Assessment the efficiency of willow water extract (WWE), indole-3-butyric acid (IBA) and micronutrients on the propagation of *Petunia x hybrida* by stem cuttings.

Asmaa M. Taha, Magd el Din F. Rida

Ornamental Plants Research Department, Horticulture Research Institute, Agriculture Research Center, Alexandria, Egypt.

ABSTRACT

Two experiments were executed during the seasons of 2022 and 2023 at a commercial nursery. The first experiment was done to assess the efficiency of willow water extract (WWE) and indole-3-butyric acid (IBA) on the rooting of *Petunia x hybrida* stem cuttings, seven treatments were done in this experiment (control, 500 ppm IBA, 1000 ppm IBA, 2000 ppm IBA, 25% WWE, 50% WWE and 100% WWE). The results showed that appliction of IBA at 500 ppm resulted in the highest survival percentage and the highest increase in root characteristics. The second experiment was carried out to study the effects of IBA, WWE with or without micronutrient fertilizer (MF) supplementation. MF consists of zinc (Zn) and iron (Fe) at 13 % was prepared at 0.5 g/l. and sprayed on the leaves of the stem cuttings three times , the first time one week from planting, and then at a week intervals. Twelve treatments were done in this experiment (control, 25 % WWE, 50% WWE, 125 ppm IBA. 250 ppm IBA, 500 ppm IBA, Control + MF, 25% WWE + MF, 50% WWE + MF, 125 ppm IBA + MF , 250 ppm IBA + MF and 500 ppm IBA + MF). The results showed that the highest survival percentage, root parameters, vegetative growth characteristics and chlorophyll content was obtained after application of 125 ppm IBA + MF. Also, the profit percentage of using 125 ppm IBA + MF to produce petunia plants by stem cuttings was assessed and recorded 100.98 %.

Key words: *Petunia x hybrid* – Stem cutting - Indole-3-butyric acid (IBA) - willow water extract (WWE) - profit percentage.

INTRODUCTION

Petunia x hybrida is an annual plant with fragrant flowers which has a funnel-shape in many colors (red, purple, pink, blue, white, and pale yellow) which cover the plants. Some are bicolored and some are striped or edged with white. Flowers are single or double, smooth or ruffled. Multiflora types bear smaller, mostly double flowers. Wave types spread or cascade much farther than others. The leaves are soft, hairy and somewhat sticky. Petunia plants are planted in the front of beds and borders, or as flowering pot plants or widow boxes, whereas spreading types, particularly the wave series can be used as ground covers (Anne, 2001). Although, petunia is commonly cultivated by seeds in Egypt, Petunia can be propagated vegetatively by terminal stem cuttings (Chatterjee, 2021). The long period from sowing to obtain mature plants encourage scientists and plant producer to recommend producing petunia by cuttings (Jauron, 1999). Petunia propagation from Stem cutting allows to obtain satisfactory number of seedling in a short time and the mother plants from which cuttings were collected can be used in decoration after the cutting (Lopez and Runkle, 2006). Moreover, stem cutting propagation method is used to obtain symmetric and true to type offspring plants**.**

Auxins have many functions in plant physiology such as : cell division stimulation, cell enlargement, cell elongation, continued growth of callus, differentiation of cells in callus, root formation on cuttings, stem elongation as well as synthesis of RNA, enzymes, protein and cell wall components (Mayer and Anderson, 1970). One of the common auxins, used in root promotion of large number of plant species is indole-3-butyric acid (IBA). IBA is nontoxic to plants

in wide range of concentrations. (Hartmann et al., 2011).

Weeping willow (*Salix babylonica*) belongs to Salicaceae family. It is a medium-sized deciduous tree growing up to 20-25 meter tall and believe live up to 20 to 30 years. It is an elegant tree with long dropping leaves of 4-16 cm long. The flowers are arranged in catkins produced in early spring. Willow water is a home brew plant rooting hormone. The usage of this water as plant hormone may be attributed to presence of two items in *Salix* species; indole-3-butyric acid (IBA) and salicylic acid (SA) which appear in high concentrations in the growing tips of salix branches (Deniau et al., 2019 and Angelo, 2011). Moreover, Rehman et al., (2018) found that placing apple cuttings in willow extract for 8 hours resulted in plant vigorous growth and root production.

First function of plant leaves is manufacturing of organic compounds through photosynthesis. Foliar- applied components permeate leaf surface through the cuticle through leaf hairs, stomata and other specialized epidermal cells or through cuticular cracks (Burkhardt and Eichert, 2001, Tukeý and Marczynski, 1984). Plants need necessity micronutrients in small quantities which can be met by foliar spray (Mengel, 2002). The mineral nutrient composition for the cuttings, especially micronutrients such as Fe, Zn, Mn, Mg and B, play a key role in controlling root morphogenesis. Iron and manganese are assistant factors and major compounds of peroxidase and can therefore affect IAA catabolism (Otiende et al., 2017).

The aim of this study was to assess the efficiency of willow water extract, indole-3-butyric acid (IBA) and micronutrient on the rooting of *Petunia x hybrida* stem cuttings and evaluate the economic value of production *Petunia x hybrida* by stem cuttings.

