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Roles of Auxins and Propagation Time in Rooting of *Kigelia pinnata* Jacq. Cuttings

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Abstract

Cuttings of *Kigelia pinnata* Jacq. were soaked for 24 hours in solutions of certain growth regulators; IAA, IBA and NAA, each at 250, 500 and 1000 ppm, in addition to untreated cuttings (control), and two propagation times (March and September) taken to define the most suitable combination for the best rooting performance.

Naphthalene acetic acid (NAA) at 250 ppm showed the highest rooting percentage (56%) followed by IAA at 250 ppm or IBA at 500 ppm; each recorded 36%, whereas untreated cuttings produced the poorest rooting (11%). Cuttings propagated in March were more successfully and superior to those taken in September to promote rooting percentage and root growth.

The best treatment which gave the maximum rooting percentage was more closely associated with stimulated root characteristics. A positive relationship between high rooting ability and high C/N ratio in cutting bases was found. Furthermore, the high rooting capacity was accompanied by a great reduction in phenolic compounds content in cutting tissues. The reduction was apparently associated with NAA at 250 ppm and the propagation in March.

Keywords: *Plant growth regulators; Root-promoting chemicals; Auxin application; Stem cutting propagation; Propagation time; Kigelia pinnata.*

Introduction

Sausage tree (*Kigelia pinnata* Jacq.) belongs to family Bignoniaceae that grows in tropical and temperate forests, multistemmed, large evergreen tree growing up to 15 m tall with a crown diameter of up to 12 m. With its fast growth rate, spreading canopy and interesting flowers and fruits, it makes a good street tree. It can be used successfully for bonsai, the thick stem being an attractive feature; Turner (2001).

The rooting of stem cuttings is commonly used in the commercial production of ornamental trees. Cuttings of some species root readily without an auxin treatment, while cuttings of other species benefit from auxin treatment through enhanced promotion of rooting; benefits may be dependent upon the species and cultivar, condition of the cutting wood, time of year, and other factors. Application of root-promoting chemicals such as indole-3-acetic acid (IAA), indole-3-butyric acid (IBA) and naphthalene acetic acid (NAA) to difficult-to-root cuttings stimulate the initiation of adventitious roots. Root initials in cutting is dependent upon the native auxins in the plant, plus an auxin synergist together, these lead to synthesis of ribonucleic acid which is involved in initiation of the root primordia; Hartmann *et al*. (2002).

Several studies have cleared that auxin treatment is helpful and beneficial in inducing adventitious root formation on cuttings of numerous ornamental tree species, this treatment exerts a strong stimulating influence on root initiation and can be very important factor. Shoushan *et al*. (1979) dipped *Araucaria excelsa* cuttings for 60s in solutions of IBA and NAA, each at 1000, 1500, 2000, 2500 and 5000 ppm. They noticed that root formation on cuttings was found to be hastened by growth regulators, and NAA at 1500 ppm induced the highest rooting percentage. Bandopadhyay *et al*. (1980) treated *Carissa carandas* with IAA, IBA and NAA, each at 100-1000 ppm. They reported that IBA at 500 ppm recorded the best rooting (75%). Singh and Motial (1982) treated *Callistemon lanceolatus* cuttings with IBA and NAA, each at 1000-4000 ppm, and they found that the best rooting (95%) was obtained by 3000 ppm IBA followed by 4000 ppm NAA (85% rooting), while the untreated cuttings showed poor rooting (23%).

