H

EGYPTIAN ACADEMIC JOURNAL OF
BIOLOGICAL SCIENCES
BOTANY

ISSN 2090-3812

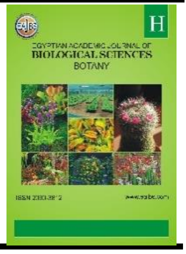
www.eajbs.com

Vol. 12 No.2 (2021)

Citation: Egypt. *Acad. J. Biolog. Sci.* (H. Botany) *Vol.12(2) pp135-148(2021)*
DOI: 10.21608/EAJBSH.2021.209460

Egypt. Acad. J. Biolog. Sci., 12(2):135 - 148 (2021)

Egyptian Academic Journal of Biological Sciences
H. Botany
ISSN 2090-3812
www.eajbsh.journals.ekb.eg.



Propagation of Croton Cuttings Relation to Hormones and Seasonal Changes

Hoda I. M. El-Gedawey
Agriculture Research Center, Horticulture Institute, Ministry of Agric., Dept. of Ornamental & Landscape Gardening, Antoniades, Alexandria, Egypt
*E-Mail: **hoda.elgedawy@yahoo.com**

ARTICLEINFO
Article History
Received:18/10/2021
Accepted:13/12/2021

***Keywords*:**
Rooting, Indole butyric acid, Seasonal changes, *Codiaeum variegatum*.

ABSTRACT

Eight experiments were carried out at Antoniades Research Branch, Ornamental Plants Research and Landscape Gardening Department Horticulture Research Institute, A.R.C., Alexandria, Egypt during the eight successive seasons, i.e. winter, spring, summer and fall during 2019 and 2020 to investigate the effect of indole butyric acid and seasonal changes on stem cuttings and rooting growth of Croton plants (*Codiaeum variegatum* L.). The cuttings were treated with four different concentrations of IBA at the rate of 1000, 2000, 3000 and 4000 ppm besides the control. Both 2000 and 3000 ppm IBA significantly improved rooting percentage%, survival % of cuttings and produced a significant increase in all vegetative root growth parameters (number of roots, fresh and dry weight of roots and root length). In addition, treated cuttings with 2000ppm also decreased the number of days to root. After 45 days, the rooting percentage gradually increased in comparison to the increase in IBA concentration to over 2000ppm, with results exceeding 88 percent in February. Furthermore, low-efficiency doses of growth regulators have led to fewer roots per cutting, potentially jeopardising the cuttings' survival under greenhouse conditions. In contrast, the greater temperature beneath the greenhouse and endogenous -auxin in the cuttings may be responsible for the rise in rooting percentage and improvement in root system metrics seen in the winter and spring after the autumn.

INTRODUCTION

Croton (*Codiaeum variegatum* L.) belongs to the family *Euphorbiaceae* grows naturally in southern Asia, Indonesia, and other eastern pacific islands in open forests. The family *Euphorbiaceae* comprises nearly 322 genera and 8910 species (Bingtao *et al*.,2008). Croton is in demand as a landscape plant because it is an evergreen shrub with alternate, simple leaves mottled with white and has yellow or red flowers. At maturity, plant color may be changed (Ogunwenmo *et al*., 2007). Crotons are, also well known for their medicinal value, where leaves extracts have many medicinal properties including purgative, sedative antifungal and anti-cancerous activities (Deshmukh and Borle,1975). The plant is considered a good natural source for the production of secondary metabolites of alkaloids, terpenes and flavonoids (Puebla *et al*., 2003; Simona *et al.*, 2008). According to high decoration values in outdoor and indoor house plants, and the ability of shrubs to thrive well in many regions of the world (Deepa and Shanthi,2013), concrete attention has been paid towards increasing the percentage of cuttings propagation, however, it is one of the difficult-to-root woody plants. Plant propagation from cuttings is the most effective way to clone plants that are identical to the stock plant than other successful methods (cuttings, grafting, by seeds and air layering (Kroin, 2016).

Generally, croton can be propagated by shoot tip cuttings, but this process is slow in response and requires large numbers of mother/stock plants. One mother/stock plant, for example, may only produce 20 plants each year from shoot tip cuttings (Nasib et al., 2008). Some authors have investigated that the substrate can improve root induction (Tillmnaa *et al*., 1994; Dai-Bisheng, 2007). Ornamental cuttings are rooted well when treated with IBA (Ibironke, 2017). Auxins are important agents for rooting difficult-to-root cuttings of woody plants. IBA was reported to have higher activity, a broader range of effectiveness in many species, it is usually used in woody plant propagation, (Hartmann and Kester, 1983). Ercisli *et al*. (2001) investigated that IBA is suitable for rooting when studying the effects of IBA on the adventitious root formation of woody cuttings plants.

Rooting in cuttings as influenced by plant species and cultivar, cutting wood conditions, cutting kinds (hardwood, semi-hardwood, softwood, and herbal cuttings), season, and a variety of other variables (Hartmann et al., 2002; Daneh-loueipour as al., 2006). While (Rosier et al., 2006) reported that the interaction of many factors in stem cells, such as auxin level, number of leaves and buds on the cuttings, amount of carbohydrate reservoir in the cuttings, stage of plant growth, stem location, and type of cutting tissue, will determine rooting capacity for stem cuttings.

The goal of this study was to look into the effects of rooting ingredients (IBA) on root ability and seasonal fluctuations in order to develop an efficient and reliable methodology for vegetatively propagating Croton plants by rooting softwood cuttings. The effects of varying concentrations of IBA sprayed on cutting during four distinct propagation seasons were studied.

MATERIALS AND METHODS

The studied experiments were conducted during the two years of 2019 and 2020 at Antoniades Research Branch, Horticulture Research Institute, A. R. C. Alexandria.

