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EFFECT OF SOME GROWTH SUBSTANCES ON ROOTING AND ENDOGENOUS HORMONES OF *Casimiroa edulis* L. CUTTINGS

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ABSTRACT: This study determines the effect of some exogenous growth substance treatments on rooting and endogenous growth hormones [the total indole-3acetic acid (IAA), gibberellic acid (GA3), cytokinins (CKs) and abscisic acid (ABA)] in stem cuttings of *Casimiroa edulis* L. (*C. edulis*). After 45 days from the treatments, results showed that, no roots were observed in the cuttings without treatment while at 1000 ppm of IBA plus sucrose, BA or pyrogallol is most preferred and more suitable for initiation of roots in cutting. The treatment with IBA 1000 mg/l + sucrose 3% produced the higher number of rooted cuttings (90%) and higher in the average number of roots (6 roots/ cutting). While the cuttings treated with IBA 1000 mg/l + sucrose 5% and IBA 1000 mg/l + pyrogallol 0.5% produced higher average root length (20 mm). Also, there was increasing determined in IAA and CKs levels of cutting treated with IBA (500 and 1000 mg/l alone or plus BA, pyrogallol or sucrose) and decreasing in ABA levels with treatments but the relationship between the rooting and endogenous hormones were uncleared.

Key words: *Casimiroa edulis,* IBA, rooting, cutting, endogenous hormones.

INTRODUCTION

White sapote (*C. edulis*) is a native tree of Mexico and Central America. It is also found in wild and cultivated areas. *C. edulis* is one of three trees species, while the other two species are woolly-leaved white sapote and the matasano de mico. *C. edulis* trees height ranges from 5 to 16 meters. The trunk has a thick grayish bark with long drooping branches. Flowers are hermaphrodite and occasionally can become unisexual (due to the effect of some aborted stigmas). There is a variation in the amount of pollen produced by the seedlings and the grafted cultivars, flowers harbouring sterile pollen and the lack of cross-pollen rationale are considered to be the primary causes of shedding immature fruits. *C. edulis* fruit is round, oval or ovoid. Because of their thin skin, discoloration (bruises) might be noticeable form the least improper harvest procedure(s). Fruits size ranges from 5 to 10 cm in diameter and is apple shaped. Fruits colour is usually light green when unripe and turns to yellow when ripe. The skin is coated with many tiny yellow oil glands. Fruits flesh is creamy with a sweet flavour and its colour is yellow or white. Fruits usually contain 1 to 6 hard white seeds. White sapotes are commonly grown from seeds and it takes 7 to 8 years from seedling to the first harvesting cycle and propagation by cutting is difficult in rooting (**Ahlawat *et al.,* 2016**).

Propagation by cuttings has high propagation coefficients and can be applied to large-scale plantations. In this experiment, we have first shown for propagation by cutting for *C. edulis* and relationships between levels of endogenous plant hormones.

The process of adventitious root formation and elongation is influenced by some internal and external factors. Among the internal factors, the key part is attributed to auxins which be under phytohormones. It is generally accepted that auxins have a certain role in rooting initiation (**Stefancic *et al.,* 2005**). Survival of

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cuttings and the attaching limit is identified with natural components of the species, for example, hormonal adjust, time of accumulation, cutting and hereditary capability of the species (**Franzon *et al.*, 2004; Fachinello *et al.,* 2005**).

Auxins stimulate adventitious root formation, and the response to auxin and its role in controlling roots formation and their length and number are critical, and auxin role in root induction is much more highlighted than its initiation (**Yan *et al.,* 2014**).

In general, roots formation in plants is happening in two phases, the first phase is sensitive to auxin content but, the second phase is auxin insensitive (**Yan *et al.,* 2014**). Roots primordia formation in cuttings is dependent upon internal auxin content and some synergistic components such as biphenyls. These compounds stimulate the related RNAs biosynthesis and hence improve roots primordia initiation (**Henrique *et al.,* 2006**).

Many diverse compounds, which are thought to influence auxin levels, have been shown to influence root formation. Phenolic compounds are regarded as being important in this context. The evidence of which is based is mostly indirect, although there is limited supporting evidence from correlative studies of phenolic levels and rooting.

Despite some conflicting results from physiological investigations, the possibility that o-dihydroxy compounds may influence root formation *via* an inhibitory influence on IAA oxidase.

Auxins are very helpful to overcome difficulties in cuttings for root induction. Indole butyric acid (IBA) is a plant growth hormone from the auxin family and is used in many horticultural plants for root induction. **Hafeez *et al.* (1988)** and **Mukhtar *et al.* (1998)** succeeded in growing guava softwood cutting by using root growth regulators.

Debnath and Maith (1990) acquired best establishing in Baruipur cultivar when plunged in 2500 mg/l IBA. However, there is persuading confirmations that auxins are fundamental for root advancement **(Hartmann and Kester, 1982**).

Many investigations have detailed that IBA increases root number in plants (**Henrique *et al.,* 2006**).

