Biological Forum – An International Journal **16(7): 44-52(2024)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Effect of various Concentrations of Growth Hormone (IBA) and Types of Cutting Sections on Rooting and Growth of *Platanus orientalis* L. Branch Cuttings

Midhat Bilal[1*], Parvez Ahmad Khan[1], Ashfaq Ahmad Mir[1], Nageena Nazir[2], Amir Bashir Wani[3], Sajad Ahmad Gangoo[4], Immad Ahmad Shah[2] and Asnain Khateeb[1]

[1]Division of Forest Biology and Tree Improvement, Faculty of Forestry,
Sher-e-Kashmir University of Agricultural Sciences and Technology-Kashmir, Benhama, Ganderbal (J&K), India.
[2]Division of Agricultural Statistics, Faculty of Horticulture,
Sher-e-Kashmir University of Agricultural Sciences and Technology-Kashmir, Shalimar, Srinagar (J&K), India.
[3]Division of Plant Biotechnology,
Sher-e-Kashmir University of Agricultural Sciences and Technology-Kashmir (J&K), India.
[4]Division of Forest Products and Utilization, Faculty of Forestry,
Sher-e-Kashmir University of Agricultural Sciences and Technology-Kashmir, Benhama, Ganderbal (J&K), India.

(Corresponding author: Midhat Bilal)*
(Received: 19 April 2024; Revised: 10 May 2024; Accepted: 02 June 2024; Published: 15 July 2024)
(Published by Research Trend)

ABSTRACT: The present investigation "Effect of various concentrations of growth hormone (IBA) and types of cutting sections on rooting and growth of *Platanus orientalis* L. branch cuttings" was carried out at experimental field of Division of Forest Biology and Tree Improvement, Faculty of Forestry, Benhama during the years 2018 and 2019 to standardize optimum concentration of growth hormones and to determine the best section of branches for rooting and growth of *Platanus orientalis* L Cuttings of 8 inches length were prepared from different sections (apical, middle and basal) of branches collected from *Platanus orientalis* L. trees in January. Before planting in March, the cuttings were treated with varying concentrations of IBA in a quick dip method for 60 seconds. The experiment was laid in Completely Randomised Design (Factorial). In all, there were thirty-nine treatment combinations comprising of twelve concentrations of IBA (1000, 2000, 3000, 4000, 5000, 6000, 7000, 8000, 9000, 10000, 11000 and 12000ppm) and Control with three cutting sections (apical, middle and basal). In case of IBA concentrations, cuttings of *Platanus orientalis* L. treated with IBA@6000ppm yielded best results for all the growth parameters *viz*., rooting (41.33%), root length (26.48 cm), average number of roots per plant (8.56), sprouting (98.89%), shoot length (35.84 cm), collar diameter (6.45 mm), number of branches per plant (2.67), leaf area (44.67 cm^2), fresh and dry biomass of shoot (21.57 g) and (10.97 g) respectively, fresh and dry biomass of root (15.49 g) and (5.11 g) respectively and in case of cutting sections, basal cuttings proved to be superior as they recorded highest results for all the characters like rooting , root length, average number of roots per plant, shoot length, collar diameter, number of branches per plant, fresh and dry biomass of shoot, fresh and dry biomass of root .

Keywords: *Platanus orientalis* L, IBA, Root, Biomass, Branches.

INTRODUCTION

Platanus orientalis L. is a tree species belonging to the family Platanaceae. It is a deep-rooting plant with roots extending the crown area. Chinar tree normally gains a height of about 25 meters with girth exceeding 50 feet in some cases. The bark is grey-brown, flaking and scaly. Leaves are arranged alternately, deeply 3, 5 or 7 lobed, 12-20 cm in length, and palmate with long stalks. Petiole lengths vary from 3 to 8 cm. Flowers are dense, unisexual spherical heads. Fruits are shaped like spheres, about 2 cm in width and are located on the leafstalk. The fruits still stay over on the trees late until the spring. The buds are large, green and protruding. The flowering begins during March-April. It grows in sunny places without continuous shade toleration. It is fit for soils such as sandy, loamy and clay and can tolerate pH from neutral to strongly alkaline. It prefers moist soil but can withstand drought, but not exposure to marine conditions. It can also withstand air-pollution. As per IUCN Red list, it is recognized as endangered in parts of its range due to the expansion of agriculture and irrigation schemes (Anonymous, 2008). *P. orientalis* L. possibly resulted from accumulation of genetic changes during intercontinental disjunctions and other impediments in geological time (Sert *et al.,* 2008; Pilotti *et al.,* 2009). *P. orientalis* L. occurs naturally in almost every forest, streams and water basins of Turkey. It is commonly used in Turkey's landscape design and there are many reports of these trees being preserved as monumental trees (Zencirkiran, 2010; Zencirkiran and Erken 2012). Differently, natural standings of *P. orientalis* L. are found in the Mediterranean region of Southern Europe and South-West Asia particularly in Iran and Turkey.