Softwood cuttings were selected from the middle of developed shoots in Croton plant. They had 3 nodes and all sizes of cuttings were 10-12 cm with two expanded leaves at studied seasons, i.e.; winter (February), spring (March), summer (June), and fall (November). After sterilization with Captan fungicides and the basal ends of croton, cuttings were dipped in hormonal treatments (IBA) in talc powder at 0.0,1000,2000,3000 and4000ppm, the cuttings planted in bags containing a mixture of sandy-clay soils(2:1) volume: volume that is used for rooting of softwood and semi-hardwood cuttings in the greenhouses, the bags potted under a tunnel in a greenhouse at an Environment temperature of cuttings was 21-27 °C and tunnel temperature was usually 22-29 °C with greenhouse humidity was maintained in the range of 80-95%, and the soil temperature was about 22-25°C. Soil pH was about 6.5. The layout of the experiment was a randomized complete block design in a factorial arrangement between the two studied factors. The first one consisted of four seasons (winter, spring, summer and fall), however, the second factor consisted of five IBA concentrations (0,1000,2000,3000 and 4000ppm). Each treatment was carried out in 4 replicates, each replication consisted of five cuttings per treatment and totally, 100 experimental units were for each bed tunnel. At the end of the experiment, after (45 days), all cuttings were excluded from the beds tunnel and the rooting response was evaluated, traits such as days of rooting (rooting start), percentage of rooting, survival percentage, number of roots, root length, number of new leaves, were determined when more than 50% of the cuttings showed roots at the tunnel. Fresh and dry weights also, were calculated. The data were carried out and from Least Significant Difference was used in the comparison of mean data at a 5% probability level. Data presented in Table (1) showed maximum, minimum and average air temperatures(c), percentage of relative humidity for each month during 2019 and 2020 years. Data were collected from a Meteorology Environmental Station located in the same experimental and research station at past weather in Alexandria, Egypt. https://www.timeanddate. come/weather/egypt/alexandria/historic/month.

Table 1: Air temperature and relative humidity in 2019 and2020 at twelve months in Alexandria for seasons.

Months	**Air temperature (°C)**			**Relative humidity %**	**Months**	**Air temperature (°C)**			**Relative humidity %**
2019	Max.	Min.	Avg.		2020	Max.	Min.	Avg.	
January	22	4	13	69	January	19	8	14	71
February	27	6	14	69	February	24	8	15	69
March	24	8	16	70	March	29	9	17	68
April	34	9	18	65	April	31	12	19	67
May	44	13	23	61	May	41	14	23	61
June	33	20	27	68	June	41	15	25	65
July	38	22	28	66	July	32	23	27	71
August	34	21	28	69	August	33	21	28	70
September	32	19	27	67	September	35	22	28	69
October	34	17	25	69	October	34	16	25	67
November	31	12	21	67	November	27	12	20	71
December	24	9	17	68	December	25	10	17	70

RESULTS AND DISCUSSION

1. Number of Days to Rooting:

The above-mentioned results in a table (2), generally, indicated that growth regulators as IBA application significantly decreased the time needed for rooting of Croton cuttings in the four seasons. The IBA at 2000 ppm decreased the time rooting to 14.35 and 14.84 in 2019 and2020, respectively. While the mean control treatment, the time to rooting ranged to 17.50 and 17.35 days in 2019 dnd2020, respectively. The maximum decrease was obtained at 2000 ppm IBA (12.80 days) in the spring season in2020. However, at 3000ppm IBA gave the most significant decrease in the number of days to rooting (13.68 days) in spring2019 compared to the control during the four seasons. These results are probably due to the application of IBA at suitable concentrations, that increased IBA oxidase activity and promoted earlier roots formation (Carpenter and Cornell,1992). Cutting was taken in March and Nov. was rooted more quickly than those taken in Feb. Spring cuttings rooted very well in the shortest time. These results might be to the existing environmental conditions at the propagation times, and/ or the endogenous auxin levels needed for promoting root formation (Hartman and Kester, 1983). According to Hartmann *et al*. (2002), IBA is the best root promoter due to its fast auxin activity and an enzymatic system of fairly slow destruction. Auxin treatment may have increased rooting in treated cuttings by supplementing the endogenous auxin concentration at the base of the cuttings, which expedited root initiation and development of root primordia (Gaspar and Hofinger, 1988). Plant growth regulators can speed up the vegetative propagation of ornamental plants and increase the number of rooted cuttings, according to Peter (2015).

Table 2: Effect of various concentrations of IBA at the four propagation times on the days to rooting of croton (*Codiaeum variegatum*) L. cuttings during 2019 and 2020 seasons.

	2019					2020				
IBA PPm	**Winter (Feb.)**	**Spring (Mrc.)**	**Summer (June)**	**Fall (Nov.)**	**Mean**	**Winter (Feb.)**	**Spring (Mrc.)**	**Summer (June)**	**Fall (Nov.)**	**Mean**
0.00	21.50	14.64	18.39	15.49	17.50	20.43	15.62	18.16	15.20	17.35
1000	18.75	14.10	15.46	14.74	15.76	17.70	14.05	16.04	14.70	15.62
2000	15.64	14.00	14.57	13.19	14.35	16.16	12.80	15.87	14.54	14.84
3000	16.37	13.68	16.37	13.61	15.01	16.53	13.42	15.80	14.61	15.09
4000	17.10	13.97	15.85	13.77	15.17	17.58	15.02	15.87	14.52	15.75
Mean	17.87	14.08	16.13	14.16		17.68	14.18	16.35	14.71	
L.S.D. at 0.05 for IBA conc. 0.74						0.66				
L.S.D.at 0.05 for prop. times 0.66						0.59				
L.S.D. at 0.05 for interaction 1.48						1.33				

Rooting Percentage:

In contrast, when shoots were cultured, they showed good signs and best roots, all IBA concentrations increased the rooting percentage of the treated cutting (Table 2) and Fig1, all IBA concentrations increased significantly the rooting percentage compared to untreated cuttings

The rooting percentages of the control ranged to 33.50%in2019and 34.81%in 2020. 2000 ppm IBA gave the best rooting percentage (73.75% and72.56% in 2019 and2020, respectively). On the other side, Winter was the best season (79.40%&80.60 in two successive seasons) in results compared to the other seasons, followed by Spring season which non -significant with Fall. Interaction between winter and 2000ppm IBA gave the highest rooting percentage (88.0&96.75 in two years, respectively).