Pimpini *et al*. (1983) found that treating *Ficus elastica* semi-hardwood cuttings with NAA at 1000 ppm increased rooting percentage and root number, where as the hardwood ones with a rate of 2000 ppm was more effective. Sundaram and Rangaswamy (1994) reported that dipping *Ficus auriculata* cuttings in IBA solution at 500 ppm for 5s before planting resulted in the highest rooting (77%), also increased root length and root dry weight. El-Sallami and Mahros (2000) cleared that rooting percentage in mid-shoot cuttings of *Euphorbia pulcherrima* was increased after pre-soaking for 20 h in 50 ppm solutions of IAA, IBA and NAA resulting in 85, 75 and 40%, respectively, while control cuttings recorded 26%. Mahros (2000) demonstrated that the highest rooting percentages of *Bougainvillea glabra* (46%) and *B. spectabilis* (73%) were obtained with IBA at 100 ppm, whereas controls recorded 27 and 24%, respectively. Sabbour *et al*. (2001) treated *Ficus retusa* and *F. benjamina* cuttings with IBA and NAA, each at 1000, 2000, 3000 and 4000 ppm and they found that the highest rooting percentages and number of roots per cutting of both species were occurred by 3000 ppm IBA or NAA. Karam and Gebre (2004) treated *Cercis siliquastrum* cuttings with IBA at the concentrations of 0, 24, 48, 72 or 96 mM, and they found that a rate of 72 mM showed the highest rooting (80%). Root length and root dry weight produced per rooted cuttings were increased with increasing IBA level. El-Sallami and Gad (2004) stated that dipping *Ficus cyathistipula* cuttings in IAA, IBA and NAA solutions, each at 100 ppm for 20 h increased rooting parentages; 72, 70 and 61%, respectively, and improved root characteristics. El-Nashar (2008) concluded that solution application of 200 ppm IBA + 10 ppm thiamin showed a stimulatory effect on adventitious root formation resulting in the highest rooting percentages and the best root characteristics of *Jasminum sambac* and *Pittosporum tobira* cuttings. El-Fouly *et al*. (2009) reported that treating *Ficus deltoidea* cuttings with NAA at 2000, 4000 and 6000 ppm increased rooting percentage, root number per cutting and root length. Abou-Zahra *et al*. (2013) appeared that treating *Gardenia jasmenoides* cuttings with NAA at 4000 ppm resulted in the highest rooting percentage and improved root characteristics. Babaie *et al*. (2014) demonstrated that treating *Ficus binnendijkii* cuttings with IBA at 4000 ppm increased root length and root dry weight. Attia (2016) found that treating *Dracaena marginata* cuttings with IAA, IBA and NAA, each at 1000 ppm showed a strong promotive effect on adventitious root formation resulting in increases in rooting percentages; 46, 73 and 32% respectively, whereas control cutting recorded 22%.

Time of year in which the cuttings are taken influenced the results obtained on rooting. In this regard, Shoushan *et al*. (1979) reported that rooting percentage was greatly influenced by the season of propagation and the plant species, spring months induced generally high rooting percentage in *Araucaria excelsa* cuttings. Hansen (1990) reported that cuttings of *Cupressus macrocarpa* taken in March gave the most satisfactory rooting than those taken in July or October. Harris and Singh (1991) stated that the best rooting of Bougainvillea cuttings was obtained from cuttings taken in spring than in the rainy season. Watkins and Wittle (1991) reported that the percentage of rooting was nearly 100% for *Cunninghamia lanceolata* cuttings taken in March, June and July, while in January, it was about 30%. Mahros *et al*. (1994) concluded that autumn was the best season for taking the cuttings of *Ficus elatica* and *Melaleuca armillaris*, whereas spring was superior to those taken during autumn for *Ficus retusa*. El-Nashar (2000) observed that the highest rooting percentage and the optimum root growth were obtained by taking *Ficus benjamina* cuttings during either autumn or spring. Klein *et al*. (2000) stated that the rooting percentage of *Myrtus communis* cuttings taken in late-winter and early-spring reached 70%, while those taken in summer only 20% of the cuttings successfully rooted.

The objective of this study was to examine the effectiveness of application of the auxins IAA, IBA and NAA on the rooting and initial growth of *Kigelia pinnata* cuttings, and the most suitable propagation time.

Materials and Methods

This work was carried out at the Floriculture Nursery, Faculty of Agriculture, Assiut University during two successive seasons of 2014 and 2015 to investigate two factors influence on the adventitious root formation on stem cuttings of *Kigelia pinnata* Jacq. The two factors subjected to study were growth regulating substances and time of year in which the cuttings are taken. Cuttings were treated with three growth regulators of IAA, IBA and NAA combined with two selected times of year (March and September) for propagation to verify the best combination and economically-viable propagation methods within horticulture and forestry.