In cuttings which are regarded with manufactured auxins, for example, IBA, groupings of IAA at the base of cuttings can build momentarily and afterward diminish before establishing, sometimes within a period as short as 24 hr. (**De Klerk *et al.,* 1999**). As reported elsewhere, IBA itself or combined with other growth regulators at high concentrations increase or accelerate the rooting of plants that exhibit particular rooting difficulties (**Sun and Bassuk, 1991**).

Endogenous hormone levels are a critical factor influencing root and callus arrangement in stem cuttings. Many reports have demonstrated a positive connection between endogenous IAA levels in cuttings and the number of extrinsic roots created per cutting (**Sivaci and Yalcin, 2007**).

A negative relationship between root development and endogenous abscisic acid (ABA) was reported by (**Pilet and Saugy, 1987**). **Hansen (1988)** reported that GA3 inhibit rooting of cuttings of many plant species. **Feito *et al.* (1996)** reported that the most active rooting systems have high levels of cytokinins mainly (zeatin and its riboside), with low IAA and ABA concentrations.

Besides hormones and growth regulators, sucrose is another main criterion affects rooting phenomenon. Along with being an energy source, sucrose is a structural monomer for the biosynthesis of many other skeletal compounds. Sugars promote the growth and development of plants. It seems that oligosaccharides deposited in the cell wall have a positive effect on root induction and growth **(Mehrabani *et al.,* 2016)**. Transport of sugars to the site of regeneration is evident during the early stages of root regeneration. This is so even where root initiation is unlikely to be limited by the local availability of carbohydrate in the region of root formation. The stimulatory effect of supplied sugars on root formation is particularly evident when auxin is also supplied to stem cuttings. This raises the possibility that supplied sugar enhances the loading and transport of auxin such that it more readily reaches potential sites of initiation. Many of these have demonstrated that sugars, including sucrose, glucose, fructose, ribose, deoxyribose, myo-inositol and dextrose, can enhance rooting response of cuttings in the presence, or absence, of supplied auxin **(Jarvis, 1986).**

The phenols play a critical role in modifying Indole acetic acid (IAA) activity, liberating endogenous auxins and forming covalently bonded auxin phenol conjugates which enhance root formation **(Coll *et al*., 2002**).

However, the little numbers of rooting studies have previously examined relationships between levels of endogenous plant hormones, [*e.g.* IAA, CKs, GA3 and ABA] and the rooting ability during root-induction.

The aim of the present work was to study the effects of IBA, BA, pyrogallol, and sucrose treatments on endogenous hormones (IAA, GA3, CKs and ABA) levels and their relationship during rooting.

MATERIALS AND METHODS

This investigation was carried out in the plant physiology lab., Department of Botany, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt.

Plant Material

The cuttings were taken from a vigorous and healthy a single tree of white sapote early in the morning during the dormant stage on begin-December 2016 in Faculty of Agriculture Farm area.

Stem cuttings used were 12 to 15 cm in length, and 7 to 11 mm in diameter with at least 2-4 buds on each cutting and all leaves were removed. All the cuttings were treated for 1.5 min in a solution of mercuric chloride 0.1 % and soaked in distilled water. The bases of the stem cuttings were soaked for 15 min in different concentrations solution of the IBA (500 and 4000 mg/l) alone or combined with BA (5 and 10 mg/l), pyrogallol (0.5 and 1.0 mg/l) or sucrose (3 and 5%) for 15 min. The cuttings soaked in distilled water were used as a control. One group of replicates each consisting of 10 cuttings were then planted immediately in a plastic planter box with wood-perlite.

The rooting studies were carried out in a climatic room in the daily period at 17-24°C. The following observations were made and data collected after 45 days from treatments were, number of rooted cuttings, number of cuttings with mortality, the total number of roots and total root length of cuttings. For each analysis, cuttings were taken, and basal parts in stem cuttings were sampled.

The data collected was analyzed using Analysis of Variance (ANOVA) and significant differences among means were calculated by Duncan's multiple range test ($p \leq 0.05$). All data were analyzed statistically by two-way ANOVA using the Costat program (version 6.3), and the figures plotted by Excel 2016 **(Costat, 1990)**.

Hormone Analyses

Hormones analyses were done according to the method of **(Tang *et al.,* 2011)**.

RESULTS AND DISCUSSION

Effect of Treatments on the Number of Rooted Cuttings

In Fig. 1 and Table 1 no roots were observed in the cuttings without IBA treatment (control) and also, at 0, 2000 and 4000 ppm treatment of IBA showed no growth of the roots (data not shown). A dose of 500 and 1000 ppm showed the best response to the growth of roots. With increased concentration of IBA from 500 to 1000 ppm increased the number of rooted cuttings while it decreased with increasing concentration of BA alone. Also, it was decreased with increasing concentration of pyrogallol. The treatment with IBA 1000 mg/l + sucrose 3% produced highe number of rooted cuttings (90%) followed by IBA 1000 mg/l + sucrose 5% and IBA 1000 mg/l + BA 5 or 10 mg/l (80%). This can be supported by the work of **Leakey (2004)** who noted that the cuttings that have a high level of auxins and cytokinins have a higher percentage of rooted cuttings. The response was also confirmed by (**Yong Jean *et al.,* 2013**) who showed that coconut water contains cytokinins which helps to stimulate the growth of roots and shoots. **Wiegel *et al.* (1984)** found that carbohydrates help in auxin transport as well as the growth of shoots and roots.