These results are probably due to the role of IBA in increasing cambial activity and stimulating root primordial formation (Eriksen and Mohammed 1974, and Hassig 1972). Many physiological studies have shown that auxin plays a central role in the developmental process of root initiation (Jarvis, 1986). Auxin has an effect on speed and increases the percentage of rooting of the stem cuttings (Kasim and Rayya, 2009). These findings could be achieved due to the mode of action of auxin for enhancing and controlling various distinctive processes such as cell growth and elongation (George and Sherrington, 1984 and Wilkins,1989).

Temperature, rainfall, and photoperiod can all alter the quantity of free auxin on mother plants, resulting in suboptimal rooting levels (Fragoso *et al*., 2017). (Osterc & Stampar, 2011). On Ficus retusa, Haikal (1992) and Eltorky and EL-Shennawy (1992) observed similar results. Cunha et al. (2012) found that cuttings of C. Zehntneri treated with a greater concentration of IBA had a higher rooting percentage. Furthermore, Naier *et al*. (2008) investigated the effect of auxin concentration on Stewartia pseudocamellia rooting and discovered that rooting hormone-treated cuttings had higher rooted percentages (71.9 percent to 93.6 percent) than control cuttings (53 percent). Admas *et al*. (2020) investigated how rooting response success was impacted by the injection of IBA rooting hormone, soil type, and the season in November. Cuttings of P. serrulata mother plants treated with 2700mg l-1 IBA resulted in 88.8% rooting, however low-efficiency concentrations of growth regulators led to fewer roots per cutting, according to the researchers.

Table 3. Effect of various concentrations of IBA at the four propagation times on the rooting percentage of croton (*Codiaeum variegatum* L.) cuttings during 2019 and 2020.

	2019					2020				
IBA PPm	Winter (Feb.)	Spring (Mrc.)	Summer (June)	Fall (Nov.)	Mean	Winter (Feb.)	Spring (Mrc.)	Summer (June)	Fall (Nov.)	Mean
0.00	63.25	19.25	13.00	38.50	33.50	58.25	26.25	14.75	40.00	34.81
1000	86.25	67.50	18.75	52.50	56.25	87.00	60.05	23.75	55.00	56.50
2000	88.00	78.75	47.50	73.75	72.00	96.75	79.50	40.75	73.25	72.56
3000	82.00	76.25	25.50	75.00	64.68	83.75	76.50	27.50	73.25	62.25
4000	77.50	71.25	18.00	58.75	56.37	77.25	71.00	20.00	59.25	56.87
Mean	79.40	62.60	24.55	59.70		80.60	62.70	25.35	60.15	
L.S.D. at 0.05 for IBA conc. 8.86						6.02				
L.S.D.at 0.05 for seasons 7.92						5.38				
L.S.D. at 0.05 for interaction 17.70						12.03				

Survival Percentage:

Data presented in Table (4) and Fig 2 showed that survival percentage was highly significant for all seasons, concentrations and their interactions. The highest results of survival (90.75% and 88.95% in two seasons, respectively), resulted from propagation cuttings of *Codiaeum variegatum* during Feb., and the highest values (65.43% and 69.25% in two seasons, respectively) resulted with 2000ppm IBA. Also, the highest values of survival percentage (100% &99.25%, in two years, respectively) resulted from the interaction between winter (Feb.) and 2000ppm IBA. The survival percentage of the control treatment was lower than those of the IBA concentrations and studied seasons. The lowest values of survival percentage were in summer in both years. As for the significant differences between propagation times, it may be realized that it is correlated with good characters of the root system due to IBA treatments. IBA is the most effective in promoting root initiation and adventitious root production in stem cuttings (Waisel *et al*.,1991). Auxin as IBA is widely used on stem cuttings for accelerating the formation of adventitious roots (Galavi *et al*., 2013). Earlier rooting and better root characteristics will obviously lead to the formation of healthy plants and higher survival percentage accordingly, similar results were reported by Haikal (1992) on *F. retusa*. , EL-Torkey and EL-Shennawy (1992)on *Ephorbia* cuttings and Shiri *et al*.,(2019) on *Duranta erecta* tip cuttings

Table 4: Effect of various concentrations of IBA at the four propagation times on the survival percentage of croton (*Codiaeum variegatum* L.) cuttings during 2019 and 2020.