In mid-March and late-September of both seasons, hardwood cuttings of 15 cm length were taken from one-year-old branches selected from healthy stock plants. Cuttings were treated with the three growth regulators tested, each used individually at the concentrations of 250, 500 and 1000 ppm. Cuttings bases were dipped to a depth of 2-3 cm in the solution treatments for 24 hours, whereas the control cuttings were dipped in distilled water.

The experiment of each propagation time consisted of 10 treatments replicated 4 times. Each treatment contained 60 cuttings planted in 20 cm-diameter plastic pots (15 cuttings/pot) filled with peat moss. The pots were arranged in a complete randomized blocks design, covered by tightly polyethylene film to maintain a high relative humidity, and placed under shaded saran-house conditions (70% shade), in which air temperatures during March ranged from 12.13 to 28.30°C and relative humidity (RH) 37.13%, whereas during September air temperatures ranged from 22.30 to 36.30°C and RH 38.43% (as the average of both seasons).

The experimental design was a split-plot; the growth regulators were considered as main plots and propagation times as sub-plots. Three months after propagation, different cutting treatments were dug up and cleaned. Data were recorded on percentage of rooted cuttings (which produced visible roots) and root characteristics. Five cutting bases (2-3 cm long in rooting zone) from each treatment were sampled and thoroughly-washed with distilled water, oven dried at 70°C for 48 hours and ground into homogenous fine powder to determine total nitrogen, total carbohydrates and total soluble phenolic compounds content. Total nitrogen was determined by semi-micro Kjeldahl method as described by Black *et al*. (1965). Total carbohydrates estimated colorimetrically using anthron sulphuric acid method according to Hansen and Moller (1975). Carbohydrate-nitrogen (C/N ratio) was calculated as an indication of rooting capability. Total soluble phenolic compounds content was determined as described previously by Vasco *et al*. (2008). Data were statistically analyzed using statistix 8.1 analytical software and the means were compared used a least significant difference (L.S.D.) test according to Dowdy and Wearden (1983).

Results and Discussion

Rooting of cuttings

The percentage of rooted cuttings of *Kigelia pinnata* showed considerable responses to the different growth regulators treatment and propagation times (Table 1). Apparently, the various root-promoting substances application significantly increased rooting percentages compared to untreated cuttings, except IAA and NAA, each at 1000 ppm in the two seasons. However, the high degree of response to rooting was resulted from NAA at 250 ppm as recorded 57.9 and 54.3% in the first and second seasons, respectively. The next high values of rooting percentage were occurred by IAA at 250 ppm or IBA at 500 ppm, each recorded 36% in average approximately. Although the low level of NAA proved to be the most effective on rooting, raising its concentration from 250 to 1000 ppm significantly decreased the efficiency, thus a concentration of 1000 ppm had the least rooting percentages; 17.3 and 19.1%

in the first and second seasons respectively. These results are in harmony with those obtained by Shoushan *et al*. (1979) on *Araucaria excelsa*, Bandopadhyay *et al*. (1980) on *Carissa carcandas*, Singh and Motial (1982) on *Callistemon lanceolatus*, Pimpini *et al*. (1983) on *Ficus elastica*, El-Sallami and Mahros (2000) on *Euphorbia pulcherrima*, and Abu-Zahra *et al*. (2013) on *Gardenia jasmenoides*.

In respect of propagation times, it was observed that cuttings taken in March was more effective in increasing rooting percentage than those taken in September resulting in 40 and 16% as means, respectively. These results are in agreement with the findings of Hansen (1990) on *Cupressus macrocarpa*, Harris and Singh (1991) on *Bougainvillea spp.*, Watkins and Wittle (1991) on *Cunninghamia lanceolata*, Mharos *et al*. (1994) on *Ficus retusa*, El-Nashar (2000) on *Ficus benjamina*, and Klein *et al*. (2000) on *Myrtus communis*. They reported that cuttings of these species taken in March were more successfully rooted than those taken in September.

The interaction among different combinations declared that NAA at 250 ppm combined with March resulted in the maximum rooting (82%). In contrast, the minimum rooting percentage (10% approximately) was occurred by any treatment of IAA, IBA and NAA, each at 1000 ppm combined with September during both seasons.