MATERIALS AND METHODS

Two experiments were carried out during the seasons of 2022 and 2023 at a commercial nursery in Alexandria, Egypt. On the 8th of October 2022, fifty homogenous seedlings of *Petunia x hybrida* plant were transplanted in 20 cm plastic pots filled with mixture of sand and clay (1:1 v/v). The transplanted plants were used as a source of the used stem cuttings (mother plant) in these experiments.

The first experiment: Assessment the efficiency of willow water extract (WWE) and indole-3-butyric acid (IBA) on the rooting of *Petunia x hybrida* stem cuttings.

On the 2nd of November 2022, one hundred and five petunia terminal stem cuttings at average tall (7 - 9 cm) were prepared from the mother plants, leaves in the lower 2 cm were removed and the basal 1 cm was dipped in a solution containing of IBA concentrations for one minute while for willow water treatments the basal 1 cm was dipped for one hour. Seven treatments were done in this experiment (control, 500 ppm IBA, 1000 ppm IBA, 2000 ppm IBA, 100% WWE, 50% WWE and 25 % WWE). Cuttings were then planted in 6 cm pots containing 50 % sand+ 50 % peat moss one cutting per pot and the pots were kept under plastic tunnel.

Preparation of willow water extract (WWE).

Tips of *Salix babylonica L.* (willow tree) branches (young and new growth) were selected. All the leaves of selected branches were removed. The willow stems were cut into small segments and placed in a glass jar. Water was added to the jar in a ratio of 500g willow stem segments: 1000 ml. water. The mixture was left for two days to extract the natural hormone. After that the willow water was separated by using a sieve. (Yaseen and Takacs-Hajos, 2022). On the 5th of December 2022 the experiment was terminated and the following data were recorded:

1-Survival percentage (%):

It was determined according to the following formula: Survival percentage (%) =

$$\frac{\text{Number of rooted and survived cuttings at the end of the experment}}{\text{Total cuttings number at the start of the experment}} X\ 100$$

2- Root characteristics:

The following data was recorded on the rooted cuttings: Root length (cm), root volume (cm^3) and root fresh & dry weights (g).

Experimental layout and statistical analysis:-

The experimental layout was a complete randomized design (CRD). It consisted of seven treatments with three replicates, and each treatment contained fifteen cuttings. The means of the studied treatments were compared by least significant different (L.S.D) test at 0.05 level of probability. The data were statistically analyzed according to the method described by Snedecor and Cochran (1989).

The second experiment: Assessment the effects of willow water extract (WWE), indole-3-butyric acid (IBA) and micronutrient fertilizer (MF) on the rooting of *Petunia x hybrida* stem cuttings

On the 13th of January 2023, one hundred and sixty five of petunia terminal stem cuttings at average tall (7 - 9 cm) were prepared from the mother plants. Eleven treatments were done in this experiment (Control , 25 % WWE , 50 % WWE , 125 ppm IBA . 250 ppm IBA, 500 ppm IBA , 25 % WWE +MF , 50 % WWE + MF , 125 ppm IBA+ MF , 250 ppm IBA + MF and 500 ppm IBA + MF).

WWE and IBA concentrations were prepared and applied on petunia cuttings by the same method in the 1st experiment, the cuttings were individually inserted in 6 cm pots containing (50 % sand + 50 % peat) and the pots were kept under plastic tunnel. Two micronutrient fertilizers (MF), the 1st contains zinc (Zn) at 13% and 2nd contains iron (Fe) at 13 % were prepared at 0.5 g/L and sprayed on the cuttings by using a hand-sprayer until the leaves were wet to run off three times. The first time one week from planting and then at a week intervals. On the 24th of February 2023 the experiment was terminated and the following data was recorded:

Survival percentage (%), root length (cm), root volume (cm^3), root fresh & dry weights (g), leaves number, vegetative growth fresh & dry weights (g), and flowers number.

Chlorophylls content: Chlorophyll a and b contents (mg/100g leaves fresh weight) were determined according to Moran (1982).

Statistical analysis:-

The layout of the experiment was a factorial in randomized complete block design (RCBD) with three replicates. Each replicate contained 15 stem cuttings; the first factor was IBA and WWE concentrations, while the other factor was MF supplementation. The means of the studied treatments were compared by L.S.D test at 0.05 level of probability. The data were statistically analyzed according to the method described by Snedecor and Cochran (1989).

Asssment the profit percentage of producing *Petunia x hybrida* by stem cuttings.

At the end of the two experiments, the best treatment which led to the best survival percentage and rooted cuttings characteristics was chosen to calculate its profit percentage for the production of *Petunia x hybrida* by stem cuttings by the following formula:

$$\textbf{Profit Percentage} = \frac{\textbf{Profit}}{\textbf{Cost Price}} \times \textbf{100}$$

RESULTS AND DISCUSSION

The first experiment: Assessment the efficiency of willow water extract (WWE) and indole-3-butyric acid (IBA) on the rooting of *Petunia x hybrida* stem cuttings

Survival percentage (%):

Figure (1) illustrated that the survival percentages after appliction of WWE at 25 % , WWE at 50 % and IBA at 500 ppm were more than the control and the highest survival percentage (74 %) was obtained after the appliction of IBA at 500 ppm while appliction of WWE at the concentrion of 100% gave no survival percenage (0%).