	2019					2020				
IBA PPm	Winter (Feb.)	Spring (Mrc.)	Summer (June)	Fall (Nov.)	Mean	Winter (Feb.)	Spring (Mrc.)	Summer (June)	Fall (Nov.)	Mean
0.00	73.75	27.50	7.50	10.0	29.68	63.25	34.25	10.00	15.00	30.62
1000	96.25	65.75	25.00	36.25	55.81	97.75	57.25	27.50	36.25	54.68
2000	100.0	56.75	43.75	61.25	65.43	99.25	67.75	48.75	61.25	69.25
3000	95.50	50.00	17.50	32.50	48.87	95.50	50.00	17.50	28.75	47.93
4000	88.25	28.75	12.50	13.75	35.81	89.00	30.25	8.75	15.75	35.93
Mean	90.75	45.75	21.25	30.75		88.95	47.90	22.50	31.40	
L.S.D. at 0.05 for IBA conc. 5.23						4.66				
L.S.D.at 0.05 for prop .times 4.68						4.17				
L.S.D. at 0.05 for interaction 10.46						9.32				

Fig. 1. Effect of indole butyric acid at 2000 ppm in Feb. on highly rooting percentage formation of stem cuttings of Croton plant

Fig.2: Effect indole butyric acid (IBA) at 2000 ppm in winter on survival percentage of stem cuttings of Croton plant.

Number of Roots Per Cutting:

It is generally known that the formation of adventitious roots in plants is controlled by growth substances and auxins are the principal hormones playing a direct role in this process (Gaspar and Hofinger, 1988). Accordingly, the formation of adventitious roots is related to an increase in the level of auxin at the stem base. Auxins can control the meristemic activity of tissues and also enhance the supply of substances at the sites of root formation. This confirms that IBA is one of the widely applicable root-forming stimulants. IBA is known to induce a high number of adventitious roots (Hartmann *et al*., 2002). All IBA treatments in Table (5) Fig 3 led to the formation of a considerable number of roots and the highest number of roots per cutting obtained at 2000 ppm IBA (13.81 and 13.03 roots per cutting in 2019 and 2020, respectively). The best season cuttings were in winter, since it was significantly better in respect to the number of roots than spring, while the differences were not significant between summer and fall. The cuttings were taken in Feb. and Mar. and treated with 2000ppm, giving the best results during the two years study.

These results may be attributed to the fact that in certain plant species, the ability to cut to root differed greatly according to the time of propagation (Hatmann and Kester 1983). Thus, cutting taken in Feb and Mar.., might have a high level of endogenous auxin, which was responsible for stimulating the root growth, and the temperature degree may be more suitable for the formation of the roots. On several woody ornamental plants, Eltorky and EL-Shennawy (1992) found similar findings, as did Yeshiwas *et al*., (2015) on roses. Cunha *et al*., (2012) also found that when Croton cuttings were treated with greater amounts of IBA, the root number of the plants varied. Nasri *et al*., (2015) found that dipping cuttings of 5 genotypes of *Rosa damascena* in 1,000 mg l-1 IBA for 24 hours before cultured resulted in the maximum rooting, callus formation, number of roots, root fresh and dry weights.

Table 5. Effect of various concentrations of IBA at the four propagation times on the number of roots per cuttings of croton (*Codiaeum variegatum* L.) cuttings during 2019 and 2020.

	2019					2020				
IBA PPm	Winter (Feb.)	Spring (Mrc.)	Summer (June)	Fall (Nov.)	Mean	Winter (Feb.)	Spring (Mrc.)	Summer (June)	Fall (Nov.)	Mean
0.00	5.30	2.00	1.12	1.20	2.40	4.30	2.58	0.50	1.25	2.15
1000	12.51	10.15	4.45	4.83	7.98	11.75	8.81	4.23	7.90	8.12
2000	18.06	14.35	11.67	11.18	13.81	17.55	13.05	7.33	14.21	13.03
3000	10.94	12.56	6.21	6.64	9.08	9.51	10.20	7.97	5.44	8.28
4000	9.02	7.60	5.18	7.40	7.30	8.75	5.81	6.69	2.97	6.05
Mean	11.16	9.33	5.72	6.25		10.37	8.09	5.34	6.35	
L.S.D. at 0.05 for IBA conc.		1.01				1.38				
L.S.D.at 0.05 for prop .times		1.13				1.23				
L.S.D. at 0.05 for interaction		2.25				2.76				

Root Length:

Data presented in Table (6) Fig4 indicated that there were highly significant differences between IBA concentrations, IBA at 2000 and 3000 ppm gave an excellent root system with respect to the total root length regardless of propagation time or season. The tallest root length was obtained at 2000 and3000 ppm (2.35&2.27cm and2.58&2.55cm in the two years of2019 and2020, respectively), while the control gave the shortest root length (0.58and0.73cm in 2019 and2020). On the other side, propagation in the spring season gave the highest tallest root length compared with all seasons. Peter (2015) said the IBA as a plant hormone with physiological effects on cell elongation and rooting has stood out. And can be accelerated the vegetative propagation of ornamental plants and IBA stimulates the absorption of nutrients and growth of croton cuttings.

The reduction of root length by high concentrations of IBA could be caused either by inhibition in the growth of the root primordial or a reduction in the number of root primordial formed (Carpernter and Cornell,1992). On the other hand, Yeshiwas *et al*., (2015) obtained those results deciphered that rose cuttings treated with 1000ppm of IBA had shown significant positive effects on most of the root and shoot parameters including root length, the number of roots per cutting, root fresh weight, root dry weight, shoot fresh and dry weight, leaf number and shoot length in December 2013 to January 2014 and the higher temperature in propagation house caused to use a low concentration of IBA.

These results, also similar to the findings of Ramtin *et al*., (2011) who found that the low concentration of IBA (1000 ppm) produced the best results for root length, number of leaves of poinsettia. These results accordance, also with Younis (2005) in the propagation of rose plants by cutting.

As mentioned earlier, the best result in most growth parameters of stem cuttings resulted from observed by the low concentration of IBA (2000ppm) used in this study and that probably due to daily average temperature (about 25°c) that was more suitable and prevailed in the propagation house during the time of the experiment that increases growth and developmental activities of plant cells, so that low concentration of hormone was enough for both growth and development of plants. This implies the optimum response curve of IBA depends on the intensity of temperatures prevailing in the propagation house. This finding is also in agreement with Taghvaei *et al.,* (2012) they concluded that the higher the temperature in the propagation house the lower is the optimum IBA-hormone concentration required for the successful vegetative propagation of stem cuttings.