The stimulatory effects of auxins on rooting have been discussed in several studies. Haissig (1974) postulated that auxins regulate the subsequent growth and development of root primordia after they have been initiated, also auxins are considered essential for cell division, cell elongation, continued growth of callus, differentiation of tissues in callus, root formation on cuttings, enhanced hydrolysis of carbohydrate, synthesis of RNA, enzymes, new proteins and cell-wall components. Li and Leung (2000) suggested that auxin may stimulate rooting by causing the acidification of cell-walls thereby enhancing cell-wall loosening and growth. Such loosening might facilitate the emergence of root initials from the stem cutting. Hartmann *et al*. (2002) stated that auxin play a vital role in stimulating the adventitious root formation on cuttings. Root initials in cuttings are dependent upon the native auxins in the plant plus an auxin synergist together, these lead to synthesis of ribonucleic acid which involved in initiation of the root primordia. Stefancic *et al*. (2007) reported that the exogenous application of auxins increased initiation of lateral roots and that lateral root development is highly dependent upon auxin group, its concentration and auxin transport. The degree of auxin activity depends on its structural peculiarities and configuration. Davis *et al*. (1995) revealed that the physiology of auxin action showed that auxin was involved in such varied plant activities as stem growth, adventitious root formation and activation of cambial cells.

On other side, a logical relationship between rooting behaviour and the atmosphere conditions around the cuttings during the propagation season was found. It was appeared that cuttings rooted vigorously in March at lower temperature (12.13-28.30°C) than in September at higher temperatures (22.30-36.30°C). In this concern, Hartmann *et al*. (2002) postulated that day time air temperatures of 21 to 27°C with night temperature about 15°C are more suitable for the best rooting of most plant species, although some cuttings rooted better at lower temperatures.

Table 1. Percentage of rooted cuttings in *Kigelia pinnata* Jacq. as affected by growth regulators and propagation times during 2014 and 2015 seasons.

Treatments (ppm)		Propagation times					
		2014 season		Mean	2015 season		Mean
		March	September		March	September	
Control	**0**	14.3	5.0	9.7	16.7	6.3	11.5
IAA	**250**	41.0	20.3	30.7	50.0	30.5	40.3
	500	29.2	15.0	22.1	27.8	20.0	23.9
	1000	24.3	10.5	17.4	25.0	13.3	19.2
IBA	**250**	42.9	10.8	26.9	33.3	10.0	21.7
	500	50.0	15.5	32.8	56.1	20.8	38.5
	1000	33.8	10.0	21.9	35.0	10.3	22.7
NAA	**250**	85.7	30.0	57.9	78.6	30.0	54.3
	500	42.9	20.5	31.7	55.8	20.5	38.2
	1000	24.3	10.3	17.3	27.8	10.3	19.1
	Mean	**38.8**	**14.8**		**40.6**	**17.2**	
L.S.D. 0.05		**Treat: 9.6**	**Time: 7.7**	**Interaction: 15.3**	**Treat: 10.0**	**Time: 8.3**	**Interaction: 16.7**

Root characteristics

Root number

It is quite clear that the most of root-promoting substances treatments significantly increased number of roots per cutting compared to untreated cuttings in the two seasons (Table 2). Whilst, IBA applied at 500 ppm recorded the highest root number followed by IAA at 250 ppm and NAA at 250 ppm resulting in 10, 8 and 6 roots per cutting, respectively. Otherwise, the lowest root number was resulted from IAA at 1000 ppm (2.5 roots/cutting). These results are in accordance with the findings of Karam and Gebre (2004) on *Cercis siliquastrum*, Sundaram and Rangaswamy (1994) on *Ficus auriculata*, and Sabbour *et al*. (2001) on some *Ficus spp*.

As for propagation times, it was noticed that cuttings taken in March had significantly higher root number than those taken in September; 7 and 3 roots per cutting, respectively. These results are in conformity with the findings of Hansen (1990) on *Cupressus macrocarpa*, Mahros *et al*. (1994) on *Ficus retusa* and El-Nashar (2000) on *Ficus benjamina*.