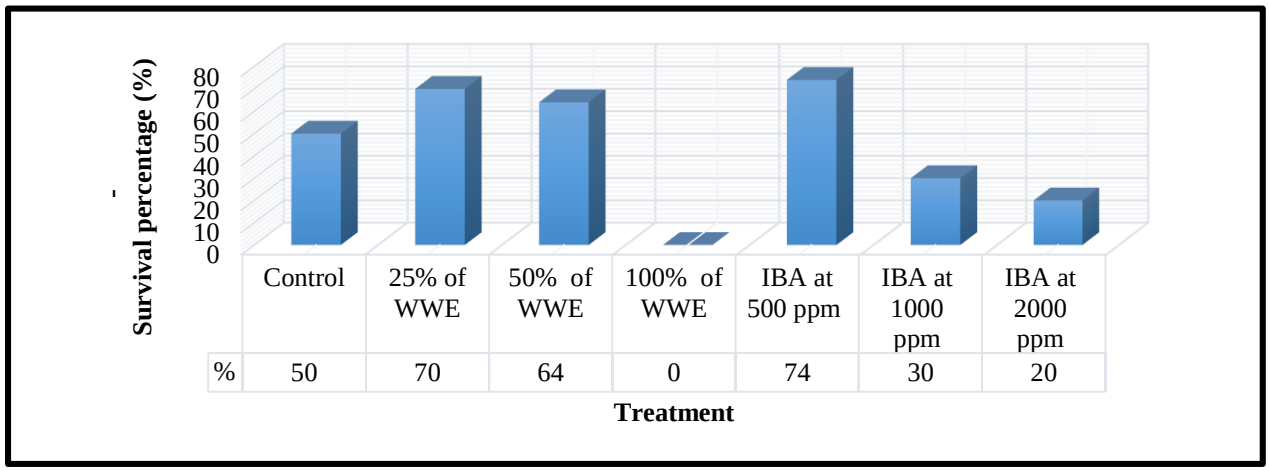

Figure (1). Effect of different treatments of WWE and IBA on survival percentage (%) of *Petunia x hybrida* stem cuttings

2- Root characteristics:

Data presented in Table (1) showed that the highest significant root length (30.33 cm) was obtained after the dipping of Petunia cuts in IBA at 500 ppm, while the lowest one (5.23 cm) was obtained for the untreated ones. For the root volume the application of IBA at 500 ppm resulted in the significant highest volume (7.30 cm^3), while the lowest one (1.2 cm^3) was recorded for the untreated cuttings.

The root fresh weight was significantly the heaviest (6 g) after the application of IBA at 500 ppm and the lowest fresh weight was recorded in the untreated cuttings. Also, data in Table (1) showed that using IBA at 500 ppm resulted in the significant heaviest root dry weight (0.997 g) and the lowest dry weight (0.22 g) was obtained for untreated cutting.

Table (1). Means of root length (cm), root volume (cm^3), root fresh weight (g) and root dry weight (g) of *Petunia x hybrid* rooted cuttings as affected by different treatments of willow water extract (WWE) and indole-3-butyric acid (IBA)

Treatments	Root length (cm)	Root volume (cm^3)	Root fresh weight (g)	Root dry weight (g)
Untreated (control)	5.23	1.20	1.30	0.220
25% of WWE	6.83	1.00	1.71	0.262
50 % of WWE	21.66	1.67	2.10	0.238
IBA at 500 ppm	30.33	7.30	6.00	0.997
IBA at 1000 ppm	13.33	1.90	1.60	0.294
IBA at 2000 ppm	22.00	3.00	4.02	0.651
L.S.D. at 0.05	4.22	0.90	1.10	0.049

L.S.D. at 0.05: Least significant different at 0.05 level of probability

The second experiment: Assessment the effect of willow water extract, indole-3-butyric acid (IBA) and micronutrient (MF) on the rooting of *Petunia x hybrida* stem cuttings

Survival percentage (%)

Figure (2-A) showed that the survival percentages after application of WWE at 25 % and WWE at 50 % were more than control and the highest survival percentage (100%) was obtained after dipping petunia cuttings in IBA at 125, 250 and 500 ppm for the effect of supplementing petunia cuttings with MF. Figure (2-B) showed that the survival percentage for cutting supplementation with MF recorded (80.28 %) while survival rate for non supplemented cuttings recorded (69.12 %). For the effect of dipping petunia cuttings in different concentrations of WWE and IBA and supplementing the cuttings with micronutrients (MF), data in Figure (2-C) showed that the highest survival percentage

(100 %) was obtained after application of IBA at 125, 250 and 500 ppm either supplemented or non-supplemented with MF.