Table 6. Effect of various concentrations of IBA at the four propagation times on the root length (cm) of croton (*Codiaeum variegatum* L.) cuttings during 2019 and 2020.

	2019					2020				
IBA PPm	**Winter (Feb.)**	**Spring (Mrc.)**	**Summer (June)**	**Fall (Nov.)**	**Mean**	**Winter (Feb.)**	**Spring (Mrc.)**	**Summer (June)**	**Fall (Nov.)**	**Mean**
0.00	0.55	0.66	0.57	0.54	0.58	0.67	1.03	0.65	0.56	0.73
1000	1.26	2.33	0.76	1.03	1.03	1.96	2.46	0.87	1.13	1.61
2000	2.76	2.74	2.40	2.35	2.35	2.93	2.76	2.43	2.12	2.58
3000	2.79	2.74	2.28	2.27	2.27	2.81	2.77	2.41	2.22	2.55
4000	1.11	2.04	2.04	2.04	2.04	1.83	2.07	2.17	2.00	2.02
Mean	1.69	2.10	1.61	1.65		2.04	2.22	1.71	1.62	
L.S.D. at 0.05 for IBA conc. 0.11						0.14				
L.S.D.at 0.05 for prop .times 0.10						0.13				
L.S.D. at 0.05 for interaction 0.22						0.29				

Root Fresh and Dry Weights:

Results showed that IBA had a significant influence on root fresh and dry weights at a 5% level (Table 7 and 8). Among the experiment, the highest root fresh and dry weights (4.63&4.65 and 1.79&1.61 mg, respectively) were recorded in the rooted cutting of croton plants with 2000 ppm IBA that showed a not significant difference compared to 3000ppm (with 4.56 and 1.65 mg of root fresh weight and root dry weight, respectively), especially in 2019. The lowest root fresh and dry weights (2.65 and 0.55 mg respectively) were recorded with the summer season of 2019 and2020, respectively. Our results were similar to those reported by Al-Salem and Karam (2001) on *Arbutus*. Stimulation of rooting process with auxin, carbohydrate transportation from leaf to root increases, therefore, it causes increasing of the dry weight of root (Hartmann *et al*., 2002). Also, Nasri *et al*., (2015) showed that the cuttings of Rosa *damascena* treated with IBA had higher root fresh weight than the control.

Table 7. Effect of various concentrations of IBA at the four propagation times on the root fresh weight of croton (*Codiaeum variegatum* L.) cuttings during 2019 and 2020

	2019					2020				
IBA PPm	**Winter (Feb.)**	**Spring (Mrc.)**	**Summer (June)**	**Fall (Nov.)**	**Mean**	**Winter (Feb.)**	**Spring (Mrc.)**	**Summer (June)**	**Fall (Nov.)**	**Mean**
0.00	2.04	2.09	1.77	1.53	1.85	2.13	2.01	1.85	2.10	2.02
1000	4.29	2.85	3.22	2.94	3.32	4.31	3.00	3.52	3.00	3.46
2000	7.80	4.25	2.25	4.24	4.63	7.70	4.26	2.73	3.93	4.65
3000	5.77	4.48	3.84	4.15	4.56	5.76	4.82	3.66	4.00	4.56
4000	4.90	4.23	2.17	2.88	3.54	4.90	4.10	2.08	2.63	3.43
Mean	4.96	3.58	2.65	3.14		4.96	3.64	3.13	2.27	
L.S.D. at 0.05 for IBA conc. 0.20						0.21				
L.S.D.at 0.05 for prop .times 0.17						0.19				
L.S.D. at 0.05 for interaction 0.40						0.43				

Table 8. Effect of various concentrations of IBA at the four propagation times on the root dry weight of croton (*Codiaeum variegatum* L.) cuttings during 2019 and 2020

	2019					2020				
IBA PPm	Winter (Feb.)	Spring (Mrc.)	Summer (June)	Fall (Nov.)	Mean	Winter (Feb.)	Spring (Mrc.)	Summer (June)	Fall (Nov.)	Mean
0.00	0.12	0.20	0.20	0.91	0.36	0.43	0.30	0.29	0.26	0.32
1000	1.07	0.69	1.16	1.14	1.01	1.18	0.56	0.76	0.91	0.85
2000	3.76	1.38	0.93	1.11	1.79	3.08	1.74	0.63	1.14	1.61
3000	2.37	1.41	1.49	1.33	1.65	1.47	1.65	0.97	1.01	1.30
4000	2.30	1.69	0.44	0.90	1.33	2.48	1.31	0.12	0.47	1.09
Mean	1.92	1.07	0.84	1.08		1.73	1.11	0.55	0.76	
L.S.D. at 0.05 for IBA conc. 0.18						0.15				
L.S.D.at 0.05 for prop .times 0.16						0.14				
L.S.D. at 0.05 for interaction 0.36						0.31				

Fig. 3: Effect of indole butyric acid on root formation of stem cuttings of Croton plant. A =1000ppm, B=2000ppm, C=3000ppm, D=4000ppm and E=0 (control).

Fig. 4. Effect IBA at 2000 and 3000ppm on root length compare to control of stem cuttings of croton plant

Fig.5. Effect of indole butyric acid at the rate of 2000 ppm on new leaves formation of stem cuttings of croton plant.