Platanus orientalis L. is the only species of Platanaceae family found in India and its growth is confined to Jammu & Kashmir State (Kozgar and Khan 2011). The notion that the Mughals brought Chinar trees into the State was denied by Wadoo (2007), according to whom there are many references to the presence of the tree in the state in the historical accounts. Chinar tree has a noteworthy cultural significance and is a common emblem of Kashmir heritage seen in various art and craft designs, embellishment of shawls, wood carving etc. As a very large, wide tree with broad, thick leaves that appear to be horizontally oriented, it is particularly appreciated for its shade and coolness it provides during the summer season. A paste made from the leaves and seeds is applied on eyes for treating ophthalmic disorder. Bark when boiled in vinegar acts as a cure for hernia, toothaches, dysentery and diarrhea. A fabric dye is manufactured from the branches and roots. The wood, called the lace wood, is used for making delicate furniture, ornamentally carved doors, fancy lacquered articles mallets, interior finish, for chopping and dressing of mat as well as fuel wood (Wadoo, 2007). Given the government restrictions such as J & K Preservation of Specific Trees Act 1967, Land Revenue Act S36 and Chinar rules on the felling of Chinar trees in the Valley in the past, the tree population has declined over the years, suffering much damage due to negligence and human greed. Chinar the 'king of trees' has been under the axe of smugglers. Their number decreased to more than half, from 42000 in 1970 to less than 27000 in the valley (Kozgar and Khan 2011).

Vegetative propagation techniques have been used to mitigate and overcome the problems which hinder the multiplication of economically important tree species of the forest (Libby and Rauter 1984). It provides a feasible substitute to the customary seedling dependant forestry (Hussey, 1986; Longman and Jenik 1990; Ali and El-Tigani 2003; Dar and Wani 2017). Rooting potential of cuttings is regulated by optimization of several endogenous as well as exogenous factors (Zsuffa *et al.,* 1977; Densmore and Zasada 1978). The endogenous factors that influence the rooting potential of cuttings include maturity of the donor, cutting position, time of collection, pre-conditioning and size of the cutting etc (Nautiyal *et al.,* 2007; Ramesh and Khurana 2007). The exogenous factors that influence the rooting potential of cuttings include rooting medium, humidity, temperature, length of day period and the intensity of light together with other treatments. Hence, it can be said that the potential of cuttings for rooting is influenced by a variety of factors that may function individually or in combination to determine the rooting potential of cuttings. Many attempts have been made to promote the rooting potential of cuttings through different substances such as growth promoters, carbohydrates and many more (Doud and Carlson 1972; Couvillon, 1988). Among different growth promoters IBA have proved its potential by promoting the root initiation and decreased plant mortality (Soni, 1970). Because of its efficacy in wide variety of plant species and its non-toxic behaviour, IBA has turned out to be the best root-promoting chemical (Sadhu, 1999). In many tree species, IBA has been documented as rooting promoter (Gurumurti and Bandari 1988; Chandra and Verma 1989; Pal, 1992; Nautiyal and Rawat 1994). However, effectiveness varies with season, concentration, chemical nature and the mode of treatment (Nanda, 1979). Other factors such as treatment, duration, moisture tension and depth of dipping also influence rooting response of cuttings (Howard, 1972). The studies carried out about the propagation of Platanus species by cutting were particularly intensive on the species of *Platanus acerifolia* Willd. and it was stated that the factors such as genotype, type of cutting, the position of the cutting-donor shoot on the mother plant, cutting stem diameter humidity and temperature of the rooting medium, and time of collection of the cuttings influence rooting (Grolli *et al.,* 2005). However, there is limited information about the propagation of *Platanus orientalis* L. by cutting (Dirr and Heuser 2006). The aim of the present study was to standardize optimum concentration of growth hormones and to determine the best section of branches for rooting of *Platanus orientalis* L. cuttings.