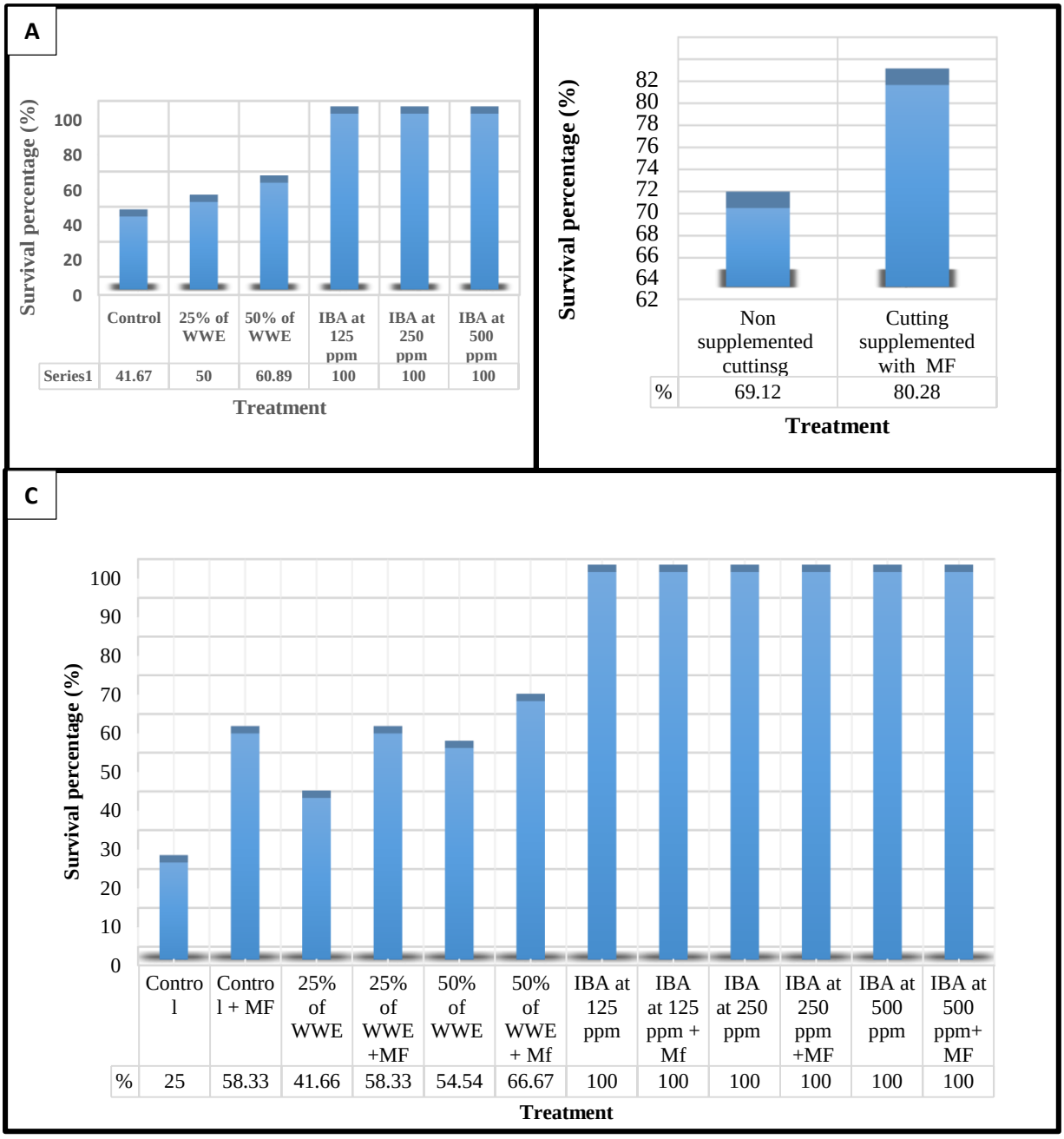

Figure (2), (A): Effect of different concentrations of IBA and WWE (B): Supplementing cuttings with MF, and (C): Dipping cuttings in different concentrations of WWE and IBA and supplementing the cuttings with (MF) on survival percentage of *Petunia x hybrida* stem cuttings.

Root growth characteristics:

For the effect of MF–supplementation, data presented in Table (2) cleared that a significant increase in root length was obtained from non–supplemented cuttings while significant increases in root volume, root fresh & dry weights and root/plant dry weight ratio were recorded after cutting supplementation with MF. For cuttings treatment, Table (2) showed that the highest significant increase in root length was obtained after dipping stem cutting in IBA at 125, 250 or 500 ppm with the same level of significant, dipping petunia cuttings in IBA at

125 caused the highest significant increase in root volume. Also, Table (2) showed that applying IBA at 125 ppm resulted in the highest significant increase in root fresh & dry weights and the highest significant increase in Root/Plant dry weight ratio was recorded after using IBA at 125, 250 or 500 ppm with the same level of significance. For the interaction between supplementing the cuttings with micronutrients (MF) and different cutting treatments (CT), data showed that application of IBA at 125,250 and 500 ppm without MF significantly increased the root length with the same level of significance. The highest significant increases in root volume, root fresh weigh and root dry weight were recorded after the application of IBA at 125 ppm +MF. Also, Table (2) showed that the highest significant increase in Root/Plant dry weight ratio was recorded after using IBA at 125, 250 or 500 ppm + MF with the same level of significance.