Number of New Leaves:

IBA significantly increased the number of new leaves in rooted cuttings (Table 9). the highest number of leaves per cutting (8.09 and 6.70at 2000 ppm IBA) were recorded in rooted cuttings that showed a significant difference compared to the control (2.91 and 2.39 leaves per cut in 2019 and2020 years, respectively) as shown in (Table 9) Fig5. Increasing new leaf production in cuttings might be attributed to increasing root number and root length in growth regulator treated cuttings that might have enabled cuttings to absorb more water and nutrients from rooting media, leading to better growth and production of new leaves. Since the root is considered as the main source of cytokinin, it may help for producing a higher leaf number. These findings are similar to those of Ingle and Venugopal (2009) on Stevia and Saed (2010) on five different pomegranate cultivars. The weight of adventitious roots was larger when cuttings had more roots. Cuttings of R. damascena have a link between the number of leaves and the weight of adventitious roots that matches the results of different R. canina 'Inermis' clones (De Vries and Dubois, 1987) In addition, Cunch *et al.*, (2012) found that the percentage of rooting, root number, root length, and the number of leaves on C. Zehntneri cuttings showed similar behaviour in response to IBA concentration. Brondani *et al.*, (2012) on Eucalyptus benthamii, Fragoso *et al.*, (2017) on Prunus serrulata, Kaur (2017) on Prunus persica L. Batch, and Shadparvar et al., (2021) on Hibiscus rosa-sinensis obtained similar findings.

Table 9. Effect of various concentrations of IBA at the four propagation times on the number of new leaves per cutting of croton (*Codiaeum variegatum*) L. cuttings during 2019 and 2020.

	2019					2020				
IBA (PPm)	**Winter (Feb.)**	**Spring (Mrc.)**	**Summer (June)**	**Fall (Nov.)**	**Mean**	**Winter (Feb.)**	**Spring (Mrc.)**	**Summer (June)**	**Fall (Nov.)**	**Mean**
0.00	2.25	3.81	0.25	1.75	2.01	2.91	2.50	1.16	2.98	2.39
1000	6.00	6.88	1.25	5.41	4.88	5.42	5.50	2.97	3.32	4.30
2000	8.75	12.50	4.25	6.87	8.09	8.16	9.88	4.00	4.78	6.70
3000	6.71	9.25	2.25	5.75	5.97	5.84	7.07	3.58	4.53	5.25
4000	4.25	4.50	2.00	3.50	3.56	3.36	3.75	0.25	3.57	2.73
Mean	5.59	7.39	1.99	4.65		5.14	5.74	2.39	3.84	
L.S.D. at 0.05 for IBA conc. 0.68						0.78				
L.S.D.at 0.05 for prop .times 0.60						0.69				
L.S.D. at 0.05 for interaction 1.36						1.56				

Conclusion:

The present investigation indicated that the best rooting was obtained with 2000 ppm IBA for *Codiaeum variegatum.* Cuttings were taken and propagated in Feb. and Mar. rooted batter than those were taken in Nov. and June. Generally, the almost studied concentration of IBA gave good results of rooting, especially in winter. And it helped to form a good rootstock.

REFERENCES

Admas, A.; S. Melese; A.Genetu; B.Kidane; Z. Yilma; M. Admasu and T. Misge (2020) .Clonal propagation of Osyris lanceolata through air layering at Bazawit Hill, Northern Ethiopia An Endangered, Medicinal and Sandal Wood Plant in East Africa. https://www.researchgate.net./publication/34016997.

Al-Salem, M.M. and N.S. Karam (2001). Auxin, wounding, and propagation medium affect rooting response of stem cuttings of Arbutus andrachne. *Horticulture Science,* 36:976-978.

Bingtao, L.I.; Q. Huaxing; M.Jin-Shuang,;Z.Hua; G.Michael, G. Hans-Joachim, E. Stefan Dressler; P. Hoffmann; L.J. Gillespie; M. Vorontsova and G.D. McPherson. 2008. Flora of China. http://www.efloras.org,dated22ndSeptember.11:163.

Brondani G. E.; I. Wendling ;A. E. Brondani; M. A. Araujo; A. L. Lopes da Silva and A. N. Gonçalves.(2012). Dynamics of adventitious rooting in mini-cuttings of *Eucalyptus benthamii* x *Eucalyptus dunnii*. *Acta Scientiarum. Agronomy Maringá*, v. 34,(2), p. 169-178.

Carpenter, W.J. and J. A. Cornell (1992). Auxin application duration and concentration govern rooting of Hibiscus stem cuttings. *Journal American Society Horticulture Science,* 117(1):68-74.

Cunha, C. M.; S. S. Maia and M. B. Coelho (2012). Cuttings of Croton zehnteneri Pax Hoffm at different concentrations of indole butric acid (Portuguese). *Ciencas Rura,* 42(4):621-626.

Dai-Bisheng. 2007. Effect of carbendazim plus thiram and triadimefon plus ethylicin on the survival rate of three kind softwood cuttings. *Huazhong Shifan Daxue Xuebao*,(Ziran Kexue Ban). 41(1):111-116.

Daneh-loueipour, N.; G.Yan ; H.J. Clarke and K.H.M. Siddique (2006). Successful stem cutting propagation of chickpea, its wild relatives and their inter- specific hybrids. *Australian Journal of Experimental Agriculture,* 46:1349-1354.

De Vries, D.P.; L.A.M. Dubois (1987). Variation for plant characters and for performance of softwood cuttings of Rosa canina 'Inermis' seedlings. *Euphytica,* 36:407-412.

Deepa, D. N. and A. Shanthi (2013). Propagation crotons from leaves. *African Journal of Agricultural Research,* 8(26) :3473-3475.

Deshmukh, S.D. and M.N. Borle (1975). Studies on the insecticidal properties of indigenous plant products. *Indian Journal of Entomology,* 37(1):11-18.

