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EFFECT OF COLLECTION DATES AND AUXINS SOURCES ON ROOTING AND GROWTH OF *LIGUSTRUM OVALIFOLIUM* HASSK CUTTINGS

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Abstract

This study was conducted to investigate the effect of collection dates and auxins treatments on root-ability and growth of *Ligustrum ovalifolium* L. cuttings. Results showed that, planting time and auxins treatments significantly affected rooting percentage, root number, root length, shoots and leaves total indole, total phenols and total sugars. Planting date in March gave the highest rooting %, the heaviest fresh and dry weights and the longest roots. The lowest rooting % was recorded in June with the lowest No. of roots followed by Sept. Auxin treatment of IBA-1000 ppm gave the highest rooting % followed by IAA then NAA. The treatments of IAA, NAA and IBA+NAA were the most effective in increasing root number. In June NAA (first season) and IBA1000 (second one) were the most effective. The treatments of IBA+NAA and IAA+NAA resulted the highest No. roots in Sept. In March, June and Sept, IAA +NAA (in first season) and IAA (in second one) gave the longest roots. Treating cuttings with IBA+NAA, IAA +NAA and IAA gave the heaviest weights of roots in March, but in June IAA+NAA and NAA were the most effective. In Aug and Dec, IBA+NAA gave the heaviest weights. Most of auxins treatments not only increased rooting % but also improved root quality. March plantation recorded the highest contents of total indole and soluble sugars and lowest phenol content with 2000 ppm IBA and 1000 ppm IAA.

***Key words*:** Ligustrum, collection dates, propagation, cutting, auxins IBA, IAA. NAA.

Introduction

California privet (*Ligustrum ovalifolium* Hassk), is native to Japan, it is a popular woody ornamental semi-evergreen, dense, fast-growing large shrub with erect stems, up to 2–5 m., branch lets glabrous-shiny, leaves half evergreen to evergreen; blades ovate to elliptic-ovate, broadly elliptic, or elliptic, glabrous, apex acute to acuminate, margins glabrous. Flowers short-pedicellate, it flowers in June and July. It is used extensively as attractive privacy hedges, landscape industry, as accent plants, foundation planting, screen or garden boundaries. It can be shaped into a fantastical specimen as a focal point. It grows up to 5 m with simple, oval glossy leaves. (Bailey, 1950 and Nesom, 2009). It is easily grown in well-drained soils in full sun to part shade, it tolerates urban conditions and high pollution.

The induction of adventitious roots on cuttings is governed by several factors as the type of cutting, rooting media, type of hormones as well as anatomical, physiological, biochemical and environmental factors (Yeshiwas *et al.,* 2015; Akram *et al.,* 2017), date of cutting collection, endogenous auxins and carbohydrates (Hartmann and Kester, 2002 and Chojnowska, 2004). Berry, 1984, reported that hardwood or semi-hard cuttings of some *Ligustrum* species planted in the spring root easily. Season of cuttings collection, has a great effect on the success rooting. Semi-ripe cuttings of *Camellia* and *Syringa*, taken April rooted well, *Berberis*, *Cotoneaster* and *Hebe* gave good rooting in summer or autumn. ((Hartmann *et al.,* 2002 and Hewson, 2012). Pijut and Moore (2002) obtained good rooting in semi-hardwood *Juglans* in late summer. On *Ulmus villosa*, Bhardwaj and Mishra (2005) recorded the best rooting% in Feb. rather than in July, due to higher levels of sugars. Polat and Çal1_kan (2009) revealed that pomegranate cuttings collected in Feb. showed a higher rooting potential than in Oct. Ling and Zhong (2012) on locust and Gulabrao *et al.,* (2012) on bamboos, reported that spring gave significantly the highest rooting% and improved growth of cuttings.On *Myrtus communis,* Abd El-Hameed (2018) found that March and Sept. planting

significantly increased rooting than June and Dec.

Many studies have shown a positive correlation between rooting potential and carbohydrates (sugars)and IAA contents of cuttings among collection dates. Izadi, et al (2017) on olive cvs showed that, the content of total phenolic affected rooting potential of the cuttings, they can affect adventitious root formation via preventing auxin degradation forming auxin-phenol complex and inhibiting auxins decarboxylation (Haissig, 1986; Wilson and van Staden, 1990).

Plant growth regulators, influence the rooting of cuttings, but auxins have the greatest effect, as a single or in combinations (Dirr and Heuser, 2006). IBA and NAA are used to promote root initiation and growth. Knox and Hamilton (1982)on *Ligustrum obtusifolium* found that IBA (1000-8000 ppm) in talc was effective on % rooting, length and weights and non-effective on *Ligustrum* × *vicaryi*. On Burford Holly plant rooting% decreased with higher level (Blythe and Sibley, 2007).Auxins stimulate lateral root formation, induce cell division, elongation and increase overall rooting % in stem cuttings of ornamental plants (Tchoundjeu *et al.,* 2002, Tchoundjeu *et al.,* 2004), they stimulate cell differentiation, promote starch hydrolysis and attraction of sugars and nutrients to the cutting base (Atangana *et al.,* 2011).

Commonly used synthetic auxins are NAA, 2, 4-D, IAA, IBA, also, naphthalene acetamide, 2, 4, 5-T, MCPA, 2-naphthyloxyacetic acid (NOA) are used as auxins.

Stoutemyer (1954) stated that 2, 4-dichlorophenoxy propionic acid and 2, 4-dichlorophenoxy butyric acid in talc have produced outstanding rooting of cuttings of *Pachysandra terininalis* and *Ligustrum quihoui* and NAA, NOAA, POAA, 2, 4-D, PAA, 4-CPA and 2, 4, 5-T, showed good results. Blythe (2014) on *Ligustrum japonicum*, found significant increase in rooting with IBA 500-3000 ppm.