The interaction effects among different treatments appeared that IBA at 500 ppm combined with March achieved the greatest root number followed by IAA at 500 ppm in March; 15 and 12 roots per cutting, respectively. On the contrary, the poorest root formation (2 root/cutting) was produced by any treatment of IAA, IBA and NAA, each at 1000 ppm combined with September.

Table 2. Number of roots per cutting of *Kigelia pinnata* Jacq. as affected by growth regulators and propagation times during 2014 and 2015 seasons.

Treatments (ppm)		Propagation times					
		2014 season		Mean	2015 season		Mean
		March	September		March	September	
Control	0	2.0	1.1	1.6	2.1	1.2	1.7
IAA	250	15.5	5.3	10.4	8.0	3.8	5.9
	500	6.1	2.5	4.3	3.7	2.0	2.9
	1000	3.2	2.2	2.7	2.7	1.8	2.3
IBA	250	6.5	2.6	4.6	7.5	3.0	5.3
	500	15.1	5.0	10.1	15.6	5.1	10.4
	1000	5.7	2.4	4.1	4.5	1.9	3.2
NAA	250	9.4	2.0	5.7	11.0	2.4	6.7
	500	6.6	2.3	4.5	7.0	3.4	5.2
	1000	9.0	1.9	5.5	3.2	1.3	2.3
	Mean	**7.9**	**2.7**		**6.5**	**2.6**	
L.S.D. 0.05		Treat: 1.6	Time: 1.3	Interaction: 2.6	Treat: 1.7	Time: 1.4	Interaction: 2.8

Root length

It is cleared from data presented in Table (3) that most of growth regulators treatments significantly increased root length compared to control in the two seasons. Both IAA and NAA treatments gradually decreased root length with increasing the hormonal concentration. The present findings are similar to that of El-Nashar (2000) on *Ficus benjamina*, El-Fouly *et al*. (2009) on *Ficus deltoidea*, and Babaie *et al*. (2014) on *Ficus binendijkii*.

Clearly, cuttings taken in March had longer roots than those taken in September during both seasons. This is similar to the observations of Harris and Singh (1991) on *Bougainvillea spp.*, Watkins and Wittle (1991) on *Cunninghamia lanceolata* and Klein *et al*. (2000) on *Myrtus communis*.

The interaction effects among different combinations indicated that the longest root system was produced by IBA at 500 ppm combined with March followed by NAA and IAA, each at 250 ppm in the same time. In contrast, NAA at 1000 ppm combined with September resulted in the shortest roots in the two seasons.

Table 3. Root length (mm) of *Kigelia pinnata* Jacq. cutting as affected by growth regulators and propagation times during 2014 and 2015 seasons.

Treatments (ppm)		Propagation times					
		2014 season		Mean	2015 season		Mean
		March	September		March	September	
Control	0	30	9	20	25	8	17
IAA	250	83	32	58	63	24	44
	500	71	28	50	37	15	26
	1000	56	19	38	35	12	24
IBA	250	42	12	27	74	21	48
	500	73	19	46	95	25	60
	1000	47	16	32	53	18	36
NAA	250	99	22	61	76	17	47
	500	83	17	50	69	14	42
	1000	35	8	22	46	11	29
	Mean	**62**	**18**		**57**	**17**	
L.S.D. 0.05		Treat: 18	Time: 14	Interaction: 29	Treat: 23	Time: 19	Interaction: 38

Root weight

It is noticed that fresh and dry root weights of *K. pinnata* were greatly affected by root-promoting substances and propagation times (Tables 4 and 5). Statistical analysis cleared that most of growth regulators treatments significantly increased root measurements. Since IAA and NAA treatments gradually decreased fresh and dry weights of roots with increasing the hormonal concentration. Among IBA treatments, a concentration of 500 ppm was more effective in producing heavier fresh and dry roots than 250 or 1000 ppm. In contrast, the lightest fresh and dry roots were resulted from IAA at 1000 ppm in the two seasons. These results are parallel to those obtained by Karam and Gebre (2004) on *Cercis siliquastrum*, Sundaram and Rangaswamy (1994) on *Ficus auriculata* and El-Nashar (2008) on *Jasminum sambac* and *Pittosporum tobira*.