EL-Torkey, M.G.M. and EL-Shennawy, Ola A. (1993). Effect of indol butric acid and propagation time on the rooting of *Ficus deltoidea* and *Euphorbia pulcherrima* cuttings. *Alexandria Journal of Agriculture Research*, 38(1):283-304

Ercisli, S.; A. Esitken ; O. Anapalio; and V. Sahin (2001): Effects of substrate and IBA concententration on adventitious root formation on hardwood cuttigs of Rosa dumalis. *Acta Horticulturae,* 690:149-152.

Eriksen, E. and S. Mohamed (1974). Rooting formation in pea cuttings ii, Influnce of IBA at different developmental stages. *Physiologia Plantarum,* 32:156-162.

Fragoso, R. de O.; C. A. Stuepp; H. C. Rickli; K. C. Zuffellato-Ribas and H. S. Koehler (2017). Maximum efficiency concentration of indole butyric acid in promoting the rooting of Japanese Flowering Cherry. *Ciência Rural, Santa Maria,* V.47(1).

Galavi, M., M.A. Karimian and S.R. Mousavi (2013). Effects of different auxin (IBA) concentrations and planting-beds on rooting grape cuttings (*Vitis vinifera*). *Annual Review and Research in Biology*, 3(4):517-523.

Gaspar, T. and M. Hofinger (1988). Auxin Metabolism During Adventitious rooting. In: Davis, T.D., Haissig, B.E., Sankhla, N. (eds.), Adventitious Root Formation in Cuttings. Portland, Dioscorides Press: 117-131.

George, E.F. and P.D. Sherrington. 1984. Plant Propagation by tissue Culture. Exegeetic Ltd., Basingtoke. U.K.709P.

Haikal, M.S. (1992). Effect of some growth regulators on root formation in terminal stem cuttings of Ficus retusa. *Alexandria Journal of Agricultural Research*, 37:301-316.

Hartmann, H.T. and D.E. Kester (1983). Plant propagation, principles and practices Fourth Ed., Prentice- Hill, INC Engleood Cliffs, New Jersy,USA. Hartmann

Hartmann, H.T.; D.E. Kester; F.T. Davies and R.L. Geneve (2002). Plant Propagation: Principles and Practices, Prentice Hall, New Delhi, India.

Hassig, B. E. (1972). Meristematic activity during adventitious root promordium development. *Plant Physiology,* 49:886-892.

Ibironke, O.A. (2017). Response of selected Ornamentals to rooting hormone in different propagation media. *Journal of Botany Research,* 1(1):22-28.

Ingle, M.R. and G.K. Venugopal (2009): Effect of different growth regulators on rooting of stevia (Stevia rebaudiana Batons) cuttings. *Karnataka Journal of Agricultural Sciences,* 22:460-461.

Jarvis, B.C. (1986): Endogenous control of adventitious rooting in non-woody cuttings. In: Jackson, M.B. (Ed.), New Root Formation in Plants and Cuttings. Martinus Nijhoff, Dordrecht, Netherlands, pp. 191-222.

Kasim, N.E. and A. Rayya (2009): Effect of different collection times and some treatments on rooting and chemical in terminal constituents of bitter almond hardwood cutting. *Journal of Agricultural and Biological Science,*5(2):116-122.

Kaur S.(2017)Evaluation of different doses of indole-3-butyric acid (IBA) on the rooting, survival and vegetative growth performance of hardwood cuttings of Flordaguard peach (*Prunus persica* L. Batch). *Journal of Applied and Natural Science,* 9 (1): 173 - 180.

Kroin, J. (2016). Hortus Plant Propagation from Cuttings guide to using plant Rooting Hormones by Foliar and Basal Methods. Hortus USA Corp. Third Edition All Right Reserved US Library of Congress ISSN 2331-0456. Support@ Hortus .com& rootinghormones.com

Naier, A., Zhang, D., Smagula, J. (2008): Rooting and overwintering stem cuttings of Stewartiapseudocamelliamaxim relevant to hormone, media, and temperature. *Horticulture Science,* 43:2124-2128.

Nasib, A., K. Ali and S. Khan. 2008. In vitro propagation of croton (Codiaeum variegatum). *Pakistan Journal of Biological Sciences,* 40(1):99-104.

Nasri F.; A. Fadakar; M. K. Saba and B. Yousefi.(2015). Study of Indole butyric acid (IBA) effects on cutting rooting improving some of wild genotypes of Damask Roses (*Rosa damascena* Mill.) *Journal of Agricultural Sciences,* Vol. 60, (3)P: 263-275.

Ogunwenmo, K.O., O.A. Idowu, C. Innocent, Esan and O.A. Oyelana. 2007. Cultivars of Codiaeum variegatum (L.) Blume (Euphorbiaceae) show variability in phytochemical and cytological characteristics. *African Journal of Biotechnology,* 6(20):2400-2405.

Osterc, G.and F.Stampar(2011) .Differences in endo/exogenous auxin profile in cuttings of different physiological ages. *Journal of Plant Physiology,* v.168, p.2088-2092.

Peter, H.R.(2015).Acclimation of croton and hibiscus seedlings in response to the application of indobutric acid and humic for rooting. *Plant Propagation Reviw Ceres,* vol, 62(3).

Puebla, P., J.L. López, M. Guerrero, M.L. Martí, L. San Román and A. San Feliciano (2003). Neo-clerodane diterpenoids from Croton schiedeanus. *Phytochemistry,* 62(4): 551-555.

Ramtin, A., A. Khalighi, E. Hadavi and J. Hekmati (2011). Effect of different IBA concentrations and types of cuttings on rooting and flowering Poinsettia pulcherrima L. *International Journal of Agriculture Science,* 1(5): 303-310.