Figure (3) illustrated that there was ovserved increment in root charcteristics after using IBA at different concentions compared with contorl and WWE treatment. Moreover, the figure cleared that the using IBA supplmented with MF caused increment in root weight and root volume.

Vegetative growth characteristics:

Data in Table (3) showed that supplementing petunia cuttings with MF resulted in significant increases in all studied vegetative growth characteristics as compared to untreated cuttings. Dipping stem cuttings in IBA at 125 ppm resulted in the highest significant increase in leaves number and vegetative growth fresh & dry weights (g). Also, Table (3) showed that the significant highest increase in flower number was obtained after application of IBA at 125 ppm and 250 ppm with the same level of significance. For the interaction between supplementing the cuttings with micronutrient (MF) and different cutting treatments (CT) Table (3) showed that the highest significant increase in leaves number, vegetative growth fresh & dry weights (g) and flowers number was recorded after application of IBA at 125 ppm + MF.

Table (2). Means of root length (cm), root volume (cm^3), root fresh weight (g), root dry weight (g) and root/plant dry weight ratio (RDW/PDW) of *Petunia x hybrid* rooted cuttings as affected by willow water extract (WWE), indole-3-butyric acid (IBA) and micronutrient fertilizer (MF).

Treatments		Root length (cm)	Root volume (cm^3)	Root fresh weight (g)	Root dry weight (g)	RDW/PDW
MFsuplementaion	Cutting treatments (CT)					
Without MF	Untreated (control)	2.60	0.22	0.32	0.03	7.30
	25% WWE	4.57	0.57	0.40	0.04	10.98
	50 % WWE	6.58	0.76	0.55	0.07	18.63
	125 ppm	11.78	2.06	2.51	0.37	46.05
	250 ppm	11.72	1.71	2.12	0.33	51.81
	500 ppm	12.15	1.73	2.25	0.35	51.18
Mean		**8.23**	**1.18**	**1.36**	**0.20**	**30.99**
With MF	Untreated (control)	1.89	0.59	0.43	0.06	13.01
	25% WWE	4.84	0.82	0.62	0.09	18.55
	50 % WWE	6.20	0.91	0.73	0.21	31.61
	125 ppm	11.17	2.71	3.93	0.73	59.24
	250 ppm	10.25	2.31	2.37	0.47	56.79
	500 ppm	10.71	2.36	2.43	0.54	60.79
Mean		**7.51**	**1.62**	**1.75**	**0.35**	**40.00**
Means of cutting treatments (CT)	Untreated (control)	2.25	0.41	0.37	0.04	10.15
	25% WWE	4.71	0.69	0.51	0.07	14.77
	50 % WWE	6.39	0.84	0.64	0.14	25.12
	125 ppm	11.48	2.38	3.22	0.54	52.65
	250 ppm	10.99	2.01	2.24	0.42	54.30
	500 ppm	11.43	2.04	2.34	0.43	55.98
L.S.D at 0.05	MF	0.3	0.08	0.27	0.03	2.33
	CT	0.5	0.15	0.46	0.05	4.03
	MF X CT	0.7	0.21	0.65	0.08	5.70

L.S.D. at 0.05: Least significant different at 0.05 level of probability

Figure (3). Effect of (A) different concentrations of IBA and WWE (B) different concentrations of IBA and WWE supplemented with MF on root characteristics of *Petunia x hybrida* stem cuttings

Table (3). Means of leaves number, vegetative growth fresh weight (g), vegetative growth dry weight (g) and flowers number of *Petunia x hybrid* rooted cuttings as affected by willow water extract (WWE), Indole-3-butyric acid (IBA) and micronutrients fertilizer (MF).

Treatments		Leaves number	Vegetative growth fresh weight (g)	Vegetative growth dry weight (g)	Flowers number /plant
MF suplementaion	Cutting treatments (CT)				
Without MF	Untreated (control)	8.33	1.44	0.32	1.92
	25% WWE	7.14	1.45	0.35	1.11
	50 % WWE	5.69	1.40	0.31	1.81
	125 ppm	9.08	2.77	0.41	2.11
	250 ppm	5.19	1.85	0.34	2.00
	500 ppm	5.44	1.63	0.32	1.99
Mean		6.81	1.76	0.34	1.82
With MF	Untreated (control)	8.39	1.48	0.31	2.11
	25% WWE	8.06	1.65	0.38	1.72
	50 % WWE	6.97	1.69	0.40	2.33
	125 ppm	11.36	3.65	0.57	2.83
	250 ppm	7.56	2.16	0.36	2.44
	500 ppm	7.19	2.02	0.35	2.00
Mean		8.25	2.11	0.39	2.24
Means of cutting treatments (CT)	Untreated (control)	8.36	1.46	0.31	2.01
	25% WWE	7.60	1.55	0.36	1.42
	50 % WWE	6.33	1.55	0.36	2.07
	125 ppm	10.22	3.21	0.49	2.47
	250 ppm	6.38	2.00	0.35	2.22
	500 ppm	6.32	1.82	0.33	2.00
L.S.D at 0.05	MF	0.42	0.17	0.03	0.15
	CT	0.72	0.30	0.05	0.26
	MF X CT	1.02	0.42	0.07	0.37