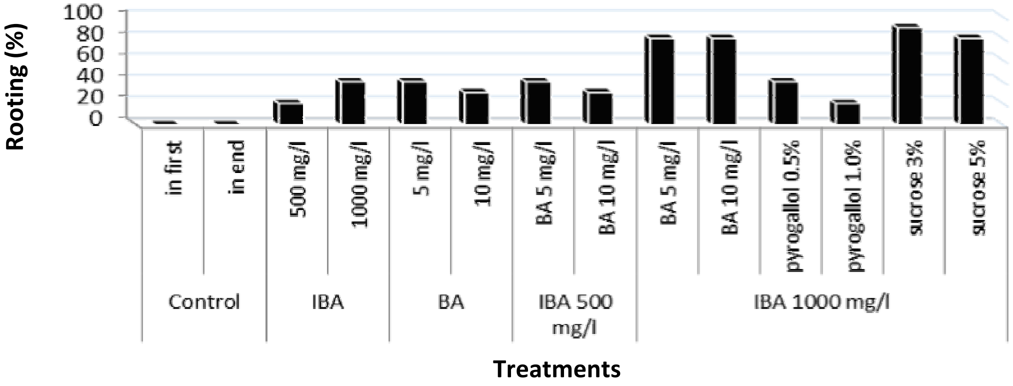

Fig. 1. Effect of treatments on the number of rooted cuttings

Table 1. Effect of treatments on rooting and endogenous hormones of *C. edulis* cuttings

Treatment	Rooting (%)	Average No. of roots/ cutting	Average length of roots (mm)	Endogenous hormones content										
				IAA		CKs		GA3		ABA		IAA /CKs ratio	IAA /ABA ratio	CKs / ABA ratio
				µg/g	(%)	µg/g	(%)	µgm/g	(%)	µg/g	(%)			
Control (in first)	0 d	0 f	0 e	3.46	0.89	3.68	0.94	362.53	92.84	20.8	5.33	0.94	0.17	0.18
Control (in end)	0 d	0 f	0 e	2.675	8.35	0.62	1.95	27.37	85.40	1.38	4.31	4.28	1.94	0.45
IBA 500 mg/l	20 e	2 cde	3 de	4.63	2.03	2.27	0.99	219.5	96.04	2.15	0.94	2.04	2.16	1.06
IBA 1000 mg/l	40 c	5 ab	13 b	21.41	5.43	8.32	2.11	363.16	92.09	1.45	0.37	2.57	14.73	5.72
BA 5 mg/l	40 c	1 ef	2 de	15.72	5.43	6.11	2.11	266.95	92.19	0.77	0.27	2.57	20.35	7.91
BA 10 mg/l	30 d	2 def	2 de	14.18	4.68	5.50	1.82	282.53	93.29	0.62	0.20	2.58	22.88	8.88
IBA 500 mg/l + BA 5 mg/l	40 c	4 ab	5 cde	18.70	6.21	7.26	2.41	273.9	90.88	1.49	0.50	2.57	12.51	4.86
IBA 500 mg/l + BA 10 mg/l	30 d	3 bcde	8 bcde	16.32	5.03	6.23	1.92	300.4	92.64	1.31	0.41	2.62	12.40	4.73
IBA 1000 mg/l + BA 5 mg/l	80 b	5 ab	11 bc	8.719	3.02	3.38	1.17	275.85	95.53	0.81	0.28	2.58	10.76	4.17
IBA 1000 mg/l + BA 10 mg/l	80 b	6 ab	7 bcde	12.38	2.88	4.81	1.12	411.86	95.84	0.65	0.15	2.57	18.83	7.32
IBA 1000 mg/l + pyrogallol 0.5%	40 c	2 def	20 b	19.07	5.08	7.41	1.97	348.01	92.68	1.02	0.27	2.57	18.64	7.24
IBA 1000 mg/l + pyrogallol 1.0%	20 e	3 bcd	6 bcde	21.88	5.38	8.50	2.09	374.93	92.27	1.03	0.26	2.57	21.06	8.18
IBA 1000 mg/l + sucrose 3%	90 a	6 a	9 bcd	18.75	7.89	7.28	3.06	210.88	88.68	0.88	0.37	2.58	21.31	8.27
IBA 1000 mg/l + sucrose 5%	80 b	5 abc	20 a	28.83	8.45	10.9	3.19	300	87.91	1.53	0.45	2.65	18.80	7.11

Control (in first) = in begin of the experiments **Control (in end)** = after 45 days from treatment

Pallardy and Kozlowski (2007) also observed that cuttings dipped in sucrose solution often improved rooting response by increasing the carbohydrates level and facilitating growth. However, high levels of sugars affected rooting by reducing the levels of nitrogen, which is essential in the rooting process **(Hartmann *et al.,* 1997)**. **Stenvall *et al.* (2009)** indicated that the accumulation of carbohydrates in plant tissues is correlated with the capacity for adventitious rooting. On the other hand, in pineapple (*A. sellowiana*) and guava (*P. guajava*), different concentrations of IBA did not influence the survival of cuttings (**Zietemann** and **Roberto, 2007**). In juvenile and mature *F. 1mmila* found that cytokinins inhibit the rooting in pre-induction phases **(Smith and Thorpe, 1975)** with a loss of inhibitory effect at later stages **(Eriksen and Mohammed, 1974)**.