Woody species respond differently to individual auxins even when many other factors are constant (Leakey, 2004 and Ou Yang *et al.,* 2015). In this regard, Struve and Arnold (1986) stated that IBA was the superior source of auxins for rooting of *A. rubrum*as compared to N-phenyl-indole-3-butyramide, phenyl reasinindole-3-thiobutyrate and phenol indole-3-butyrate. Sharma *et al.,* (2002) on *Acalyphawilkesiana* obtained the highest rooting%, longest roots, highest No. of roots, fresh weight of roots and shoot parameters (leaf number, shoot number and length) with 2000 ppm IBA. Dirr and Heuser (2006) on some camellias stated that rooting was best in summer and improved with IBA alone or plus NAA in talc. Guo, *et al.,* (2009) on *Paeonia* found that 2000ppm IBA gave the best rooting traits (percentage, number and length). On *Bougainvillea spectabilis*, Mehraj *et al.,* (2013) treated with IBA-talc at 1000 ppm obtained the highest rooting %, higher No. of roots and longest roots. Babaie *et al.,* (2014 b) showed that IBA (4000 and 6000 mg/l) had the greatest impact on the success of rooting of *Ficus benjamina*. Also, Babaie *et al.,* (2014a) on *F. Binnendijkii* obtained the longest shoots and maximum No.of leaves with 2000-4000 ppm IBA. On *Duranta erecta*, Singh *et al.,* (2014) found that IBA (4000 ppm) gave the highest rooting %. Whereas, Singh *et al.,* (2015) on *Grewiaasetica* found that IBA 2000 ppm gave the highest rooting%, longest shoots and roots and leaf number. Fetouh *et al.,* (2016) on *Ligustrum japonicum* stated that IBA treatments improved the rooting success to 65% over control.

On the other hand, Amissah and Bassuk (2007) stated that IBA and NAA were more effective than IAA for rooting cuttings. Whereas, Abu-Zahra *et al.,* (2013) on *Gardenia* obtained the highest rooting %, No.of roots and root lengths with NAA (1000-4000 ppm). But, Hassanein (2013) on *Ficus Hawaii* reported that IAA was more effective than IBA or NAA. Danu *et al.,* (2017) on *Ficus variegate* noticed that the No. of roots increased with increasing IBA level, but reduced the growth. On *Myrtus communis*, Abd El-Hameed (2018) found that 4000 ppm IBA significantly recorded the highest rooting%. Celik, *et al.,* (2019) *Ligustrum japonicum* stated that IBA at 2000 ppm gave the highest rooting%.

Several studies confirmed the effectiveness of IAA and NAA in rooting of cuttings and rooting potential. Bose *et al.,* (1973) obtained the highest rooting % in cuttings treated with IAA 1000 ppm. Sari and Qrunfleh (1995) *Jasminum. grandiflorum* found that NAA treatments (500-1000 ppm) were most effective in January, March and May. Sharma *et al.,* (2002) on *Acalypha wilkesiana* stated that rooting% and length were good in 2000 ppm IAA treated cuttings as well as shoot parameters. Tripathi *et al.,* (2003) on poinsettia, recorded the highest rooting %, the longest roots and the highest root weights in IAA-treated cuttings and the highest No. of roots in 1000 ppm NAA. On *Nerium, Bougainvillea and Jasminum*, Sultana (2006) found that NAA had significant effects on the rooting performance and showed higher rooting%. It was found that NAA at 5000 ppm increased rooting % to 75% over control of *Schefflera arboricola* (Sevik *et al.,* 2015). Abidin and Metali (2015) on *Dilleniasuf fruticosa* found that treating cuttings treated with NAA and IAA significantly increased root length produced more leaves. Fathi *et al.,* (2020) found that the highest rooting%

7Schefflera arboricola cuttings was obtained from cuttings treated with 1000 mg L-1 NAA.

Materials and Methods

This study was conducted in the Depart. of Ornamental Hort., Fac. of Agric., Cairo Univ, during the seasons of 2017/2018 and 2018/2019 to investigate the effect of cutting collection dates and some auxins sources and concentrations on root-ability of *Ligustrum ovalifolium* Hassk, cuttings. Semi-hardwood cuttings (12-14 cm, 0.4-0.5 cm diameter, 1-2 leaves) were collected from 5- year old shrubs grown in four dates, *i.e.* Dec. March, June and Sept. in both seasons. The basal end of cuttings were dipped in the talc power containing the different auxins treatments. Singly as follows: Control, IBA 1000, 2000 and 4000ppm, IAA1000, NAA500ppm, NA-amide 500 ppm and chlorophenoxy acetic acid (CPA) 500, or in some combinations with IBA at 1000 (BA+NAA, IBA+N-amide, IBA +CPA) and with IAA at 1000 ppm (IAA +NAA, IAA+N-amide and IAA+CPA). The cuttings were lightly tapped off to remove any excess talc powder and immediately inserted into plastic box, containing rooting medium (peat moss+ sand + perlite at 2:1:1, v/v), under greenhouse condition. The cutting were irrigated once every two or three days. Sixty cuttings in three replicates were used for each treatment. Data recorded: The cuttings were kept in the rooting media for 90 days, at the end of this period, the following measurements were recorded: Rooting percentage, main root number/cutting, root length (cm), fresh and dry weights of roots/cutting, shoot number and leaves number/cutting. The contents of total indoles (mg/g F.W) was done as described by Larson *et al.,* (1962) and modified by Selim *et al.,* (1978), total phenols (mg/g F.W) was estimated as described by Daniel and George, (1972). Total soluble sugars (% D.W) by Smith *et al.,* (1956) method.

Statistical layout and analysis: The experimental layout was (CRD) in factorial treatments (Snedecor and Cochran, 1990) where planting dates were designed as factor a, auxins treatments were designed as factor b, which arranged in completely randomized design. L.S.D at 5% test was used for comparison between means of the studied treatments.