L.S.D. at 0.05: Least significant different at 0.05 level of probability

Chlorophyll a and b contents

Data presented in Table (4) cleared that supplementing petunia cuttings with MF resulted significant increase in chlorophyll a and b contents as compared to untreated cuttings. For the effect of different cutting treatments, Table (4) showed that the highest significant increase in chlorophyll a content was recorded after application of IBA at 125 ppm. While the highest significant increase in chlorophyll b content was recorded after application of WWE at 50 % and IBA at 125 ppm at the same level of significance. For the interaction between supplementing the cuttings with micronutrient (MF) and different cuttings treatments (CT), Table (4) showed that the highest significant increases in chlorophyll a and b contents were recorded after application of WWE at 25% + MF, WWE at 50% + MF and IBA at 125 +MF at the same level of significance.

Table (4). Means of chlorophyll a (Chl. a) and chlorophyll b (Chl. b) contents (mg/ 100g fresh weight) of *Petunia x hybrid* rooted cuttings as affected by willow water extract (WWE), indole-3-butyric acid (IBA) and micronutrients fertilizer (MF).

Treatments		Chlorophyll a (mg/ 100g fresh weight)	Chlorophyll b (mg/ 100g fresh weight)
MF suplementaion	**Cutting treatments (CT)**		
Without MF	**Untreated (control)**	14.13	6.58
	25% WWE	13.52	12.46
	50 % WWE	20.63	12.64
	125 ppm	29.28	17.19
	250 ppm	23.18	13.82
	500 ppm	24.55	14.83
Mean		20.88	12.92
With MF	**Untreated (control)**	14.63	7.09
	25% WWE	32.89	19.98
	50 % WWE	34.60	21.86
	125 ppm	35.95	22.08
	250 ppm	27.04	16.72
	500 ppm	23.27	17.75
Mean		28.06	17.58
Means of cutting treatments (CT)	**Untreated (control)**	14.38	6.84
	25% WWE	23.21	16.22
	50 % WWE	27.62	17.25
	125 ppm	32.61	19.64
	250 ppm	25.11	15.27
	500 ppm	23.91	16.29
L.S.D at 0.05	**MF**	1.77	1.40
	CT	3.06	2.43
	MF X CT	4.33	3.43

L.S.D. at 0.05: Least significant different at 0.05 level of probability

Assessment the profit percentage of producing *Petunia x hybrida* by stem cuttings.

Data listed in Table (5) cleared that profit percentage of producing 800 plants by stem cuttings from 100 mother plants of *Petunia x hybrida* by dipping the cuttings in IBA at 125 ppm supplement with micronutrient fertilizer (MF) at 0.5 g/l. (three times through the rooting period) was 100.98 % where the average number of the taken cuttings from one mother plant were 8 cuttings at two times and the plant life of the mother plant lasted to the end of its flowering time., the number of survived mother plants after transplanting were 90 plants and the number of survived produced plants were 800 plants.

Table (5). Profit percentage of producing 800 plants by stem cuttings from 100 mother plants of *Petunia x hybrida*.

Cost price for the produced plants (EGP)		Selling price for the produced plants (EGP)	
- 100 Mother plant price	1000 E£	- Total selling price for 90 mother plants	900 E£
- 800 (12 cm plastic pots) price	640 E£	- Total selling price for 800 produced plants from mother plants	3200 E£
- Soil, labor and maintenance expenses for 800 produced plants from mother plants	320 E£		
- Fertilizer and hormone for 800 produced plants from mother plants	80 E£		
- Total cost	**2040 E£**	**Total selling price**	**4100 E£**
- Profit	**2060 E£**		
- Profit percentage	**100.98 %**		

DISCUSSION

The results in the first experiment cleared that using willow water extract effectively increased the cutting rooting percentage and characteristics which may be explained by the presence of IBA and salicylic acid in the willow water extract (Knapke et al., 2018). Salicylic acid is characterized by its ability on growth increment and anti-senescence (Raskin, 1995). Also, results cleared that dipping petunia cuttings in IBA at 500 ppm in the first experiment and IBA at 125 in the second experiment resulted in the highest percentage of rooting and root characteristics. The encouragement effect of IBA on the rooting of the cuts may be attributed to its ability to promote root primordia initiation and growth through cell multiplication (Fogasa and Fett-Neto, 2005), increment the levels of total soluble sugar, starch, protein and peroxidase activity (Husen and Pal, 2007) and motivation of sugars and nutrients by the hydrolysis of starch to the base of the cuttings (Das et al., 1997).