MATERIALS AND METHODS

The present study was conducted in the experimental field of Division of Forest Biology and Tree Improvement, Faculty of Forestry, Benhama during the years 2018 and 2019. Cuttings of 8 inches length were prepared from different sections of branches collected from one available *Platanus orientalis* L. tree located in the vicinity of the campus on 28th of January, 2018.The collected cuttings were dumped in soil till planting on 14th of March, 2019. The cuttings were treated with different concentrations of growth hormone (IBA) before planting. The experiment was laid in polybags filled with sand, soil and FYM in the ratio of 1:2:1 as potting media. The experimental trial was laid at Faculty of Forestry, Benhama as per the details given below

(a) IBA Concentration

T_1	Control	**T_4**	3000 ppm	**T_7**	6000ppm	**T_{10}**	9000 ppm	**T_{13}**	12000ppm
T_2	1000 ppm	**T_5**	4000 ppm	**T_8**	7000 ppm	**T_{11}**	10000 ppm		
T_3	2000 ppm	**T_6**	5000 ppm	**T_9**	80000 ppm	**T_{12}**	11000 ppm		

(b) Sections of cuttings:

S_1	Apical section
S_2	Middle section
S_3	Basal section

No. of cuttings/treatment combination : 10
No. of replications : 03
Design : Completely Randomized Design (Factorial)

The growth parameters studied were rooting percent (%), root length (cm), average number of roots per plant, sprouting percent (%), shoot length (cm), collar diameter (mm), average number of branches per plant, leaf area (cm^2), above ground fresh and dry weight (g) and below ground ground fresh and dry weight (g). The data collected was analyzed using the software OP-STAT.

RESULTS AND DISCUSSION

A. Growth hormone (T)

Results in Table 1 indicated that there was significant impact of IBA on rooting and other root characters of cuttings. A comparatively higher percentage of rooting was found in IBA-treated cuttings. While the percentage of rooting under treated cuttings was lower. Maximum rooting (41.33%) was recorded for IBA@6000ppm. The maximum number of roots with substantial length was induced by this IBA treatment and thus provided a well-developed root system for better establishment of rooted cuttings. Lowest rooting (29.39%) was recorded under untreated cuttings. The reason behind this might be that the application of IBA may have increased the speed of translocation and movement of carbohydrates to the base of cuttings and consequently triggered rooting (Aminah *et al.,* 1995), as the efficiency of auxins to facilitate adventitious root development in stem cuttings is well known (Ragonezi *et al*., 2010). These results draw support from the findings of Bhattacharjee and Balakrishna (1991) in *Hiptage madhblota* and Hibiscus, Swamy *et al*. (2002) in *Grewia optiva* and *Robinia pseudoacacia*.

As shown in Table 1, the different concentrations of IBA had a considerable effect on the root characters such as length of root, average number of roots per plants and fresh and dry root biomass. All the concentrations of IBA affected root length and number of roots per plant. However, maximum root length (26.48 cm) and number of roots per plant (8.56) was recorded in IBA@6000ppm, while the minimum root length (13.07 cm) and number of roots (3.67) was recorded in Control. The reason behind this might be that the application of IBA led to the cell division and cell elongation, which promoted the root length (Abidin and Baker 1984) or may be PGRs facilitated the hydrolysis and mobilisation of sugars and nutrients to the base of cuttings (Das *et al.,* 1997). Induction of highest number of roots may be attributed to the fact that, growth regulators in many species, stimulate cambial activity involved in root initiation as confirmed in Pea by Digby and Wanerman (1965). These findings are also in agreement with the findings of Mahmood *et al.* (2017) who reported increase in root length and number of roots per plant in *Paulownia tomentosa* on application of Seradix 3.

With respect to fresh and dry biomass of root, the results revealed that among different concentrations of IBA, IBA@6000ppm recorded maximum fresh and dry biomass (15.49 g) and (5.11 g) respectively. The minimum fresh and dry biomass (6.01 g) and (1.98 g) was recorded under Control. This can be attributed to the maximum root length and number of roots per plant obtained by this concentration. These findings also draw support from the findings of Gehlot *et al*. (2014) who confirmed increase in biomass of root system on application of IBA while working on *Azadirachta indica.* Also, Hussein and Khurshid (2017) in *Olea europaea* L. reported similar findings of increase in biomass of root on application of IBA.

The impact of IBA on cuttings varied considerably with respect to above ground *i.e*., shoot characters in the present study. Shoot characters *viz*., sprouting percent, length of shoot, collar diameter, average number of branches per plants, leaf area, fresh and dry biomass of shoot are shown in Table 2. The findings showed that in terms of sprouting percent, various IBA levels differed significantly from each other. IBA@6000ppm recorded the maximum sprouting (98.89%), which was superior over all the other treatments. The lowest (72.22%) was recorded in Control. It was also found that a sharp decrease in sprouting percent of cuttings occurred at higher concentrations (beyond 7000ppm). The upsurge in sprouting percent of cuttings treated with IBA may have resulted from the stimulation of hydrolysis of nutrient reserves and their mobilization. Sprouting in control may have occurred due to the already stored carbohydrates in the cuttings. Differences in sprouting between treatments may be caused by the varying levels of auxin absorption by cuttings. Nanda *et al.* (1975) confirmed that the use of auxin contributed to the breakdown of starch into soluble sugars, and most of this was used to produce new sprouts. Pain and Roy (1981) reported substantial sprouting gains due to the use of IBA and other chemicals in *Dalbergia sisoo.* Decline in sprouting at higher concentrations of IBA may be due to super-optimal quantities.