On the mechanism of auxin-induced growth, Kozlowski *et al.* (1991) declared that the growth processes promoted by auxin refer to the behavior of two geotropic mechanisms which seem to be remarkably different. The first is that of the cell division involves complex differentiation. The other quite distinct behaviour is the increase in cell osmotic pressure causes the expansion and rigidity.

Apparently, cuttings taken in March produced heavier fresh and dry roots than those taken in September. These results are in conformity with those reported by Shoushan *et al*. (1979) on *Araucaria excelsa*, Harris and Singh (1991) on *Bougainvillea spp.,* Klein *et al*. (2000) on *Myrtus communis*, and El-Nashar (2000) on *Ficus benjamina*. They concluded that root growth was greatly influenced by the season of propagation and they found that cuttings taken during spring were superior to those taken in autumn.

The interaction effects on root weight appeared that the heaviest fresh and dry roots were resulted from IBA at 500 ppm combined with March. Otherwise, the lightest fresh and dry roots were obtained by IAA and NAA, each at 1000 ppm in September.

Obviously, a direct relationship between the rooting capacity and the favourable root characteristics was found. Mertens and Wright (1978) explained that the rhythmic growth of woody plants was occurred by absorbing nitrogen in roots which reacts with carbohydrates to promote their development. Hartmann *et al*. (2002) stated that the large root size on cutting enhanced shoot growth rate, and root reduction has been associated with shoot stunting. A large size of root system absorbs high rates of water and nutrients which translocate to the shoot system and lead to more growth and development.

Table 4. Fresh weight of roots (mg/cutting) of *Kigelia pinnata* Jacq. as affected by growth regulators and propagation times during 2014 and 2015 seasons.

Treatments (ppm)		Propagation times					
		2014 season		Mean	2015 season		Mean
		March	September		March	September	
Control	0	106	32	69	92	28	60
IAA	250	580	204	392	416	146	281
	500	160	64	112	178	71	125
	1000	145	51	98	127	45	86
IBA	250	260	93	177	300	107	204
	500	567	199	383	590	207	399
	1000	423	148	286	492	172	332
NAA	250	465	104	285	475	106	291
	500	294	69	182	308	72	190
	1000	261	53	157	279	57	168
	Mean	**326**	**102**		**326**	**101**	
L.S.D. 0.05		Treat: 102	Time: 81	Interaction: 163	Treat: 96	Time: 79	Interaction: 161

Table 5. Dry weight of roots (mg/cutting) of *Kigelia pinnata* Jacq. as affected by growth regulators and propagation times during 2014 and 2015 seasons.

Treatments (ppm)		Propagation times					
		2014 season		Mean	2015 season		Mean
		March	September		March	September	
Control	0	13	4	9	11	3	7
IAA	250	77	27	52	48	17	33
	500	33	13	23	30	12	21
	1000	24	8	16	24	8	16
IBA	250	43	15	29	52	18	35
	500	86	30	58	103	36	70
	1000	74	26	50	86	30	58
NAA	250	81	18	50	83	18	51
	500	62	11	37	65	12	39
	1000	35	8	22	37	8	23
	Mean	**53**	**16**		**54**	**16**	
L.S.D. 0.05		Treat: 18	Time: 14	Interaction: 29	Treat: 16	Time: 13	Interaction: 27

Endogenous substances

Carbohydrate-nitrogen (C/N) ratio

It is clearly noticed that all treatments significantly increased C/N ratio in cutting bases compared to control, except IAA at 1000 ppm in the second season (Table 6). The treatments of IAA gradually decreased C/N ratio with increasing the hormonal concentration, the treatments of NAA also followed a similar pattern to IAA concentrations. Whilst, IBA at 500 ppm resulted in a higher significant increase in C/N ratio than 250 or 1000 ppm in both seasons.