Synergistic interactions between auxin pyrogallol have been confirmed in cuttings taken from material grown in the light but not the dark **(Jarvis, 1986)**. It is possible, therefore, that synergism between supplied phenolics and auxin may only occur when cuttings are rooted in the light or taken from stock material raised in the light.

Effect of Treatments on Number of Roots

Results showed that, treatment with IBA 1000 mg/l + sucrose 3% and IBA 1000 mg/l + BA 10 mg/l were significantly higher in average number of roots (6 roots/cutting), followed by IBA 1000 mg/l + BA 5 mg/l and IBA 1000 mg/l + sucrose 5% (5.0 and 4.0 respectively) compared with control (0.0) as shown in Table 1 and Fig. 2. IBA is a root promoting hormone that stimulates the activity of cambium to initiate roots **(Rahman *et al.,* 1991)**. Application of rooting hormone to enhance rooting capability of cutting has been suggested by many authors **(Akram *et al.* 2017)**. **Sen (2006)** reported that the average number of roots of *Flacourtia jangomas* cuttings was significantly escalated due to the application of IBA.

The maximum number of roots was achieved in 0.4% IBA treated cuttings and the minimum was with untreated. **Hossain *et al.* (2002)** reported that exogenous auxin (0.4% IBA) application appreciably ($p<0.05$) increased the number of roots per cuttings of Jackfruit. In another experiment **Hossain *et al.* (2004)** reported in *Chukrasia velutina* the highest number of roots per cutting treated with 0.4% IBA solution compared with untreated cutting. **Pirkhazri *et al.* (2010)** showed that the effect of different concentrations of IBA on number of roots in cuttings of apple and reported that the maximum number of roots in cuttings was obtained in cutting treated with 2500 ppm and the lowest was in the control.

Effect of Treatments on Root Length

In Table 1 and Fig. 3 the results of different average root length between treatments show that there are significant differences. The treatments with cytokinin showed negative growth in root elongation. While the cuttings treated with IBA 1000 mg/l + sucrose 5% and IBA 1000 mg/l + pyrogallol 0.5% produced higher average root length (20 mm) followed by IBA 1000 mg/l and IBA 1000 mg/l + pyrogallol 1.0 % (13 and 12 mm, respectively). These results confirmed with **Davies and Joiner (1980)** who found that BA inhibited rooting at early initiation stages. While root length increased with an increase in IBA concentration (except for the quick dip method).

Increased *S. carpocapsae* efficacy against This finding concurs with a report by **Howard (1985)**. Also, **Werner *et al.* (2010)** found that cytokinins are negative regulators of root formation and elongation. **Ezekiel (2010)** documented that a higher number of roots, root length and root volume per cutting was observed in IBA treatment than control. Many researchers, for example, **Opuni-Frimpong *et al.* (2008)** and **Husen and Pal (2007)** reported that IBA has an important role in the development of adventitious roots, improving quality of roots and increasing root biomass. Signaling due to IBA and other hormones enhanced polysaccharide hydrolysis to provide energy for meristematic tissues of roots **(Ezekiel, 2010)**. Moreover, this may be due to the hormonal action to regulate several physiological activities in a proper way such as transpiration and plant development including root-shoot initiation and elongation **(Shan *et al.,* 2012)**. **Tonietto *et al.* (2001)**, working with two cultivars of *Prunus domestica* verified that IBA increases rooting, the number and length of roots of both cultivars. IBA, according to the authors, because it facilitates root formation, gave the roots more time to grow thus reaching higher lengths which is an indirect effect of IBA.