The maximum shoot length (35.38 cm) was found in IBA@6000ppm, which was superior over all the other treatments, while the lowest (17.66 cm) was found in Control. However, IBA at higher concentration (beyond 7000ppm) reduced the shoot length. Sarkisova (1964); Chauhan and Maheshwari (1970) have also documented the ability of IBA to promote shoot growth in Vine and Peach cuttings respectively. Decrease in shoot length at higher concentrations of IBA may be attributed to the toxic or inhibitory effect of IBA at higher levels.

Significant effects of IBA have been observed on collar diameter (mm), number of branches per plant and leaf area (cm^2) of cuttings. Maximum collar diameter (6.45 mm), number of branches per plant (2.67) and leaf area (44.67 cm^2) was recorded at IBA@6000ppm, while the minimum collar diameter (4.10 mm), number of branches (1.00) and leaf area (20.62 cm^2) was recorded in Control. Zarad and Saleh (1994) confirmed that IBA may cause assistance for the development of root, which in turn leads to the absorption of elements as well as conversion of starch to soluble sugars that are transported, contributing to cell division and elongation, thereby improving the qualitative vegetative growth. These results are in conformity with the findings of Mahmood *et al.* (2017) who reported that the use of Seradix 3 enhanced the length of shoot, number of branches per plant, number of leaves per rooted cutting and collar diameter in *Paulownia tomentosa.* Moreover, Hussain *et al.* (2016) in *Ulmus villosa* and Kumar *et al.* (2017) in *Punica granatum* L. reported increase in shoot characters on application of IBA. With respect to fresh and dry biomass of shoot, the results revealed that among different concentrations of IBA, IBA@6000ppm recorded maximum fresh and dry biomass (21.56 g) and (9.43 g) respectively. The minimum fresh and dry biomass (10.07 g) and (4.52 g) respectively, was recorded under Control. This can be attributed to the maximum shoot length, collar diameter and number of branches per plant obtained by this concentration. These findings are in line with the findings of Al-Ma'athid *et al.* (2009) who reported increase in the fresh and dry weight of shoot system on application of Seradix in *Pelaryonium zonale*. Similar findings were reported by Hussein and Khurshid (2017) in *Olea europaea* and L., Mahmood *et al.* (2017) in *Paulownia tomentosa.*

B. Type of cutting section (S)

Table 3 (Fig. 1) clearly indicates that there was a significant impact of cutting section on the rooting of cuttings. Among the three types of cuttings, maximum (45.18%) rooting was recorded in basal cuttings, whereas, apical cuttings recorded the minimum rooting (26.38%). The reason behind this may be that apical cuttings are less mature, so it is easy to lose water, dry out and die (Khan *et al.,* 2006) or basal cuttings possess more natural accumulation of endogenous auxin than apical cuttings, which facilitates the initiation and development of roots (Lebrun and Roggemans 1998). These findings draw support from the findings of Ibironke (2013) who reported that basal cuttings of *Duranta repens* rooted better than apical cuttings.

Table 1: Effect of IBA on rooting and root characters of *Platanus orientalis* L. cuttings.

Character / Treatment	Rooting percent (%)	Root length (cm)	Average number of roots per plant	Fresh root biomass (g)	Dry root biomass (g)
T_1	29.39 (5.49)	13.07	3.67 (2.27)	6.01	1.98
T_2	31.67 (5.69)	14.73	4.22 (2.37)	7.14	2.35
T_3	33.39 (5.84)	17.39	5.11 (2.56)	9.01	2.97
T_4	34.94 (5.96)	17.81	5.33 (2.60)	9.31	3.07
T_5	36.00 (6.05)	20.52	6.33 (2.79)	11.24	3.71
T_6	39.56 (6.34)	24.70	7.89 (3.06)	14.22	4.95
T_7	41.33 (6.45)	26.48	8.56 (3.16)	15.49	5.11
T_8	40.22 (6.36)	24.86	7.78 (3.03)	14.33	4.47
T_9	37.33 (6.16)	22.29	6.89 (2.88)	12.50	4.12
T_{10}	35.72 (6.03)	21.01	6.44 (2.80)	11.59	3.83
T_{11}	33.94 (5.88)	20.68	6.33 (2.78)	11.35	3.75
T_{12}	32.44 (5.76)	18.27	5.33 (2.60)	9.63	3.18
T_{13}	31.61 (5.68)	15.43	4.44 (2.42)	7.61	2.51
C.D. ($P \leq 0.05$)	**0.26**	**0.69**	**0.04**	**0.49**	**0.08**

Figures in parentheses are square root transformed values

Table 2: Effect of IBA on shoot characters of *Platanus orientalis* L. cuttings.