Results and Discussion

Rooting parameters

As shown in table 1 collecting cuttings during March gave the highest rooting% in both seasons and the lowest values were recorded in June. Treating the cuttings with IBA at 1000 ppm recorded the highest rooting (59.47 %) followed by IAA 1000 ppm (58.20 %). There were no-significant differences among the following treatments IAA1000, NAA500, IAA+NAA and IAA+ CPA, in comparison to IBA at1000ppm. Concerning the interaction effect, cutting collected in March treated with IBA1000 ppm recorded the highest rooting %, in both seasons (74.86

Table 1: Percentage of rooted cuttings (%) in *Ligustrum ovalifolium* as affected by collection dates and auxins treatments 2018 and 2019 seasons.

Seasons/ Auxins (ppm)	Rooting %									
	First season, 2018					Second season, 2019				
	March	June.	Sept.	Dec..	Mean (b)	March	June.	Sept.	Dec..	Mean(b)
Control	56.44	27.50	40.37	47.25	42.89	51.50	24.75	47.77	42.93	41.74
IBA 1000	74.86	46.70	55.33	61.00		87.82	45.03	60.87	70.15	65.97
IBA 2000	67.28	45.72	49.50	54.67	54.29	82.35	40.50	54.45	62.87	60.04
IBA 4000	66.87	44.07	51.25	57.73	54.98	80.87	39.67	56.75	66.33	60.91
IAA 1000	70.33	46.67	53.47	62.33	58.20	78.67	42.90	62.17	71.67	63.85
NAA 500	64.47	42.75	56.87	64.00	57.02	82.08	43.70	64.75	67.60	64.53
N-amide 500	57.57	34.37	47.27	48.87	47.02	68.96	37.33	48.67	56.20	52.79
CPA 500	53.67	33.50	38.50	40.50	41.54	60.33	34.25	42.35	49.87	46.70
IBA * +NAA	66.00	43.50	46.50	42.50	49.62	67.50	45.25	42.35	48.87	50.99
IBA+N-amide	57.00	36.50	44.50	42.25	45.06	60.50	29.25	42.35	48.57	45.17
IBA+CPA	60.87	38.57	46.50	49.33	48.85	68.33	43.81	48.95	56.75	54.46
IAA* +NAA	69.70	49.05	55.13	57.57	57.86	85.65	44.67	57.34	66.50	63.54
IAA+N-amide	66.50	42.22	51.25	56.50	54.12	78.12	39.98	56.35	64.97	59.86
IAA+CPA	65.40	45.41	54.67	60.67	56.53	80.25	44.75	60.13	67.77	63.23
Mean	64.07	41.18	49.37	53.23		73.78	39.70	53.23	60.08	
LSD 5%	A: 4.67	B: 6.90	AxB :10.55			A: 3.29	B: 5.44	AxB :8.20		

(*IBAat 1000ppm, *IAAat 1000ppm)

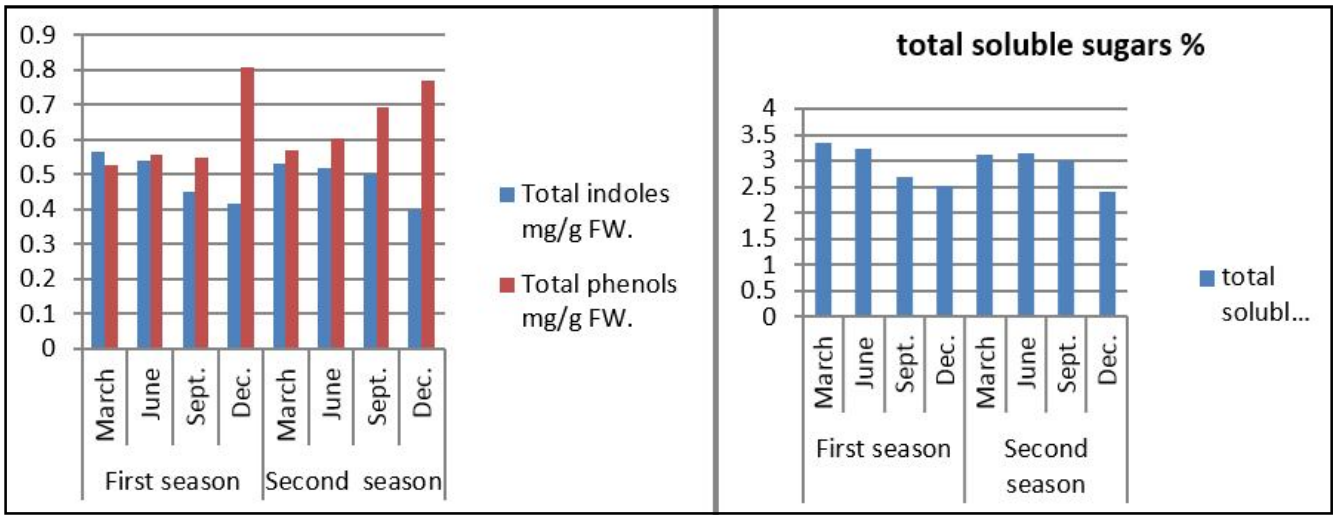
and 87.82%), whereas, in June and Sept, it was obtained with NAA, IBA1000. and IAA. In Dec, rooting % was the highest with NAA, IAA and IBA 1000 in descending order, in the first season and with IAA and IBA, in the second one.

The number of roots/cutting table 2 and Fig. 1 in the two seasons was the highest during March, whereas June batch produced the lowest No. of roots /cutting, followed by September. The treatments of NAA combined with IBA 1000 or IAA 1000ppm gave the highest No. roots / cutting. A significant interaction was recorded between planting dates and auxins treatments, as cuttings collected in March and December, treated with IAA, IBA+NAA and IAA+NAA significantly formed the highest number of roots/cutting. The lowest No. of roots was obtained from untreated (control) in all collecting dates. Treating the cuttings with CPA alone was more effective than its combinations with IAA or IBA, the opposite trend was recorded in case of N-amide.