The obtained results in the second experiment showed that supplementing petunia cuttings with micronutrient resulted in increment in rooting percentage and root characteristics. These increment can be explained by its role in induction and formation roots, where zinc has a remarkable function in cell division, DNA and RNA metabolism and protein structure which lead to root formation (Marschner, 1995), moreover Zn is important for auxin structure through the biosynthetic pathway that takes place by the promotion of the auxin precursor, tryptophan which lead to formation of auxin (IAA) (Hartmann et al., 2011). Carbohydrate metabolism and protein synthesis are activated by zinc which lead to root development (Fageria, 2004). For the effect of supplementing the cuttings with Fe, it can be mentioned that iron has a function in chlorophyll and carotenoid biosynthesis (Terry and Abadía ,1986 , Kim et al., 2012). The excess in the level of photosynthetic pigment leads to higher photosynthetic rates, and subsequently encourage the formation of the root system. (Briat et al., 2015, El-Jendoubi et al., 2011).

RECOMMENDATION

From the above mentioned results, it is advised to dip petunia terminal stem cuttings in IBA at 125 ppm with three times of foliar spray of micronutrient fertilizer (MF) at 0.5 /L on the leaves of the cuttings, the MF contains zinc (Zn) and iron (Fe) at 13 %, the first time after one week from cuttings plant, one week intervals to produce *Petunia x hybrida* by terminal stem cuttings. This treatment resulted the highest survival percentage, root parameters, vegetative growth characteristics and chlorophyll content.

REFERENCES

Angelo, E. (2011). How to Make Home Made Plant Rooting Hormone – Willow Water. www.deepgreenpermaculture.com.

Anne, H. (2001). Annuals, Perennials, & Bulbs. Creative Homeowner. Upper Saddle River , New-Jersey USA. p. 72

Briat, JF., Dubos, C. and Gaymard, F. (2015). Iron nutrition, biomass production, and plant product quality. Trend. Plant Sci., 20 (1) :33- 40.

Burkhardt, J. and Eichert, T. (2001). Stomatal uptake as an important factor in foliar nutrition, p1046–1047. In: Horst, W. J. and Marschner, H. (eds.). Plant Nutrition. Kluwer Academic Pub- lishers, Boston, MA.

Chatterjee, S. (2021). Commercial Flowers 3rd Edition, vol 4. Daya Publishing House New Delhi- India p 219

Das, P., Basak, U. and Das, A. (1997). Metabolic changes during rooting in pregirdled stem cuttings and air layers. J. of Heritiera Bot Bull Acad Sin., 38: 91-95.

Deniau, M.G., Bonafos, R., Chovelon, M., Parvaud, C.E., Furet, A., Bertrand, C., Marchand, P.A. (2019). Willow Extract (Salix cortex), a Basic Substance of Agronomical Interests. Int. J. Bio-Resour. Stress Manag., 10 (4) :408 -418.DOI: 10.17660/ActaHortic.2006.711.51

El-Jendoubi, H., Melgar, J C., Álvarez-Fernández, A., Sanz, M., Abadía, A and Abadía, J. (2011). Setting good practices to assess the efficiency of iron fertilizers. Plant Physiol. Biochem., 49 (5): 483-488.

Fageria, NK. (2004). Dry matter yield and nutrient uptake by lowland rice at different growth stages. J. Plant Nutr, 27 (6): 947-958. https://doi.org/10.1081/PLN-120037529.

Fogasa, C.M. and Fett-Neto, AG. (2005). Role of auxin and its modulators in the adventitious rooting of *Eucalyptus* species differing in recalcitrance. Plant Growth Regulation, 4(1):1-10.

Hartmann, H.T., Kester, D.E., Davies, FT. and Geneve, RL. (2011). Plant propagation and practices. Practice Hall International Editions. 6th Ed., pp. 279-414. https://herbsocietyorg. presencehost.net/file_download/4f47d dcd-52f2-4b14-a959-698b475a7142.

Husen, A. and Pal, M. (2007). Metabolic changes during adventitious root primordium development in *Tectona grandis* Linn. f. (Teak) cuttings as affected by age of donor plants and auxin (IBA and NAA) treatment. New Forests, 33 (3): 309-323. Doi:10.1007/s11056-006-9030-7.

Jauron, R. (1999). Selecting and Planting Petunias, Horticulture and Home Pest news February , 19 Issue, PP 14-15.

Kim, S.H., Ahn, Y.O., Ahn, M.J, Lee, H.S. and Kwak, S. (2012). Down-regulation of carotene hydroxylase increases carotene and total carotenoids enhancing salt stress tolerance in transgenic cultured cells of sweet potato. Phytochemistry, 74: 69-78.

Knapke, D., Readal, M., Stravinsky, D., Wells, L., and Wilson, M.J. (2018). The herb society of America's notable native herbal tree willow *Salix* L. species. The Herb Society of America.

Lopez, R.G. and Runkle, E.S. (2006). Daily light integral influences rooting and quality of petunia cuttings. Acta Hortic. 711: 369-374.

Marschner, H. (1995) Mineral Nutrition in Higher Plants. Academic Press, London, UK.