Character / Treatment	Sprouting percent (%)	Shoot length (cm)	Collar diameter (mm)	Average number of branches per plant	Leaf area (cm^2)	Fresh shoot biomass (g)	Dry shoot biomass (g)
T_1	72.22 (8.52)	17.66	4.10	1.00 (1.58)	20.62	10.07	4.52
T_2	76.67 (8.80)	21.04	4.55	1.33 (1.68)	26.60	12.51	5.31
T_3	81.11 (9.06)	22.71	4.77	1.33 (1.68)	29.29	13.88	5.80
T_4	84.44 (9.23)	24.75	5.04	1.78 (1.81)	33.56	15.73	6.65
T_5	86.67 (9.36)	26.78	5.31	2.22 (1.92)	37.09	17.17	6.95
T_6	95.56 (9.82)	31.61	5.95	2.33 (1.95)	41.61	19.31	8.11
T_7	98.89 (9.99)	35.38	6.45	2.67 (2.04)	44.67	21.57	9.44
T_8	97.78 (9.94)	33.29	6.18	2.67 (2.04)	41.79	19.86	9.06
T_9	90.00 (9.53)	30.88	5.86	2.33 (1.95)	40.83	19.01	6.94
T_{10}	86.67 (9.36)	28.79	5.58	2.00 (1.86)	39.03	17.89	6.11
T_{11}	82.22 (9.12)	27.69	5.43	2.00 (1.86)	37.47	16.31	5.70
T_{12}	78.89 (8.93)	25.60	5.16	2.00 (1.86)	35.72	14.24	5.09
T_{13}	77.78 (8.87)	22.31	4.72	1.33 (1.68)	33.31	11.63	4.99
C.D. ($P \leq 0.05$)	**0.41**	**0.79**	**0.10**	**0.04**	**1.49**	**0.81**	**0.39**

Figures in parentheses are square root transformed value

Table 3: Effect of type of cutting section on root characters of *Platanus orientalis* L. cuttings.

Character / Cutting section	Rooting percent (%)	Root length (cm)	Average number of roots per plant	Fresh root biomass (g)	Dry root biomass (g)
S_1	26.38 (5.23)	15.73	4.56 (2.45)	7.82	2.58
S_2	34.03 (5.91)	19.05	5.74 (2.67)	10.21	3.37
S_3	45.18 (6.80)	24.59	7.77 (3.03)	14.14	4.67
C.D. (P≤0.05)	**0.12**	**0.33**	**0.09**	**0.24**	**0.16**

Figures in parentheses are square root transformed values

Table 4: Effect of type of cutting section on shoot characters of *Platanus orientalis* L. cuttings.

Character / Cutting Section	Sprouting percent (%)	Shoot length (cm)	Collar diameter (mm)	Average number of branches per plant	Leaf area(cm^2)	Fresh shoot biomass (g)	Dry shoot biomass (g)
S_1	89.67 (9.43)	21.29	4.59	1.38 (1.69)	31.45	11.68	5.33
S_2	85.38 (9.27)	25.81	5.18	1.85 (1.82)	36.03	14.92	6.25
S_3	82.31 (9.11)	33.32	6.18	2.54 (2.00)	39.04	21.67	7.96
C.D.(P≤0.05)	**0.20**	**0.38**	**0.05**	**0.02**	**0.72**	**0.37**	**0.19**

Figures in parentheses are square root transformed values

Table 5: Effect of the interaction between IBA and type of cutting section on rooting and root characters of *Platanus orientalis* L. branch cuttings.