In both seasons table 3 and Fig. 1 cuttings planted in March and June significantly produced the longest roots and the shortest ones were in Sept. In the first season, IAA+NAA produced the longest roots, followed by IAA then IBA+NAA, the shortest roots were recorded for untreated cuttings. In the second season, IAA and IBA at 4000 ppm resulted the longest roots. A pronounced increase in root length was achieved with the treatment of IBA+ N-amide and IBA at 1000ppm.The interactions

Table 2: Number of roots /rooted cuttings in *Ligustrum ovalifolium* as affected by collection dates and auxins treatments 2018 and 2019 seasons.

Seasons/ Auxins (ppm)	Number of roots/cutting									
	First season, 2018					Second season, 2019				
	March	June.	Sept.	Dec..	Mean (b)	March	June.	Sept.	Dec..	Mean(b)
Control	7.36	2.81	3.65	5.00	4.71	8.73	2.87	4.94	7.8	6.09
IBA 1000	10.16	4.10	5.72	6.26	6.56	12.79	5.12	7.63	7.74	8.32
IBA 2000	11.17	5.07	6.80	8.34	7.84	14.71	6.47	9.74	10.15	10.27
IBA 4000	11.46	4.95	6.23	7.73	7.59	14.36	6.13	9.29	9.44	9.81
IAA 1000	14.29	5.42	7.00	9.44	9.04	17.72	7.42	9.99	11.29	11.60
NAA 500	10.30	6.28	6.52	8.48	7.89	12.26	7.80	10.06	10.35	10.11
N-amide 500	9.67	4.14	5.77	6.32	6.48	12.04	5.21	8.13	9.19	8.64
CPA 500	10.76	5.82	6.60	8.11	7.82	12.82	7.84	8.84	10.63	10.03
IBA +NAA	13.59	6.14	9.05	9.33	9.50	15.58	7.41	12.62	11.50	11.77
IBA+N-amide	10.30	4.18	7.22	6.38	7.02	12.26	5.25	9.36	7.80	8.67
IBA+CPA	10.65	3.97	5.57	6.80	6.75	12.68	5.01	7.65	8.36	8.43
IAA+NAA	13.45	7.47	7.67	8.90	9.37	16.74	9.07	10.14	10.80	11.69
IAA+N-amide	11.35	5.17	5.64	8.48	7.66	14.22	5.69	8.95	10.32	9.80
IAA+CPA	9.95	4.49	4.11	7.52	6.52	12.58	5.64	6.94	9.2	8.59
Mean	11.03	5.00	6.25	7.65		13.54	6.21	8.88	9.61	
LSD 5%	A:0.44	B:0.67	AxB :1.44			A: 0.58	B: 0.84	AxB :1.58		



Figs. (1&2): Total soluble indoles , phenols Total phenols and Total soluble sugars in rooted cuttings.

Table 3: Root length (cm) in rooted cuttings in *Ligustrum ovalifolium* as affected by collection dates and auxins treatments 2018 and 2019 seasons.

Seasons/ Auxins (ppm)	Root length (cm)									
	First season, 2018					Second season, 2019				
	March	June.	Sept.	Dec..	Mean (b)	March	June.	Sept.	Dec..	Mean(b)
Control	6.12	5.36	6.06	5.71	5.81	6.80	6.94	5.08	5.69	6.13
IBA 1000	8.98	7.14	6.10	6.62	7.21	8.15	8.11	6.73	7.57	7.64
IBA 2000	9.96	9.79	6.86	7.25	8.47	7.56	7.23	5.46	6.93	6.80
IBA 4000	8.44	7.34	7.86	7.08	7.68	8.43	8.11	7.64	8.34	8.13
IAA 1000	9.63	9.12	8.22	8.20	8.79	10.01	8.80	8.32	6.68	8.45
NAA 500	9.10	8.71	7.36	7.34	8.13	7.11	6.96	5.56	5.88	6.38
N-amide 500	7.63	6.13	6.13	6.00	6.47	7.57	7.33	7.07	6.93	7.23
CPA 500	8.61	6.65	6.72	7.22	7.30	6.36	7.14	6.38	7.44	6.83
IBA +NAA	8.90	8.85	8.40	8.31	8.62	7.41	7.24	6.27	5.84	6.69
IBA+N-amide	7.39	7.31	7.15	6.13	7.00	8.31	8.41	7.46	6.66	7.71
IBA+CPA	7.56	6.90	5.99	6.27	6.68	5.08	6.31	5.53	6.31	5.81
IAA+NAA	10.5	9.86	8.86	7.62	9.21	7.63	7.36	7.07	7.52	7.40
IAA+N-amide	9.25	6.27	7.07	6.69	7.32	7.63	8.04	5.52	7.48	7.17
IAA+CPA	8.67	6.76	8.12	7.67	7.81	7.91	5.85	7.32	5.66	6.69
Mean (a)	8.63	7.59	7.21	7.01		7.57	7.42	6.53	6.78	
LSD 5%	A:0.23	B:0.44	AxB :0.92			A: 0.26	B:0.62		AxB:1.08	

revealed that in March, June and Sept., the treatment of IAA +NAA was the most effective in increasing the length of roots in first season and the treatment of IAA in the second one. In December, IBA at 4000 ppm, was the most effective one.

Fresh and dry weights of roots/cutting (g)

As shown in tables 4 & 5 cuttings collected during March (in both seasons) gave the highest significant values of fresh and dry weights of roots, while the lowest one was recorded in Sep. (first season) and June (second one). Treating cuttings with IBA+NAA, IAA+NAA and IAA produced the highest root weights. But, in Sept. IBA+NAA gave the heaviest fresh roots, whereas in Dec. IBA +NAA treatment was the most effective in

Table 4: Fresh of roots/g cutting in rooted cutting in *Ligustrum ovalifolium* as affected by collection dates and auxins treatments 2018 and 2019 seasons.