A positive relationship between rooting ability of *K. pinnata* cuttings treated with different treatments of growth regulators under selected times of propagation and their C/N ratios in base tissues was found. It is obvious that the highest rooting percentages resulted from NAA at 250 ppm, IBA at 500 ppm and IAA at 250 were associated with the highest C/N ratios. Similarly, cuttings taken in March which gave the maximum rooting percentage were markedly higher in C/N ratio than those taken in September which were correlated with the minimum rooting percentage. These results are in agreement with those obtained by El-Nashar (2000) on *Ficus benjamina*, Mahros (2000) on *Bougainvilla spp.*, El-Sallami and Gad (2004) on *Ficus cyathistipula*, El-Nashar (2008) on *Jasminum sambac* and *Pittosporum tobira*, and Attia (2016) on *Dracaena marginata*. They found that the high rooting ability was greatly associated with high C/N ratio in cutting bases due to more accumulation of carbohydrates or less nitrogen content. Other investigators have suggested that carbohydrate levels in cuttings may increase to levels that are "supraoptimal" for root formation. Carbohydrates may function solely as a source of metabolic fuel which is necessary to provide the energy needed for root formation; Haissig (1974) and Gibson (2005).

It has been suggested that auxin-carbohydrate interaction are important in regulating root formation. Auxins may enhance rooting by increasing the transport of carbohydrates to the site of root formation; Roitsch and Gonzalez (2004). Some authors have noted that carbohydrate and nitrogen compounds are capable of stimulating root formation; hence rooting capacity has been linked to them; Druege and Kadner (2008). Carbohydrate-nitrogen (C/N) ratios have long been used to estimate influences of nitrogen, and of carbohydrates and nitrogen, on rooting. It is generally held that high C/N ratios favour rooting; Haissig (1974).

Table 6. Carbohydrate-nitrogen (C/N) ratio in cutting base tissues of *Kigelia pinnata* Jacq. as affected by growth regulators and propagation times during 2014 and 2015 seasons.

Treatments (ppm)		Propagation times					
		2014 season		Mean	2015 season		Mean
		March	September		March	September	
Control	0	9.45	1.03	5.24	9.53	1.04	5.29
IAA	250	15.31	4.00	9.66	15.41	4.02	9.72
	500	13.46	3.07	8.27	13.62	2.93	8.28
	1000	10.68	2.10	6.39	10.79	1.96	6.38
IBA	250	14.14	2.14	8.14	14.33	2.16	8.25
	500	17.48	4.36	10.92	17.63	4.17	10.90
	1000	12.98	2.07	7.53	13.12	2.09	7.61
NAA	250	18.73	3.90	11.32	18.88	3.87	11.38
	500	15.83	3.07	9.45	15.94	3.05	9.50
	1000	11.66	2.68	7.17	11.79	2.70	7.25
	Mean	**13.97**	**2.84**		**14.10**	**2.80**	
L.S.D. 0.05		**Treat: 1.13**	**Time: 0.90**	**Interaction: 1.80**	**Treat: 1.14**	**Time: 0.94**	**Interaction: 1.91**

Total soluble phenolic compounds (TSPC)

It is cleared from data presented in Table (7) that all growth regulators applications significantly decreased TSPC content in cutting bases of *K. pinnata* compared to untreated cuttings during the two seasons. In IAA treatments, the TSPC was gradually decreased with increasing the hormonal concentration, while NAA treatments showed the reverse trend to that of IAA concentrations. Since IBA at 500 ppm was markedy higher in TSPC level than in 250 or 1000 ppm; mostly the differences were significant. Whilst, the highest TSPC concentration was occurred by NAA at 1000 ppm in both seasons. These results are in accordance with the findings of Stefancic *et al*. (2007), Osterc and Stampar (2008) and Pop *et al*. (2011).

The inhibitory effect of phenolic on rooting are commonly attributed to the enhancement of indoleacetic oxidase, but it is very probable that other actions such as an interference with oxidative phosphorylation are involved; Bhattacharya (1989). Furthermore, Heuser and Hess (1972) concluded that the regulatory effect of phenols is not primarily through the effects of IAA oxidation. Norcini and Heuser (1988) suggested that the effects of phenolics are primarily on metabolic systems rather than on hormonal systems. Hess (1962) found that the phenolic compound catechol reacts synergistically with IAA in root production in the mung bean bioassay. Since the mung bean itself is a good source of phenols, it may be that oxidation of an ortho-dihydroxy phenol is one of the first steps leading to root initiation.