Character	Rooting percent (%)			Root length (cm)			Average number of roots per plant			Fresh root weight (g)			Dry root weight (g)		
Cutting section / Treatment	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
T_1	24.00 (4.98)	29.33 (5.49)	34.83 (6.00)	11.33	12.92	14.96	3.00 (2.12)	3.67 (2.27)	4.33 (2.41)	4.69	6.06	7.27	1.55	2.00	2.40
T_2	24.00 (5.00)	30.67 (5.61)	40.33 (6.45)	12.54	13.77	17.87	3.33 (2.20)	4.00 (2.31)	5.33 (2.61)	5.55	6.51	9.35	1.83	2.15	3.08
T_3	26.00 (5.19)	32.00 (5.75)	42.17 (6.58)	14.95	15.73	21.48	4.33 (2.41)	4.33 (2.41)	6.67 (2.88)	7.27	7.83	11.92	2.40	2.58	3.94
T_4	27.00 (5.29)	32.00 (5.74)	45.83 (6.85)	15.44	16.04	21.96	4.33 (2.41)	4.33 (2.41)	7.00 (2.92)	7.62	8.05	12.26	2.51	2.65	4.05
T_5	27.00 (5.29)	33.33 (5.86)	47.67 (7.00)	17.10	18.56	25.89	5.00 (2.55)	6.00 (2.74)	8.00 (3.08)	8.80	9.84	15.07	2.91	3.25	4.97
T_6	30.00 (5.57)	37.33 (6.18)	51.33 (7.26)	22.14	22.37	29.61	7.00 (2.92)	7.00 (2.96)	9.67 (3.34)	12.39	12.55	17.72	4.09	4.91	5.85
T_7	29.00 (5.48)	40.00 (6.40)	55.00 (7.48)	20.14	26.88	32.42	6.33 (2.80)	8.67 (3.19)	10.67 (3.49)	10.97	15.77	19.73	3.62	5.20	6.51
T_8	28.00 (5.39)	38.33 (6.27)	54.33 (7.44)	18.53	25.64	30.41	5.67 (2.68)	8.00 (3.08)	9.67 (3.34)	9.82	14.89	18.29	3.24	4.14	6.04
T_9	27.00 (5.29)	37.33 (6.18)	47.67 (7.00)	16.80	21.22	28.83	5.00 (2.55)	6.33 (2.80)	9.33 (3.29)	8.59	11.74	17.17	2.83	3.88	5.66
T_{10}	26.67 (5.26)	34.67 (5.96)	45.83 (6.85)	14.94	20.99	27.10	4.33 (2.41)	6.33 (2.80)	8.67 (3.19)	7.26	11.57	15.93	2.40	3.82	5.26
T_{11}	25.00 (5.10)	34.67 (5.97)	42.17 (6.58)	14.57	20.92	26.55	4.00 (2.35)	6.33 (2.80)	8.67 (3.19)	7.00	11.52	15.54	2.31	3.80	5.13
T_{12}	25.00 (5.10)	32.00 (5.74)	40.33 (6.45)	13.48	17.92	23.40	3.67 (2.27)	5.33 (2.61)	7.00 (2.92)	6.22	9.38	13.29	2.05	3.09	4.39
T_{13}	24.33 (5.03)	30.67 (5.62)	39.83 (6.40)	12.46	14.64	19.21	3.33 (2.20)	4.00 (2.34)	6.00 (2.74)	5.49	7.05	10.30	1.81	2.33	3.40
C.D.(P≤0.05)	0.40			1.20			0.15			0.85			0.28		

Table 6: Effect of the interaction between IBA and type of cutting section on shoot characters of *Platanus orientalis* L. cuttings.