Seasons/ Auxins (ppm)	Fresh weight of roots/cutting (g)									
	First season, 2018					Second season, 2019				
	March	June.	Sept.	Dec..	Mean (b)	March	June.	Sept.	Dec..	Mean(b)
Control	0.567	0.363	0.410	0.486	0.457	0.724	0.414	0.450	0.761	0.587
IBA 1000	0.958	0.651	0.543	0.626	0.694	1.219	0.692	0.807	0.832	0.887
IBA 2000	1.271	0.821	0.686	0.839	0.904	1.332	0.782	1.159	1.180	1.113
IBA 4000	1.084	0.683	0.740	0.775	0.821	1.215	0.595	1.067	1.000	0.969
IAA 1000	1. 330	0.829	0.764	1.038	0.990	1.425	0.775	1.206	1.351	1.189
NAA 500	0.911	0.925	0.715	0.860	0.853	0.930	0.839	1.220	1.195	1.046
N-amide 500	0.792	0.555	0.549	0.571	0.617	0.944	0.540	0.883	0.947	0.829
CPA 500	0.933	0.774	0.658	0.819	0.796	1.119	0.839	1.001	1.116	1.019
IBA +NAA	1.501	0.828	1.033	1.050	1.103	1.610	0.780	1.549	1.414	1.338
IBA+N-amide	0.992	0.541	0.746	0.586	0.716	1.248	0.521	1.090	0.848	0.927
IBA+CPA	0.824	0.538	0.524	0.627	0.628	0.994	0.458	0.813	0.841	0.777
IAA+NAA	1.363	1.122	0.966	0.924	1.094	1.584	1.120	1.239	1.252	1.299
IAA+N-amide	0.831	0.707	0.513	0.718	0.692	1.109	0.718	0.705	0.973	0.876
IAA+CPA	0.991	0.722	0.716	0.898	0.832	1.062	0.725	1.010	1.195	0.998
Mean	1.025	0.732	0.683	0.773		1.180	0.700	1.014	1.065	
LSD 5%	A: 0.053	B:0.128	AxB :0.215			A: 0.047	B:0.110		AxB :0.233	

(*IBA at 1000ppm,*IAA at 1000ppm).

Table 5: Dry weight of roots/g cutting in rooted cutting in *Ligustrum ovalifolium* as affected by collection dates and auxins treatments 2018 and 2019 seasons.

Seasons/ Auxins (ppm)	Dry weight of roots/g cutting									
	First season, 2018					Second season, 2019				
	March	June.	Sept.	Dec..	Mean (b)	March	June.	Sept.	Dec..	Mean(b)
Control	0.114	0.085	0.093	0.105	0.099	0.139	0.098	0.125	0.099	0.115
IBA 1000	0.210	0.127	0.128	0.135	0.150	0.240	0.143	0.157	0.159	0.175
IBA 2000	0.259	0.137	0.139	0.143	0.170	0.243	0.178	0.174	0.183	0.195
IBA 4000	0.208	0.130	0.148	0.166	0.163	0.237	0.178	0.165	0.159	0.185
IAA 1000	0.230	0.137	0.197	0.193	0.189	0.255	0.219	0.205	0.185	0.216
NAA 500	0.215	0.148	0.163	0.185	0.178	0.224	0.162	0.177	0.195	0.190
N-amide 500	0.177	0.108	0.128	0.142	0.139	0.207	0.154	0.146	0.146	0.163
CPA 500	0.187	0.148	0.145	0.122	0.151	0.214	0.179	0.174	0.167	0.184
IBA +NAA	0.285	0.195	0.199	0.222	0.225	0.259	0.210	0.209	0.236	0.228
IBA+N-amide	0.218	0.134	0.163	0.152	0.167	0.224	0.168	0.156	0.145	0.173
IBA+CPA	0.191	0.124	0.119	0.129	0.141	0.208	0.144	0.158	0.146	0.164
IAA+NAA	0.292	0.167	0.165	0.232	0.214	0.278	0.168	0.200	0.243	0.224
IAA+N-amide	0.168	0.112	0.126	0.140	0.137	0.203	0.133	0.155	0.168	0.165
IAA+CPA	0.222	0.138	0.175	0.148	0.171	0.210	0.191	0.157	0.170	0.182
Mean (a)	0.213	0.135	0.149	0.158		0.224	0.166	0.168	0.171	
LSD 5%	A: 0.0 26	B:0.048	AxB :0.066			A: 0.016	B:0.029	AxB :0.078		

(*IBA at 1000ppm,*IAA at 1000ppm).

fresh weight and IAA+NAA treatment gave the heaviest dry roots. IBA1000 ppm+ NAA and IAA +NAA gave the heaviest root weights, the lowest ones were recorded in the untreated cuttings.

In general, planting dates affected significantly the rooting % of cuttings and No. of roots/ cutting. March gave the highest rooting% and the heaviest fresh and dry weights as well as the longest roots. The stimulant effects may be attributed to the effect of temperature and photosynthetic rate prevailed during this period (Devlin and Witham, 1986)which leads to produce more carbohydrates, that help the initiation of roots. (Rahman *et al.,* 1991). Similar findings were reported by Rana *et al.,* (1995) on mulberry, Hartmann *et al.,* (2002) *Camellia,* Blythe and Sibley (2007) on Burford Holly and Hewson (2012) on *Syringa, Berberis*, *Cotoneaster* and *Hebe*. On *Ulmus villosa*, Bhardwaj and Mishra (2005) stated that rooting % and root number were better in Feb. rather than in July as cuttings had higher levels of sugars. Abd El Hameed, (2018) on *Myrtus communis*, found that cuttings planted in March significantly increased values of rooting.