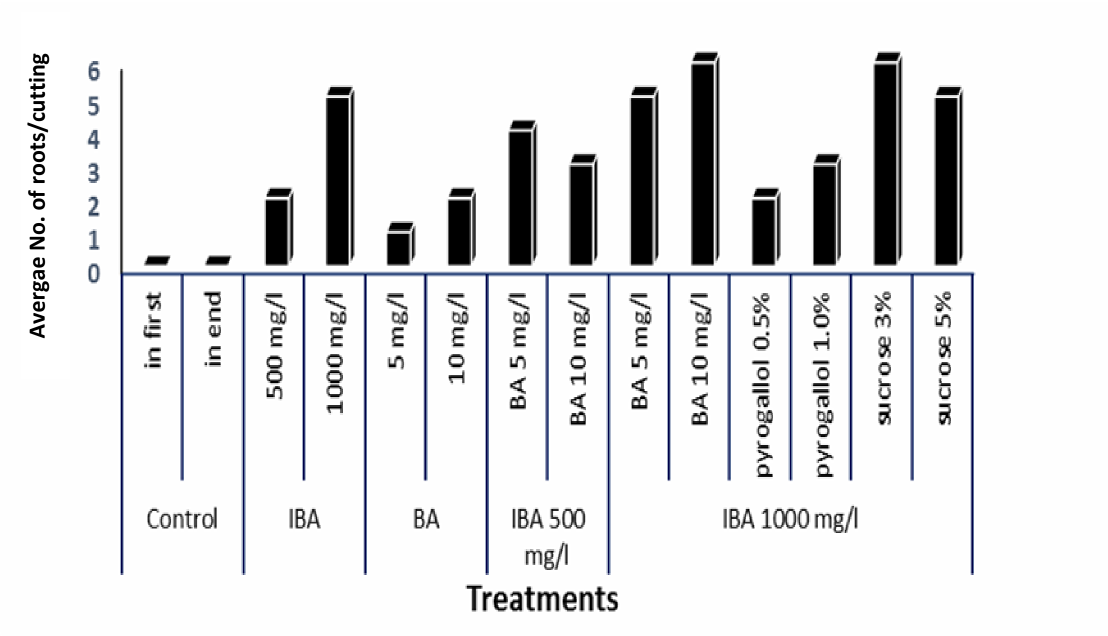

Fig. 2. Effect of treatments on average number of roots per cuttings

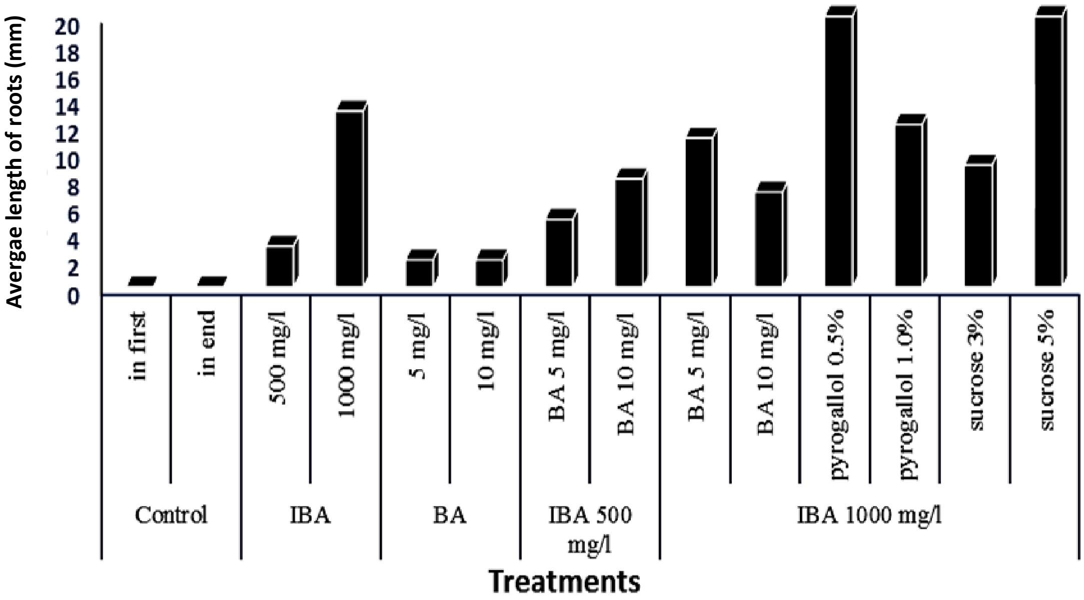

Fig. 3. Effect of treatments on average length of roots per cuttings

Similar observations were reported by **Cunha *et al.* (2004)** in a research work with *Sapium glandulatus* cuttings, wherein their length increased with IBA doses. The highest number of root observed in cuttings treated with moringa leaf extract was due to the presence of Zeatin which a component of auxin is found in the extract from moringa leaf that aid root elongation and formation as reported by **Culver *et al.* (2012). Samanda *et al.* (2015)** reported that in chrysanthemum, IBA increased the roots number. Moreover, they reported that, root initiation and later development went to reduce the carbohydrates pool accumulated at the cutting basal end.