Character	Sprouting percent (%)			Shoot length (cm)			Collar diameter (mm)			Average number of branches per plant			Leaf area (cm^2)		
Cutting section / Treatment	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
T_1	80.00 (8.95)	73.33 (8.59)	63.33 (8.02)	15.31	17.46	20.21	3.79	4.08	4.44	1.00 (1.58)	1.00 (1.58)	1.00 (1.58)	18.22	20.23	23.41
T_2	80.00 (9.00)	76.67 (8.78)	73.33 (8.62)	17.91	19.67	25.54	4.14	4.37	5.15	1.00 (1.58)	1.00 (1.58)	2.00 (1.87)	24.56	26.61	28.63
T_3	86.67 (9.36)	80.00 (9.00)	76.67 (8.81)	19.35	20.36	28.42	4.33	4.46	5.53	1.00 (1.58)	1.00 (1.58)	2.00 (1.87)	25.64	29.53	32.71
T_4	90.00 (9.53)	80.00 (8.99)	83.33 (9.18)	21.66	22.49	30.11	4.63	4.75	5.75	1.33 (1.68)	2.00 (1.87)	2.00 (1.87)	30.74	33.41	36.53
T_5	90.00 (9.53)	83.33 (9.18)	86.67 (9.36)	22.33	24.23	33.78	4.72	4.97	6.24	1.67 (1.77)	2.00 (1.87)	3.00 (2.12)	34.68	36.71	39.88
T_6	100.00(10.05)	93.33 (9.70)	93.33 (9.71)	28.33	28.61	37.88	5.52	5.55	6.78	2.00 (1.87)	2.00 (1.87)	3.00 (2.12)	34.61	42.42	45.72
T_7	96.67 (9.88)	100.00(10.05)	100.00(10.05)	26.91	35.91	43.33	5.33	6.52	7.51	2.00 (1.87)	3.00 (2.12)	3.00 (2.12)	37.84	45.51	50.65
T_8	93.33 (9.71)	100.00(10.05)	100.00(10.05)	24.83	34.33	40.72	5.05	6.31	7.16	2.00 (1.87)	3.00 (2.12)	3.00 (2.12)	39.97	40.88	44.53
T_9	90.00 (9.53)	93.33 (9.70)	86.67 (9.36)	23.27	29.41	39.95	4.85	5.66	7.06	2.00 (1.87)	2.00 (1.87)	3.00 (2.12)	34.61	42.42	45.45
T_{10}	90.00 (9.54)	86.67 (9.35)	83.33 (9.18)	20.66	29.01	36.71	4.50	5.61	6.63	1.00 (1.58)	2.00 (1.87)	3.00 (2.12)	33.54	40.72	42.82
T_{11}	83.33 (9.18)	86.67 (9.36)	76.67 (8.81)	19.35	27.77	35.97	4.33	5.44	6.53	1.00 (1.58)	2.00 (1.87)	3.00 (2.12)	31.85	38.66	41.91
T_{12}	83.33 (9.18)	80.00 (8.99)	73.33 (8.62)	18.89	25.11	32.81	4.26	5.09	6.11	1.00 (1.58)	2.00 (1.87)	3.00 (2.12)	31.55	36.83	38.77
T_{13}	83.33 (9.18)	76.67 (8.80)	73.33 (8.62)	18.00	21.17	27.77	4.15	4.57	5.44	1.00 (1.58)	1.00 (1.58)	2.00 (1.87)	29.89	33.46	36.56
C.D.($P \leq 0.05$)	N.S			1.37			0.18			0.06			2.58		

Figures in parentheses are square root transformed values

Table 7: Effect of the interaction between IBA and type of cutting section on shoot characters of *Platanus orientalis* L. cuttings.

Character	Fresh shoot weight (g)			Dry shoot weight (g)		
Cutting section / Treatment	S_1	S_2	S_3	S_1	S_2	S_3
T_1	7.87	9.23	13.12	3.53	4.14	5.90
T_2	9.53	11.62	16.39	4.45	5.42	6.05
T_3	10.77	13.42	17.45	5.10	6.05	6.25
T_4	13.00	14.87	19.33	6.05	6.25	7.66
T_5	13.23	15.98	22.29	6.25	6.35	8.26
T_6	15.04	17.44	25.46	6.36	7.20	10.77
T_7	14.29	20.24	30.18	6.25	8.86	13.20
T_8	13.10	18.11	28.38	5.98	8.26	12.95
T_9	12.77	17.01	27.25	5.88	6.02	8.93
T_{10}	12.37	16.85	24.45	5.37	6.02	6.94
T_{11}	11.13	14.59	23.20	5.33	5.88	5.88
T_{12}	9.84	13.23	19.64	4.48	5.42	5.37
T_{13}	8.91	11.39	14.59	4.24	5.38	5.33
C.D.($P \leq 0.05$)	1.40			0.67		

Significant effects of cutting sections on the root length and number of roots per plant have been recorded. The results presented in Table 3 (Fig. 1) indicated that maximum root length (24.59 cm) and number of roots per plant (7.77) was recorded in basal cuttings, while as minimum root length (15.73 cm) and number of roots per plant (4.56) was recorded in apical cuttings. These results are consistent with the findings of Ochoa *et al.* (2002) in *Nerium oleander* L. who reported that the basal cuttings produced maximum root length and number of roots as compared to apical cuttings.