From the previous data, in March IBA at 1000 ppm gave the highest rooting % followed by IAA then NAA and IAA+NAA, IAA then IBA+NAA produced the longest roots. In June NAA (first season) and IBA1000 (second one) were the most effective. In Aug. and Dec., NAA, IBA1000 ppm and IAA increased the rooting%. The treatments of IBA+NAA and IAA+NAA resulted the highest No. roots and the heaviest weight of roots, in March. Knox and Hamilton (1982) on *Ligustrum* found that IBA (1000-8000 ppm) in talc were effective on % rooting, root length and fresh and dry weights. Houle and Babeux (1998) obtained similar results. Swamy *et al.,* (2002) stated that low level of IBA enhanced the roots number and rootlength in *Grewia optiva*. Similarly, De Souza and De Lima (2005), Tworkoski and Takeda (2007) and Saffari and Saffari (2012)obtained best rooting with IBA (2000 ppm).Rooting is enhanced by using auxins singly or in combinations (Dirr and Heuser, 2006).

Some woody species respond differently to individual auxin even when many other factors are constant (Leakey, 2004, Ou Yang *et al.,* 2015).Celik, *et al.,* (2019) stated that IBA at 2000 ppm gave the highest rooting%. Also, Shiri, *et al.,* (2019) on *Duranta erecta* obtained the best roots with IBA-5000ppm. It is well known that auxins induce cell division, elongation and adventitious root formation and play a significant role in stimulating root initiation in cuttings of woody ornamental plants (Tchoundjeu *et al.,* 2002, Tchoundjeu *et al.,* 2004), auxins stimulate cell differentiation, promote starch hydrolysis and the attraction of sugars and nutrients to the cutting base (Atangana *et al.,* 2011). The treatments levels of IBA and NAA produced the longest roots of *Bougainvillea glabra* (Bosela *et al.,* 2010). Shakouri *et al.,* (2012) reported that NAA stimulated the root system of *Dracaena sanderiana* cuttings, but Rahdari *et al.,* (2014) on *Cordyline terminalis* obtained the best

roots with NAA+ IBA.Gad (*2019)* on *Tabernaemontan-adivarticata* stated that fresh and dry weights of roots, showed considerable responses to IAA and IBA more than NAA.

Vegetative growth

Data in table 6 show that planting date had a significant effect on the shoot formation, in both seasons. Collecting cuttings in March gave the highest No. shoots, followed by summer collection. In both seasons, all auxins treatments significantly increased the formation of shoots/ cuttings and IBA +NAA produced the highest No. shoots. A marked increase in shoot production was recorded with the treatments of IBA (2000ppm), NAA and AA+CPA. The interaction show that the treatment of IBA1000ppm +NAA, was the most effective in formation of shoots / cutting, at the different collecting dates.

As shown in table 7 the number of leaves showed significant increases in March and June over other dates. Treating cuttings with IBA 1000ppm + NAA and IBA4000 ppm in the first season and IAA+CPA in the second one, were the most effective on leaf formation. A significant interaction was recorded, as treating cuttings in the different dates with IBA+NAA produced the highest No.of leaves/cuttings.

In conclusion, planting date had a significant effect on the shoot and leaves growth. Collecting cuttings in March and June gave the highest No. shoots and leaves and the treatment of IBA +NAA produced the highest No. shoots and leaves. A marked increase in shoot production was recorded with IBA (2000-4000 ppm*)*, NAA and IAA+CPA .In this respect, Swamy *et al.,* (2002) found that, IBA significantly enhanced the formation of leaves/cuttings in *Grewia optiva.* Ling and Zhong (2012) reported that planting cuttings in May improved the vegetative growth of cuttings. Baloni, *et al.,* (2017) on pomegranate stated that 2500ppm IBA gave the best shoots/cutting. Also, Gad (2019) on *Tabernae montana* obtained the highest No. of branches and leaves with IBA.

Chemical composition

Total indole (mg/g F. W): Data in table 8 revealed that, March plantation recorded the highest total indole content, followed by June, then the content decreased significantly to the minimum in Dec. It was found that the highest indole contents were recorded with 2000 ppm IBA and 1000 ppm IAA, also there were marked increases with CPA-treatment (first season) and IBA+NAA (both seasons). The interaction showed that the highest indole contents were recorded in March in cuttings treated with IAA, CPA then IBA (2000ppm), this was the case in the first season and with IAA and IBA at 2000ppm, in the second one.

Total phenol (mg/g F.W): In both seasons table 9 March plantation recorded the lowest content of total phenols and the highest content in Dec. In the first season, IBA + NAA significantly reduced the content of total phenols to the minimum, followed IBA 4000 ppm, in the second season, the minimum values were obtained with

Table 6: Number of shoots/rooted cuttings in *Ligustrum ovalifolium* as affected by collection dates and auxins treatments 2018 and 2019 seasons.

Seasons/ Auxins (ppm)	No. of shoots/cutting									
	First season, 2018					Second season, 2019				
	March	June.	Sept.	Dec..	Mean (b)	March	June.	Sept.	Dec..	Mean(b)
Control	2.12	2.33	1.24	1.66	1.84	2.26	2.75	2.41	1.45	2.22
IBA 1000	2.94	2.82	1.89	1.96	2.40	3.22	2.91	2.03	2.00	2.54
IBA 2000	3.57	4.69	2.31	2.12	3.17	3.84	4.88	2.49	2.15	3.34
IBA 4000	3.52	3.99	2.31	2.22	3.01	3.84	4.15	2.49	2.19	3.17
IAA 1000	3.43	3.15	2.45	2.24	2.81	3.76	3.28	2.64	2.28	2.99
NAA 500	3.57	4.55	2.24	1.96	3.08	3.91	4.74	2.41	2.07	3.28
N-amide 500	2.94	3.08	2.17	1.89	2.52	3.22	3.21	2.34	1.93	2.68
CPA 500	3.71	3.99	2.48	2.13	3.07	4.07	4.15	2.64	1.75	3.15
IBA +NAA	4.48	4.76	2.80	2.31	3.59	4.91	4.96	3.02	2.36	3.81
IBA+N-amide	3.08	3.36	2.42	2.15	2.76	3.37	3.50	2.64	1.71	2.81
IBA+CPA	3.44	2.80	1.82	2.03	2.52	3.22	2.91	1.96	2.07	2.54
IAA+NAA	3.29	3.85	2.13	1.96	2.80	3.60	4.01	2.26	2.00	2.97
IAA+N-amide	3.15	3.54	2.24	2.15	2.77	3.45	3.64	2.41	2.22	2.93
IAA+CPA	3.92	4.20	2.31	2.17	3.15	4.30	4.37	2.49	2.22	3.35
Mean (a)	3.37	3.65	2.20	2.07		3.64	3.82	2.45	2.03	
LSD 5%	A: 0.07	B:0.19	AxB 0.43			A: 0.09	B:0.21	AxB :0.49		

