly augmented this character. It is obivious that medium concentration (5 ppm) was the most effective treatment in this connection during first season, while ther were no significant differences among this treatment and low concentration (2.5 ppm) or full Hogland strength.

Number of leaves/shoot was significantly amplified by treating the cuttings with 1000 ppm IBA before culturing. Using of water as an alternative medium to peat moss did not significantly affect on this character. Results showed that there was a liner relationship between increasing of Hogland solution strength or IBA concentration each alone and improvement of number of leaves/shoot. The maximum number of leaves/shoot was gained with the highest concentration of IBA, noting that there was no significant difference between this treatment and using of full Hogland solution strength during second season in this connection.

Table 1. Effect of different hydroponic solutions and peat moss on rooting percentage, No. of days to first root appearance, No. of roots/cutting and root length (cm) of *Bougainvillea buttiana* "Mrs butt" cutting during 2016 and 2017 seasons after 60 days

Treatment	Rooting (%)		No. of days to first root appearance		No. of main roots/cutting		Root length (cm)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Peat moss without IBA	12.50	6.25	32.9 b	37.1 b	3.5 f	4.0 f	5.05 e	6.15 e
Peat moss with IBA 1000 ppm	37.50	31.25	26.9 ef	33.8 c	5.10 e	6.5 e	7.51 c	6.90 d
Water	31.25	37.50	39.0 a	39.1 a	4.8 e	6.0 e	7.43 c	7.75 c
Quarter Hoagland	43.75	50.00	29.6 c	36.0 b	5.5 e	11.1 d	6.51 d	7.25 cd
Half Hoagland	50.00	50.00	29.4 cd	33.6 c	12.0 cd	11.2 d	6.13 d	6.08 e
Full Hoagland	75.00	62.50	28.1 de	29.0 d	11.4 d	10.6 d	5.40 e	5.33 f
2.5 ppm IBA	75.00	68.75	29.0 cd	28.8 d	12.8 c	12.5 c	8.40 b	9.50 b
5 ppm IBA	81.25	100.00	28.9 cd	26.6 e	22.2 b	18.1 b	10.01 a	11.47 a
10 ppm IBA	93.75	100.00	26.0 f	23.0 f	30.1 a	29.0 a	8.61 b	10.92 a

Table 2. Effect of different hydroponic solutions and peat moss on No. of shoots/cutting, shoot length (cm), No. of leaves/shoot and survival percentage of *Bougainvillea buttiana* "Mrs butt" cutting during 2016 and 2017 seasons after 60 days

Treatment	No. of shoots/cutting		Shoot length (cm)		No. of leaves/shoot		Survival percentage	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Peat moss without IBA	1.3 d	1.0 e	4.50 e	5.06 cd	4.5 g	5.7 e	100	100
Peat moss with IBA 1000 ppm	1.7 cd	2.0 d	5.90 c	6.50 b	7.2 cd	7.6 cd	100	100
Water (control)	1.7 cd	2.0 d	4.65 e	4.73 d	4.7 g	6.0 e	87.50	93.75
Quarter Hoagland	1.8 c	2.3 cd	4.33 e	5.51 c	5.6 f	6.9 d	93.75	100
Half Hoagland	1.9 bc	2.5 bc	5.41 d	6.21 b	7.1 de	8.2 c	81.25	87.50
Full Hoagland	2.2 b	2.9 ab	6.51 b	7.60 a	8.5 b	10.1 a	75.00	75.00
2.5 ppm IBA	2.2 b	2.6 bc	6.22 bc	7.91 a	6.5 e	8.3 c	100	93.75
5 ppm IBA	2.2 b	3.0 a	7.11 a	7.80 a	7.8 c	9.0 b	100	100
10 ppm IBA	3.0 a	3.0 a	6.50 b	6.67 b	9.8 a	10.5 a	100	93.75

Survival percentage of rooted cuttings was ranged between 75 and 100%. The lowest percent (75%) was recorded with full strength Hogland solution, while many other treatments gained 100% survival percentage. Of course cuttings cultured in peat moss had the maximum survival percentage because it did need to reculture, while cuttings cultured in Hogland solution especially at full strength produced the lowest values.

DISCUSSION

Effect of Hydroponic System Compare to Peat moss Medium on Root Initiation and Development

The present study results clearly demonstrate that hydroponic system offers a new promising method for propagation of bougainvillea by cuttings.