Effect of Treatments on IAA, CKs, GA3 and ABA Concentrations

At late phase after 45 days from treatments, changes in endogenous hormone levels during adventitious rooting in plant propagation are still unclear. In Table 1 and Figs. 4, 5 and 6 the IAA and CKs concentrations were significantly increased with IBA, BA and sucrose treatments while endogenous ABA was decreased (Table 1 and Fig. 7), IAA and CKs concentrations were higher than in the cuttings treated with IBA 1000 mg/l + sucrose 5% followed by IBA 1000 mg/l + pyrogallol 1.0% and IBA 1000 mg/l recorded (28.83, 21.88 and 21.41µg/g fresh weight) of IAA and (10.9, 8.5 and 8.32 µg/g fresh weight) of CKs, respectively and recorded high percent of rooting and average length of roots. The lowest endogenous IAA and CKs were showed in the cuttings without treatments and which were the highest in endogenous ABA. **Yeboah *et al.* (2009)** found that the wood types dipped in different sucrose levels significantly gave lower phenol levels compared to the control. Cuttings dipped in 15% sucrose solution recorded significantly higher rooting percentage, more roots and longer roots than both the control and 25% sucrose treatment. **Qaddoury and Amssa (2004)** found that, the root formation in date palm offshoots was significantly improved by IBA treatment and the contents of phenolic compounds increased steeply after IBA treatment and then decreased. Also, **Zhang and Guo (2006)** found that primordial initiation was generally associated with high IAA contents in *Paulownia fortune*. -IAA producing ability of the tissues increases with IBA treatments. In many different woody taxons, it has been proved that IBA can convert to IAA **(Gergő, 2011).** Some reports showed that exogenous IBA could induce the changes in enzyme activities (peroxidase and IAA oxidase) and their effector's contents (phenolics) allowing the establishment of the favorable endogenous hormone balance **(Ribnicky *et al.,* 1996; Gaspar *et al.,* 1997)**. Auxin treatment enhances the movement of boron (B), nitrogen (N), Zinc (Zn) and potassium (K) from the leaves and buds of the cuttings to the rooting zone **(Blazich *et al.,* 1983)**.

Low ABA concentrations favored root primordial initiation in these cuttings. The endogenous ABA was significantly decreased with all of the treatments while it was higher than 5.33 and 4.31 µg/g fresh weight in cutting without treatment in beginning and end of the experiment, respectively on the other hand endogenous ABAwas lower than 0.62 µg/g fresh weight in cutting treated with BA 10 mg/l alone. Cytokinins were postulated to antagonize the ABA effect on plant behavior **(Nishiyama *et al.,* 2011)**. Increased ABA levels in xylem sap and leaves of grape vines were found accompanied by decreased tZ-type cytokinins concentrations in root and shoot under partial root-zone drying **(Stoll *et al.,* 2000).**

The GA3 concentrations was different and uncleared with all of the treatments. The endogenous GA3 was higher than 411.86 µg/g fresh weight in treatment with IBA 1000 mg/l + BA 10 mg/l.

Cytokinin and its interaction with ABA may be important for regulating plant root system architecture. **Yamaguchi and Sharp (2010)** found that maintenance of root elongation by ABA was conferred by its regulation of ion homeostasis, osmotic adjustment, and cell wall extensibility. **Xu *et al.* (2013)** reported that increased ABA accumulation under moderate osmotic stress was responsible for root growth promotion which may have occurred through the regulation of auxin transport in root tips. The crosstalk between ABA and auxin may play an important role in regulating root growth **(Yamaguchi and Sharp, 2010)**. On the other hand, in some cases, ABA has no apparent inhibitory effect on rooting of cuttings **(Kracke and Cristoferi, 1983;Kelen and Ozkan, 2003)**. For example, Grape is difficult to root although