IBA4000 ppm and IAA+N-amide. The highest total phenol content was recorded for un-treated cuttings at the different dates.These results are in line with that of Fouad *et al.,* (1989) on olive and Abd El-hameed (2018) on myrtle.

Total soluble sugars (%DW)

Data presented in table 10 indicate that March and June plantations recorded the highest soluble sugars content, then it was decreased significantly to the minimum value in Dec. The highest soluble sugars contents were obtained in cuttings treated with IBA at 2000 ppm and IAA at 1000 ppm, in both seasons. Similar results were obtained by Bhadrwaj *et al.,* (1996) on *Ulmus laevigata* prepared and planted in spring which had higher levels of starch, sugar, total carbohydrate along with better rooting.

Table 7: Number of leaves /rooted cuttings in *Ligustrum ovalifolium* as affected by collection dates and auxins treatments 2018 and 2019 seasons.

Seasons/ Auxins (ppm)	No. leaves/cutting									
	First season, 2018					Second season, 2019				
	March	June.	Sept.	Dec..	Mean (b)	March	June.	Sept.	Dec..	Mean(b)
Control	6.93	6.28	4.48	3.95	5.41	8.60	7.58	4.83	5.01	6.51
IBA 1000	8.08	7.28	3.78	4.92	6.02	9.87	7.58	4.07	5.01	6.63
IBA 2000	8.62	12.19	4.62	5.25	7.67	11.56	12.70	4.98	5.37	8.65
IBA 4000	10.62	10.37	5.62	5.66	8.07	12.56	10.81	4.98	6.73	8.77
IAA 1000	9.43	8.19	5.94	5.60	7.29	10.34	8.53	5.25	5.73	7.47
NAA 500	9.81	11.83	4.48	4.90	7.76	11.77	12.33	4.83	5.01	8.49
N-amide 500	7.08	8.00	4.34	4.72	6.04	8.87	8.35	4.68	4.83	6.68
CPA 500	10.20	10.00	4.90	6.25	7.84	7.19	10.81	5.28	5.37	7.16
IBA +NAA	12.32	12.37	8.60	8.77	10.52	14.51	12.89	6.04	7.91	10.34
IBA+N-amide	7.47	8.73	4.96	5.25	6.60	9.29	9.10	5.30	5.37	7.26
IBA+CPA	8.08	7.28	5.64	5.07	6.52	8.87	7.58	3.92	5.19	6.39
IAA+NAA	9.04	10.01	5.20	4.98	7.31	9.92	10.43	4.53	5.01	7.47
IAA+N-amide	8.66	9.19	4.48	5.42	6.94	10.50	9.48	4.83	5.55	7.59
IAA+CPA	10.78	10.92	4.62	5.42	7.94	13.82	11.38	4.98	6.55	9.18
Mean (a)	9.08	9.47	5.12	5.44		10.55	9.97	4.89	5.62	
LSD 5%	A: 0.33	B: 0.51	AxB :1.13			A: 0.45	B: 0.78	AxB :1.26		

(*IBA at 1000ppm,*IAA at 1000ppm)

Table 8: Total soluble indoles mg/g FW in rooted cuttings of *Ligustrum ovalifolium* as affected by collection dates and auxins treatments 2018 and 2019 seasons.

Seasons/ Auxins (ppm)	Total Soluble Indole mg/g FW									
	First season, 2018					Second season, 2019				
	March	June.	Sept.	Dec..	Mean (b)	March	June.	Sept.	Dec..	Mean(b)
Control	0.452	0.412	0.387	0.337	0.397	0.420	0.425	0.400	0.3	0.385
IBA 1000	0.575	0.537	0.475	0.375	0.491	0.575	0.712	0.550	0.350	0.545
IBA 2000	0.687	0.738	0.525	0.400	0.588	0.588	0.612	0.712	0.437	0.583
IBA 4000	0.630	0.525	0.575	0.487	0.554	0.637	0.612	0.470	0.462	0.546
IAA 1000	0.712	0.600	0.462	0.513	0.569	0.737	0.663	0.612	0.525	0.635
NAA 500	0.387	0.487	0.425	0.375	0.419	0.487	0.487	0.600	0.325	0.474
N-amide 500	0.650	0.612	0.387	0.350	0.500	0.375	0.400	0.375	0.362	0.378
CPA 500	0.700	0.660	0.537	0.338	0.562	0.437	0.425	0.487	0.380	0.432
IBA +NAA	0.588	0.612	0.450	0.488	0.535	0.587	0.550	0.600	0.488	0.556
IBA+N-amide	0.425	0.410	0.350	0.387	0.393	0.440	0.338	0.412	0.337	0.381
IBA+CPA	0.487	0.437	0.475	0.462	0.465	0.613	0.525	0.437	0.400	0.493
IAA+NAA	0.562	0.550	0.388	0.412	0.478	0.552	0.525	0.450	0.337	0.466
IAA+N-amide	0.413	0.425	0.375	0.437	0.413	0.600	0.450	0.487	0.435	0.493
IAA+CPA	0.638	0.575	0.475	0.463	0.538	0.425	0.525	0.463	0.475	0.472
Mean (a)	0.565	0.541	0.449	0.416		0.533	0.517	0.503	0.400	
LSD 5%	A:0.02	B:0.04	AxB :0.07			A: 0.03	B:0.06	AxB :0.09		

Many studies have shown a positive correlation between rooting potential and carbohydrate content of cuttings as Guo, *et al.,* (2009) on *Paeonia* and Abd El Hameed, (2018) on *Myrtus communis*.