Mayer, B.S and Anderson, O.B. (1970). Plant Physiology 2nd Ed., Van Nostr and Rein fold Comp., New York. pp: 555-569.

Mengel, K. (2002). Alternative or complementary role of foliar supply in mineral nutrition. Acta Hortic., 594: 33-47, DOI: 10.17660/ActaHortic.2002.594.1

Moran, R. (1982). Formula for determination of chlorophyll pigment extracted with

N,N Diethylformamide. Plant Physiol., 69 (6): 1376-1381.

Otiende, MA., Nyabundi, JO., Ngamau, K. and Opala, P. (2017). Effects of cutting position of rose rootstock cultivars on rooting and its relationship with mineral nutrient content and endogenous carbohydrates. Sci. Hortic., 225: 204–212.

Raskin, I. (1995). Salicylic Acid. In: Plant Hormones and Their Role in Plant Growth and Development, 2nd Ed. P.J. Davies (ed.). Kluwer Academic Publishers, Dordrecht. pp. 88-205.

Rehman , A., Shirin, K. M ., Syed , A.Z. , Malik , A.A. and Shahid, M. (2018) . To study the effect of willow extract on apple cuttings for different time duration. Journal of Biology, Agriculture and Healthcare, 8 (13) : 21-24.

Snedecor, G W. and Cochran, W. (1989). Statistical Methods, Eighth Edition Press Ames, Iowa State

Terry, N. and Abadia, J. (1986). Function of iron in chloroplasts. J. Plant Nutr., 9 (3): 609-646.

Tukeý, H.B. and Marczynski, S. (1984). Foliar nutrition - old ideas rediscovered. Acta hortic., 145: 205-212. Doi: 10.17660/actahortic. 145.21

Yaseen, A.A. and Takacs-Hajos M. (2022). The effect of plant biostimulants on the macronutrient content and ion ratio of several lettuce (*Lactuca sativa* L.) cultivars grown in a plastic house. South African Journal of Botany, 147 :223-230

الملخص العربي

تقييم مدى كفاءة المستخلص المائي لنبات الصفصاف ، حمض أندول -3 - بيوتريك و العناصر الصغرى في إكثار نبات البيتونيا بواسطة العقل الساقية

أسماء محمد طه - مجد الدين فؤاد رضا

قسم بحوث الزينة وتنسيق الحدائق- معهد بحوث البساتين - مركز البحوث الزراعية - الإسكندرية – جمهورية مصر العربية

تم إجراء تجربتين خلال موسمي 2022 و 2023 في مشتل تجاري. **التجربة الأولى** لتقدير مدى كفاءة المستخلص المائي لنبات الصفصاف، حمض أندول-3- بيوتريك في تجذير العقل الساقية لنبات البيتونيا، تم اجراء 7 معاملات في هذه التجربة (كنترول ، 500 ، 1000 ، 2000 جزء في المليون اندول-3- بيوتريك اسيد ، 100 %، 50 % ، 25 % المستخلص المائي لنبات الصفصاف). اظهرت النتائج أن معاملة العقل بـ500 جزء في المليون اندول -3-بيوتريك اسيد أعطت أعلى نسبة بقاء ونجاح للعقل، وأعلى زيادة في صفات الجذور .

التجربة الثانية اجريت لدارسة تاثيرالأندول -3- بيوتريك اسيد والمستخلص المائي لنبات الصفصاف والعناصر الصغرى على انتاج نبات البيتونيا عن طريق العقل الساقية. تم استخدام سماد عناصر صغرى به (الزنك والحديد بتركيز 13 %) بمعدل 0.5جرام/لتر رشا على أوراق العقل الساقية ثلاث مرات على فترات أسبوعية وتم الرش في المرة الأولى بعد اسبوع من الزراعة. وتم أجراء 12 معاملة (كنترول، 25 % المستخلص المائي لنبات الصفصاف، 50 % المستخلص المائي لنبات الصفصاف، 500 جزء في المليون اندول-3- بيوتريك اسيد، 250 جزء في المليون اندول-3- بيوتريك اسيد، 125 جزء في المليون اندول-3- بيوتريك اسيد، كنترول + عناصر صغرى، 25% المستخلص المائي لنبات الصفصاف + عناصر صغرى، 50 % المستخلص المائي لنبات الصفصاف + عناصر صغرى، 500 جزء في المليون اندول-3- بيوتريك اسيد + عناصر صغرى، 250 جزء في المليون اندول-3- بيوتريك اسيد + عناصر صغرى، 125 جزء في المليون اندول-3- بيوتريك اسيد + عناصر صغرى). اظهرت النتائج أن أعلى نسبة بقاء ونجاح للعقل، أعلى صفات للجذور وللنمو الخضري وكذلك أعلى محتوى من الكلورفيل تم الحصول عليها من معاملة العقل بـ 125 جزء في اندول-3- بيوتريك اسيد + عناصر صغرى.

تم حساب هامش صافي الربح من إنتاج نبات البيتونيا بطريقة العقل الساقية باستخدام المعاملة 125 جزء في المليون اندول-3- بيوتريك اسيد + عناصر صغرى وسجل 100.98 %.