All hydroponic solution treatments proved to be more effective than using peat moss medium concerning root initiation, number of initiated roots and growth. In a similar approach to this result, **Soffer and Burger (1989)** found that rooting percentage, number of roots/cutting and total root length of *Ficus benjamina* was greater in aero-hydroponic system than either solid medium (perlite : vermiculite 1:1 or sand : peat : redwood bark 1:1:1, *V/V*). Also, **Tawfik (2001)** on some ornamental plants observed that root initiation and development occurred faster in water air-flow system than in peat moss. Moreover, **El-Shamy and Helal (2008)** on *Ficus elastica* var. decora recorded similar result. This enhancing effect of hydroponic system on rooting may be due to that good oxygen dissolving and supply could be achieved by using this system, since it is well known that oxygen is essential for root formation (**Soffer and Burger, 1988**). Another reason is that the key to successful propagation medium is a good water management (**Hartmann *et al.*, 2006**) which prevents cutting dehydration during rooting period.

Effect of Nutrient Salt Concentration in Hydroponic Rooting Media on Root Initiation and Development

It has been difficult to quantify the effect of nutrient on root primordial initiation versus root primordial elongation (**Hartmann *et al.,* 2006**). The promotive effect of increasing nutrient salt concentration in rooting medium on number of initiated roots/cutting which observed in this study was previously demonstrated by **Bertram (1991)** on *Hibiscus rosa-sinensis* cuttings rooted in water culture system and **El-Shamy and Helal (2008)** on *Ficus elastica* var. decora cuttings rooted in hydroponic system. On the other side, the enhancing effect of decreasing nutrient salt level on root development has been reported in some micropropagation studies such as **Hasegawa (1980)** on rose, **Deshpande *et al.* (1998)** on *Ficus religiosa* and **Kaur and Kant (2000)** on *Acacia catechu* and confirmed here. Also, **El-Shamy and Helal (2008)** on *Ficus elastica* var. decora observed similar effect.

Effect of IBA Concentration in Hydroponic Rooting Media on Root Initiation and Development

It has been repeatedly confirmed that auxin is required for initiation of adventitious roots on stems, and indeed, it has been shown that divisions of the first root initial cells are dependent upon either applied or endogenous auxin (**Hartmann *et al.,* 2006**). This fact was also confirmed in this study since treating cuttings with 1000 ppm IBA before culturing or addition of IBA to hydroponic solution at any investigated concentrations (2.5, 5 or 10 ppm) increased rooting percentage, number of roots/cutting and root length and as well as decreased the number of days to first root appearance compared with control treatment (culturing of cuttings in peat moss or water without IBA).

The enhancing effect of increasing IBA concentration on root initiation and growth which demonstrated in this investigation is in harmony with earlier studies on Bougainvilleas (**Seyedi *et al*., 2013; Sultana *et al*., 2016; Singh *et al*., 2017**).

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إكثار الجهنمية بوتيانا "مسز بت" باستخدام نظام المزارع المائية

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زرعت العقل الساقية لنبات الجهنمية بوتيانا "مسز بت" فى البيت موس (قبل أو بعد نقعها فى إندول حمض البيوتريك بتركيز ١٠٠٠ جزء فى المليون) أو فى وحدات زراعة مائية تحتوي على الماء أو محلول هوجلاند بتركيزات مختلفة (ربع أو نصف أو كامل تركيز الأملاح) أو محلول إندول حمض البيوتريك بتركيز ٢,٥ أو ٥ أو ١٠ جزء فى المليون، حيث وجد أن معاملة العقل قبل الزراعة في البيت موس كان أكثر فاعلية من الزراعة بدون معاملة، كما ثبت أن استخدام محلول إندول حمض البيوتريك بتركيز متوسط (٥ جزء في المليون) أو مرتفع (١٠ جزء فى المليون) قد أدى للحصول أعلى القيم فيما يتعلق بنسبة التجذير، وعدد الجذور على العقلة، وطول الجذور وعدد الأفرخ/عقلة وطول الفرخ وعدد الأوراق/فرخ ونسبة البقاء بعد إعادة الزراعة، كذلك فإن زراعة العقل في محلول ١٠ جزء فى المليون إندول حمض البيوتريك قد أدى للإسراع بتكوين الجذور على العقل مقارنة ببقية المعاملات.

المحكمـــــون:
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