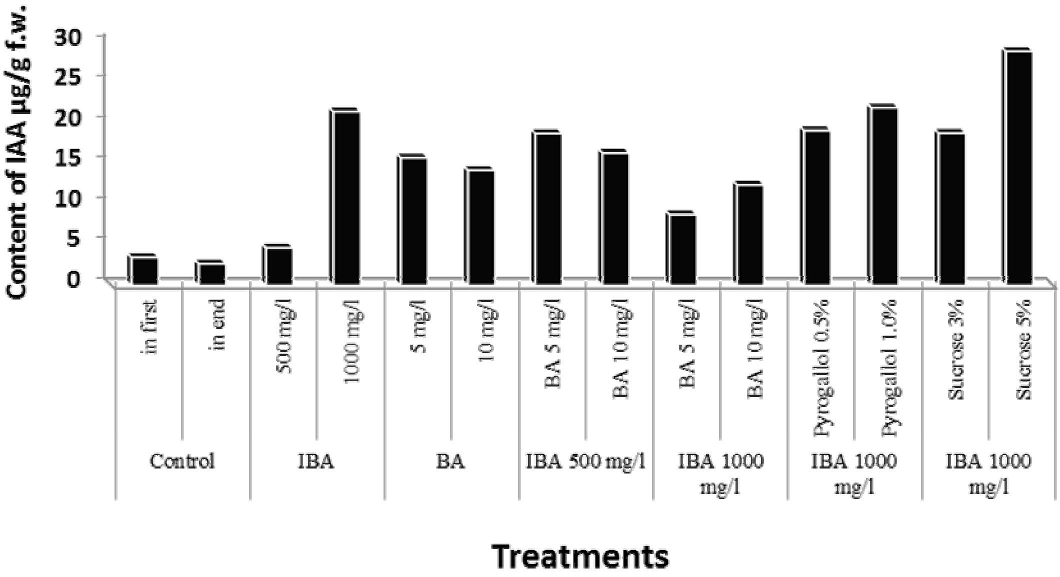

Fig. 4. Effect of treatments on content of IAA in cuttings

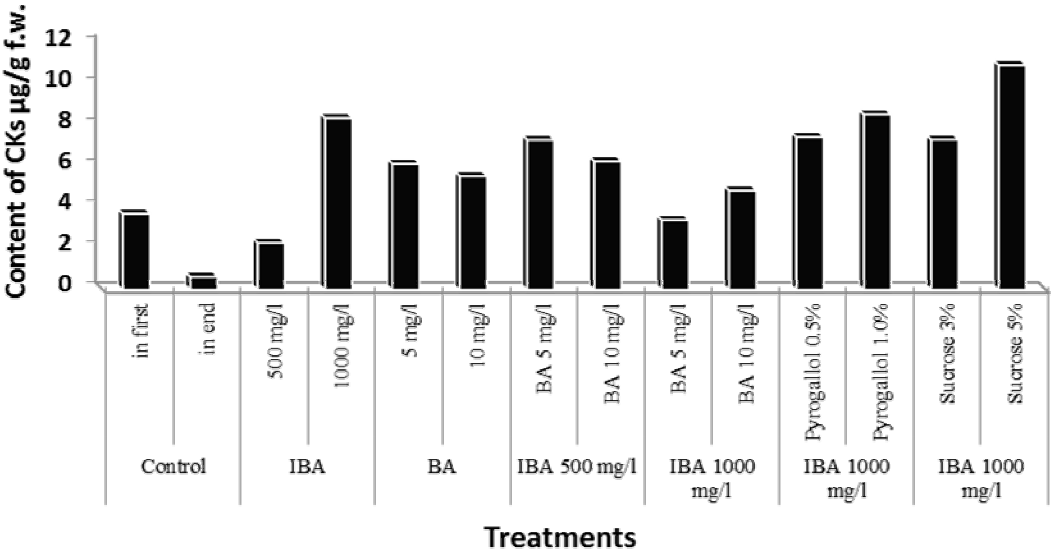

Fig.5. Effect of treatments on content of CKs in cuttings

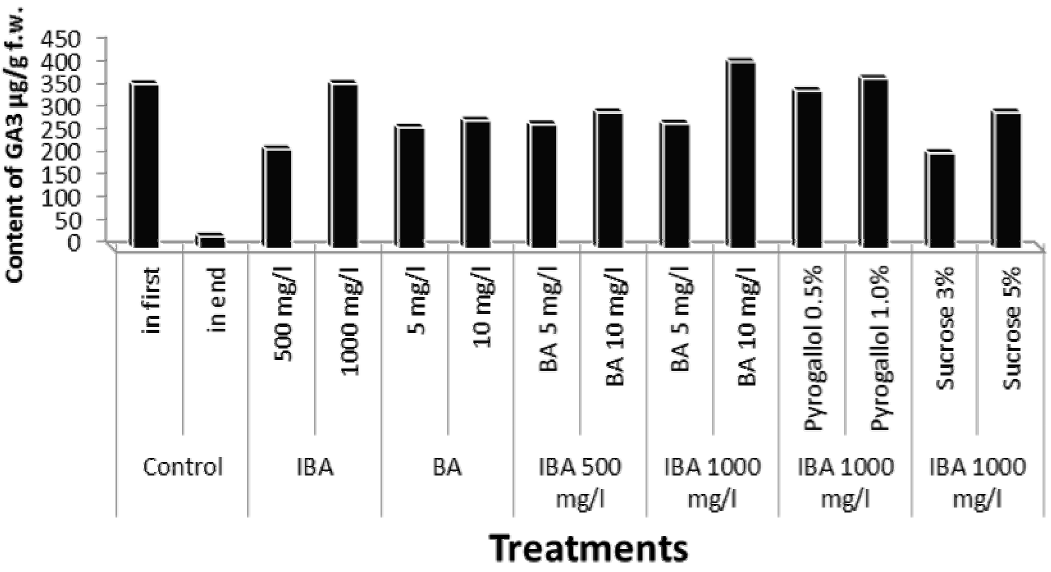

Fig. 6. Effect of treatments on content of GA3 in cutting

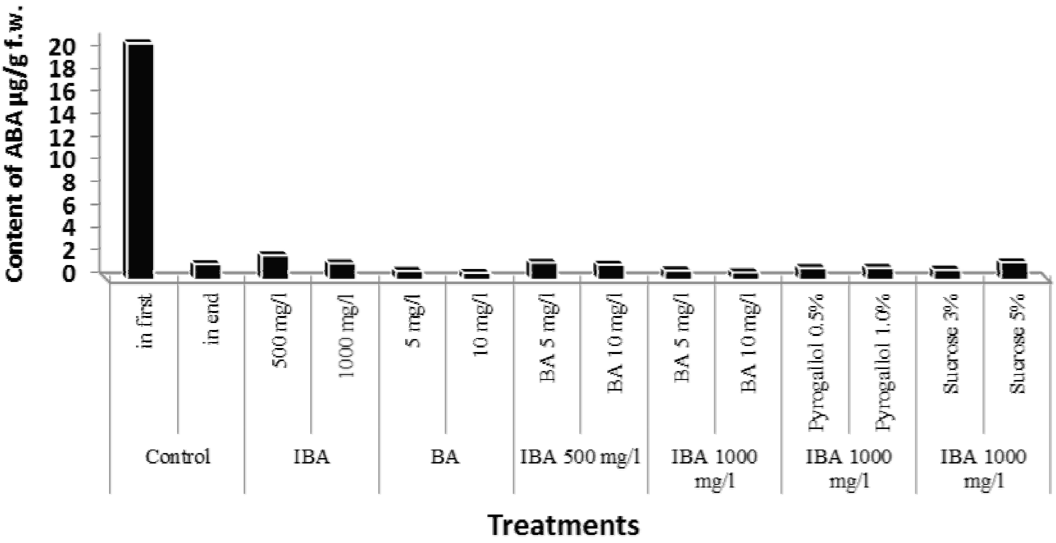

Fig. 7. Effect of treatments on content of ABA in cutting

its ABA content is higher than that of readily-rooting plants (**Theophilus *et al.,* 2010**). ABA can promote rooting of other plants (**Hartung and Turner 1980**).

The auxin/cytokinin ratio ranging between 2: 2.65 in the treatment cutting where was higher than in the cuttings treated with IBA 1000 mg/l + sucrose 5% and record high percent of rooting and the average length of roots. It seems likely, therefore, that the requirement for root initiation is for a low cytokinin level and favorable auxin: cytokinin ratio.

The auxin/ABA ratio was higher than (22.88) in the cuttings treated with BA 10 mg/l alone while was lower than (0.17) in cuttings without treatment. Also, the cytokinin/ABA ratio was higher than (8.88) in the cuttings treated with BA 10 mg/l alone while was lower than (0.18) in cuttings without treatment.

It is generally accepted that endogenous hormones level, especially auxins and cytokinin ratio, play a central role during adventitious rooting and the auxin/cytokinin ratio rises before the formation of root primordium and decreases after the formation of root primordium (**Cline *et al.,* 1997; Song *et al.,* 2004**). **Petridou and Porlingis (1997)** reported that application of GA3 promoted root development in cuttings of mungbean only in a small degree and this effect was increased by lBA and sucrose.