Randhawa, G.S., Mukhopadhyay, A. (1994): Floriculture in India. Allied Publishers Ltd., Bombay, India.

Rosier, C.L., Frampton, J., Goldfarb, B., Blazich, F.A., Wise, F.C. (2006): Improving the Rooting Capacity of Stem Cuttings of Virginia Pine by Severe Stumping of Parent Trees. *Southern Journal of Applied Forestry,* 30(4):172-181.

Saed, J.O. (2010): Rooting response of five pomegranate varieties to indolebutyric acid concentration and cuttings age. *Pakistan Journal of Biological Sciences,* 13:51-58. Shukla

Shadparvar, V.; M. Torkashvand and A. Alinejad. (2021) Effect of IBA and Soil mixture on rooting of (*Hibiscus rosa- sinensis*). *European Journal of Experimental Biology,* Oct., (11).

Shiri M.; R. M. Mudyiwa; M. Takawira; C. Musara and T. Gama.(2019).Effects of rooting media and indole-3-butyric acid (IBA) concentration on rooting and shoot development of *Duranta erecta* tip cuttings. *African Journal of Plant Science,* Vol. 13(10), p. 279-285

Simona, D.M.; G. Fulvio; Z. Franco; V. Sara; F. Gelsomina ;V. Francesco and I. Maria (2008). Identification of minor secondary metabolites from the latex of croton lechleri (Muell-Arg) and evaluation of their antioxidant activity. *Molecules,* 13 (6): 12191229.

Taghvaei, M., H. Sadeghi and M. Baghermiri, 2012. Interaction between the concentrations of growth regulators, type of cuttings and rooting medium of Capparis spinosa L. cutting. *International Journal of Agriculture Science Research and Review,* 2(6): 783-788.

Tillmann, M. A. A.; C. Cavariani; Z. Piana and K. Minami.(1994). Comparacao enter diversos substrats no enraizamento de estacas de croton (*Codiaeum variegtum* L.). *Science Agriculture,*51(1):17-20.

Waisel, Y. Ashel, A., Kafkafi, U. (1991): Plant roots: the hidden half. New York; March dekker, Inc.

Wilkins, M.B. (1989). Advanced plant physiology. The Bath Press, Avon.13-15.

Yeshiwas, T. ; M. Alemayehu and G. Alemayehu.(2015). Effects of Indole Butric Acid (IBA) and stem cutting on Growth of stenting- propagation Rose in Bahir Dar, Ethiopia. *World Journal of Agriculture Sciences,* 11(4):191-197.

Younis, A., 2005. Effect of various hormones and different rootstocks on rose propagation. *Caderno de Pesquisa SÈr. Bio. Santa Cruz do Sul,* 17(1): 111-118.

ARABIC SUMMARY

إكثار عقل الكروتن وعلاقته بهرمونات التجذير والتغيرات الموسميه

هدى اسماعيل محمد الجداوى*
* معهد بحوث البساتين- قسم بحوث الزينه بأنطونيادس - مركز البحوث الزراعية - الاسكندريه - مصر

أجريت هذه الدراسه خلال عامى 2019 و 2020بفرع بحوث الزينه بحديقه أنطونيادس بالاسكندريه التابعه لمعهد بحوث البساتين – مركز البحوث الزراعيه مصر وذلك لدراسه تأثير المعامله بأحد منظمات النمو والتى تتمثل فى هرمون أندول حمض البيوتريك لقواعد العقل الساقيه لنباتات الكروتن وذلك بأربع تركيزات مختلفه وهى 1000 و2000 و3000 و4000 جزء فى المليون وذلك بخلاف الكنترول (العقل الغير معامله بالهرمون) ولقد كانت المعاملات على مدار العام فى أربع مواسم مختلفه وهى الشتاء والربيع والصيف والخريف لكل عام من عامى الدراسه.

وقد اظهرت النتائج أنه عند معامله قواعد العقل ب 2000 جزء فى المليون من أندول حمض البيوتريك فى فصلى الشتاء والربيع ، أدت الى زياده معنويه فى نسبه التجذير للعقل ونسبه البقاء وكذلك عدد الاوراق الجديده الناتجه لكل عقله.

إيضا أظهرت النتائج تحسن واضح وزياده معنويه فى صفات المجموع الجذرى من حيث عدد الجذور وطولها وكذلك الوزن الطازج والجاف للجذور الناتجه مع جميع المعاملات والتركيزات المستخدمه من هرمون التجذير(أندول حمض البيوتريك) ، خاصه مع 2000و3000 جزء بالمليون فى فصل الشتاء والربيع ويتبع ذلك فصل الخريف.

وقد أظهرت النتائج كذلك، إن كافه المعاملات أدت الى نقص معنوي فى عدد الايام اللازمه لدفع عقل نباتات الكروتن للتجذير على مدار الأربع مواسم مقارنه بالكنترول وقد سجل أقل نقص معنوى خلال فصل الربيع.

وفقا لهذه النتائج ، يتضح أن معامله عقل نباتات الكروتن بتركيزات منخفضه من أندول حمض البيوتريك (2000جزء فى المليون) كانت أفضل من التركيزات المرتفعه (4000 جزء فى المليون) ، وأن هذه التركيزات أدت ألى تحسن واضح فى صفات النمو للمجموع الجذرى خصوصا إذا ما توافرت درجه الحراره ودرجه الرطوبه المناسبه فى فصل النمو، وكان كل من فصل الشتاء والربيع يليهم الخريف من الفصول المناسبه لنمو المجموع الجذرى مع معامله العقل بهرمون التجذير تحت ظروف الزراعه فى الصوب الزجاجيه.