Conclusion

Therooting behaviour in stem cuttings of Ligustrum was highly responded to collecting dates and auxins treatments. Planting dates and auxins treatments significantly affected rooting percentage, root number, root length, shoots and leaves total indole, total phenols and total sugars. Planting date in March gave the highest rooting %, the heaviest fresh and dry weights and the longest roots. Auxin treatment of IBA-1000 ppm gave the highest rooting % followed by IAA then NAA. The treatments of IAA, NAA and IBA+NAA were the most effective in increasing root number. Treating cuttings with IBA+NAA, IAA +NAA and IAA gave the heaviest

Table 9: Total phenols mg/g FW in rooted cuttings of *Ligustrum ovalifolium* as affected by collection dates and auxins treatments 2018 and 2019 seasons.

Seasons/ Auxins (ppm)	Total phenols mg/g FW.									
	First season, 2018					Second season, 2019				
	March	June.	Sept.	Dec..	Mean (b)	March	June.	Sept.	Dec..	Mean(b)
Control	0.650	0.735	0.748	0.990	0.780	0.765	0.841	0.879	0.898	0.845
IBA 1000	0.566	0.650	0.618	0.790	0.656	0.592	0.624	0.739	0.821	0.694
IBA 2000	0.530	0.579	0.523	0.765	0.599	0.630	0.579	0.617	0.777	0.650
IBA 4000	0.452	0.502	0.433	0.752	0.534	0.374	0.510	0.605	0.630	0.529
IAA 1000	0.528	0.420	0.440	0.749	0.534	0.413	0.707	0.816	0.617	0.638
NAA 500	0.552	0.541	0.497	0.812	0.600	0.503	0.573	0.797	0.790	0.665
N-amide 500	0.595	0.733	0.675	0.755	0.689	0.654	0.745	0.841	0.867	0.776
CPA 500	0.725	0.650	0.719	0.775	0.717	0.752	0.809	0.816	0.892	0.817
IBA +NAA	0.352	0.434	0.426	0.763	0.493	0.637	0.694	0.810	0.592	0.683
IBA+N-amide	0.495	0.395	0.459	0.875	0.556	0.478	0.464	0.561	0.811	0.578
IBA+CPA	0.365	0.459	0.465	0.887	0.544	0.408	0.433	0.528	0.765	0.533
IAA+NAA	0.575	0.548	0.510	0.821	0.613	0.650	0.510	0.605	0.799	0.641
IAA+N-amide	0.467	0.503	0.503	0.760	0.558	0.453	0.413	0.503	0.752	0.530
IAA+CPA	0.561	0.663	0.643	0.821	0.672	0.652	0.561	0.617	0.756	0.646
Mean (a)	0.529	0.558	0.547	0.808		0.568	0.604	0.695	0.769	
LSD 5%	A:0.04	B:0.07	AxB :0.012			A: 0.05	B:0.07	AxB :0.014		

Table 10: Total soluble sugars mg/g FW in rooted cuttings of *Ligustrum ovalifolium* as affected by collection dates and auxins treatments 2018 and 2019 seasons.

Seasons/ Auxins (ppm)	Total soluble sugar % D.W									
	First season, 2018					Second season, 2019				
	March	June.	Sept.	Dec..	Mean (b)	March	June.	Sept.	Dec..	Mean(b)
Control	3.00	2.70	2.31	2.01	2.50	2.91	2.77	2.40	1.80	2.47
IBA 1000	3.45	3.21	2.85	2.58	3.02	4.26	3.45	3.30	2.19	3.30
IBA 2000	4.11	4.42	3.15	2.40	3.52	3.64	3.52	4.26	2.61	3.51
IBA 4000	3.36	3.15	3.45	2.91	3.21	3.64	3.81	2.82	2.76	3.25
IAA 1000	4.23	3.60	2.76	3.07	3.41	3.97	4.41	3.66	3.15	3.79
NAA 500	2.32	2.88	2.55	2.42	2.54	2.89	2.89	3.60	1.98	2.84
N-amide 500	3.90	3.66	2.31	2.10	2.99	2.40	2.25	2.25	2.16	2.26
CPA 500	4.11	3.96	3.21	2.02	3.32	2.55	2.61	2.91	2.28	2.58
IBA +NAA	3.52	3.66	2.73	2.92	3.20	3.30	3.49	3.63	2.92	3.33
IBA+N-amide	2.55	2.14	2.12	2.31	2.28	2.02	2.28	2.46	2.01	2.19
IBA+CPA	2.91	2.61	2.85	2.74	2.77	3.15	3.67	2.61	2.40	2.96
IAA+NAA	3.36	3.30	2.58	2.46	2.92	3.16	2.56	2.70	2.01	2.62
IAA+N-amide	2.47	2.55	2.4	2.59	2.50	2.73	3.61	2.89	2.61	2.96
IAA+CPA	3.82	3.48	2.37	2.77	3.11	3.15	2.58	2.78	2.88	2.85
Mean (a)	3.36	3.23	2.68	2.52		3.12	3.14	3.02	2.41	
LSD 5%	A:0.25	B:0.37	AxB :0.49			A: 0.20	B:0.27	AxB :0.44		

weights of roots in March. Most of auxins treatments not only increased rooting % but also improved root quality. March plantation recorded the highest contents of total indole and soluble sugars and reduced phenol content along with IBA and IAA treatments.

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