Debi *et al.* (2005) indicated that the effect of cytokinins on initiation, emergence and elongation of lateral root in rice. Both the CKs and zeatin at 1.0 µM and higher concentration inhibited lateral root formation by inhibiting the initiation of lateral root primordia. **Bollmark *et al.* (1988)** showed that cytokinins inhibited the cell division during the early phase of the organization of adventitious root primordia in pea stem cuttings. It confirms the statement by **Eriksen (1974)**, who said that cytokinin treatments can be decreased rooting. Beside of general mobilization of nutrients (**Petho, 2002**),

Conclusions

In *Casimiroa edulis* L. the results indicate the importance of plant growth regulators (especially auxin), and their ratios, for rooting in cuttings. This study showed that IBA, BA, sucrose and pyrogallol treatments increased rooting percentages. Herein, we also have reported that exogenous plant growth regulator (lBA and BA) may be effective on the root formation by increasing of the total IAA and CKs and decreasing of ABA levels of stem cuttings.

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تأثير بعض مواد النمو على التجذير والهرمونات الداخلية لعقل نبات السبوتا البيضاء

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فى هذا البحث تم دراسة تأثير بعض المعاملات الخارجية على التجذير وعلى الهرمونات الداخلية (إندول ٣ حامض الخليك والسيتوكينين وحامض الجبريليك وحامض الأبسيسيك) للعقل الساقية لنبات السبوتا البيضاء قبل وبعد ٤٥ يوم من المعاملة لم يلاحظ أى تكون للجذور على العقل غير المعاملة (الكنترول) بينما المعاملة مع تركيز ١٠٠٠ جزء فى المليون من إندول حامض البيوتريك مع السكروز أو البنزيل أدينين أو البيروجالول كانت مفضلة لتخليق الجذور على العقل، أنتجت المعاملة بتركيز ١٠٠٠ جزء فى المليون من إندول حامض البيوتريك مع السكروز ٣% أعلى نسبة تجذير للعقل (٩٠%) وأعلى متوسط لعدد الجذور على العقل (٦ جذور/عقلة). بينما العقل المعاملة مع تركيز ١٠٠٠ جزء فى المليون من إندول حامض البيوتريك مع السكروز ٥% و ١٠٠٠ جزء فى المليون من إندول حامض البيوتريك مع البيروجالول ٠,٥ % أعطت أعلى متوسط لطول الجذور (٢٠ مم)، أيضا كانت هناك زيادة قدرت فى مستويات إندول ٣ حامض الخليك والسيتوكينين وحامض الجبريليك ونقص فى مستوى حامض الأبسيسيك مع المعاملات لكن العلاقة بين هذة الهرمونات الداخلية وبين التجذير كانت غير واضحة.

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