Table 7. Total soluble phenolic compounds content (mg/g dry wt.) in cutting base tissues of *Kigelia pinnata* Jacq. as affected by growth regulators and propagation times during 2014 and 2015 seasons.

Treatments (ppm)		Propagation times					
		2014 season		Mean	2015 season		Mean
		March	September		March	September	
Control	0	5.47	8.69	7.08	5.28	8.39	6.84
IAA	250	3.92	5.53	4.73	3.90	5.55	4.73
	500	3.49	4.97	4.23	3.14	4.45	3.80
	1000	3.09	4.35	3.72	2.62	3.69	3.16
IBA	250	2.60	3.72	3.16	2.23	3.17	2.70
	500	3.06	4.28	3.67	3.54	4.94	4.24
	1000	2.37	3.59	2.98	2.47	3.78	3.13
NAA	250	2.44	4.38	3.41	2.32	4.16	3.24
	500	3.69	5.20	4.45	3.51	4.97	4.24
	1000	4.77	8.01	6.39	4.63	7.78	6.21
	Mean	**3.49**	**5.27**		**3.36**	**5.09**	
L.S.D. 0.05		Treat: 0.68	Time: 0.56	Interaction: 1.14	Treat: 0.63	Time: 0.50	Interaction: 1.00

Finally, it could be recommended to propagate *Kigelia pinnata* cuttings in March after treating with NAA at 250 ppm that proved to be the most effective combination in increasing rooting percentage (82%) and improving root characteristics for commercial production.

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دور الأوكسينات وموعد الإكثار علي تجذير عقل المشطورة

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الملخص

أجريت هذه الدراسة بمزرعة أبحاث نباتات الزينة بكلية الزراعة – جامعة أسيوط خلال موسمى ٢٠١٤، ٢٠١٥ بهدف تحديد استجابة قدرة تجذير عقل المشطورة للمعاملة بمنظمات النمو (إندول حمض الخليك، إندول حمض البيوتريك، نفثالين حمض الخليك – بتركيزات ٢٥٠ ، ٥٠٠ ، ١٠٠٠ جزء فى المليون لكل منهم) بالإضافة إلى معاملة المقارنة. وقد نقعت قواعد العقل في محاليل المعاملات المختلفة لمدة ٢٤ ساعة ثم زرعت فى بيت موس. وتم تكرار التجربة خلال موعدى إكثار (مارس ، سبتمبر) في كل موسم.

وكانت أهم النتائج ما يلى:

–أظهرت المعاملة بنفثالين حمض الخليك بتركيز ٢٥٠ جزء في المليون تأثيراً منشطاً قوياً في تكوين الجذور العرضية على العقل وحققت أعلي نسبة تجذير (٥٦%) يليها أستعمال أى من المعاملتين إندول حمض الخليك بتركيز ٢٥٠ جزء في المليون، إندول حمض البيوتريك بتركيز ٥٠٠ جزء فى المليون (٣٦%)، بينما أظهرت معاملة المقارنة أدنى نسبة تجذير (١١%).

–كان الإكثار في مارس أكثر نجاحاً معطياً أعلي نسبة تجذير (٤٠%) مقارنة بالعقل المأخوذة في سبتمبر (١٦%).

–أظهرت المعاملات التى تفوقت في نسبة التجذير والتى نشطت نمو الجذور وتطورها تحسناً واضحاً فى قياسات النمو الجذرية.

–وجدت علاقة موجبة بين القدرة العالية على التجذير وزيادة نسبة الكربوهيدرات إلى النيتروجين فى أنسجة قواعد العقل.

–ارتبطت القدرة العالية على التجذير بنقص جوهرى في محتوى أنسجة العقلة من المركبات الفينولية، وقد أتضح ذلك جلياً عند المعاملة بنفثالين حمض الخليك بتركيز ٢٥٠ جزء فى المليون، وكذلك عند الإكثار في مارس.

–يمكن النصح بإكثار عقل المشطورة في مارس بعد معاملتها بنفثالين حمض الخليك بتركيز ٢٥٠ جزء فى المليون بهدف الإنتاج التجارى، حيث أعطت هذه المعاملة المشتركة أعلى نسبة تجذير (٨٢%) وأفضل نمو للجذور.