With respect to fresh and dry biomass of root, the results presented in Table 3 revealed that among three cutting sections, basal cuttings recorded maximum fresh and dry biomass (21.56 g) and (9.43 g) respectively, whereas minimum fresh and dry biomass (10.07 g) and (4.52 g) respectively was recorded for apical cuttings. This can be attributed to the maximum root length and number of roots per plant gained by this cutting section (Al- Bebewat, 2011). These results are in conformity with the findings of Zalensy *et al.* (2011) in Populus and Mahmood *et al*. (2017) in *Paulwonia tomentosa.* The results in Table 4 clearly indicate that maximum sprouting (89.67%) was recorded for apical cuttings, whereas basal cuttings recorded minimum sprouting (82.31%). These findings are in line with the findings of Ali *et al.* (2008) who reported that apical cuttings of *Berberis aristata* DC gave higher sprouting as compared to middle and basal cuttings. The results presented in Table 4 indicated that basal cuttings recorded maximum shoot length (33.32 cm) (Fig. 1), collar diameter (6.18 mm), average number of branches per plants (2.54) and leaf area (39.04 cm^2) respectively. Minimum values for shoot length (21.29 cm), collar diameter (4.59 mm), average number of branches per plants (1.38) and leaf area (31.45 cm^2) was recorded for apical cuttings. This might be attributed to the fact that different types of cuttings, which differed from one another in the amount of storage nutrient substrates, basal cuttings contain more storage nutrient substrates than intermediate and apical cuttings which contribute to cell division and elongation, leading to the growth and improvement in shoot characters. These results are in line with the findings of Ibironke (2013) in *Duranta repens* and Kumar *et al.*(2017) in *Punica granatum.*

Fig. 1. Comparative shoot and root lengths of different cutting sections.

Results regarding the biomass presented in Table 4 revealed that among three cutting sections, basal cuttings recorded maximum fresh and dry biomass (21.67 g) and (7.96 g) respectively, whereas minimum fresh and dry biomass (11.68 g) and (5.33 g) respectively was recorded for apical cuttings. This can be attributed to the maximum shoot length, collar diameter, average number of branches per plants and leaf area gained by this cutting section (Al- Bebewat, 2011). These findings draw support from the findings of Zalensy *et al*. (2011); Populus and Kumar *et al*. (2017) in *Punica granatum*.

C. Interaction between growth hormone and type of cutting section (T × S)

As indicated in Table 5, maximum rooting (55.00%) was recorded in S_3T_7 (basal × 6000ppm), while the minimum rooting (24.00 %) was recorded in S_1T_1 (apical cutting without any treatment). Interaction between cutting section and IBA concentration was found to be significant. Also, maximum root length (32.42 cm) was recorded in S_3T_7 (basal × 6000ppm), while the minimum (11.33 cm) was recorded in S_1T_1 (apical cutting without any treatment). Also, maximum average number of roots per plant (10.67) was recorded in S_3T_7 (basal × 6000ppm), while the minimum (3.00) was recorded in S_1T_1 (apical cutting without any treatment). Interactions between cutting sections and IBA concentrations were found to be significant. With regard to root biomass, maximum fresh biomass of root (19.73g) was recorded in S_3T7 (basal × 6000ppm), while the minimum (4.69g) was recorded in S_1T1 (apical cutting without any treatment). For dry biomass of root, maximum dry biomass of root (6.51 g) was recorded in S_3T_7 (basal × 6000ppm), while the minimum (1.55 g) was recorded in S_1T_1 (apical cutting without any treatment). Interaction between cutting section and IBA concentration was found to be significant as evident from Table 5. As evident from Table 6, interaction between cutting section and IBA concentration was found to be non- significant. However, maximum sprouting percent (100.00) was recorded in S_1T_6 (apical cutting × 6000ppm), S_2T_7 (middle × 7000ppm) and S_3T_7 (basal × 6000ppm), while the minimum sprouting (63.33) was recorded in S_3T_1 (basal cutting without any treatment). Also, maximum shoot length (43.33 cm) was recorded in S_3T_7 (basal × 6000ppm), while the minimum (15.31 cm) was recorded in S_1T_1 (apical cutting without any treatment). Maximum collar diameter (7.51 mm) was recorded in S_3T_7 (basal × 6000ppm), while the minimum (3.79 mm) was recorded in S_1T_1 (apical cutting without any treatment). Interactions between cutting sections and IBA concentrations were found to be significant. Also, maximum average number of branches (3.00) was recorded in S_3T_7 (basal × 6000ppm), S_3T_8 (basal × 7000ppm), S_2T_7 (middle × 6000ppm) and S_2T_8 (middle× 7000ppm), while the minimum (1.00) was recorded in S_1T_1 (apical cutting without any treatment), S_1T_2 (apical × 1000ppm), S_2T_1 (middle cutting without any treatment), S_3T_1 (basal cutting without any treatment) and S_2T_2 (middle× 1000ppm). Also, maximum leaf area (50.65 cm^2) was recorded in S_3T_7 (basal × 6000ppm), while the minimum (18.22 cm^2) was recorded in S_1T_1 (apical cutting without any treatment). Maximum collar diameter (7.51 mm) was recorded in S_3T_7 (basal × 6000ppm), while the minimum (3.79 mm) was recorded in S_1T_1 (apical cutting without any treatment), interactions between cutting sections and IBA concentrations were found to be significant. From Table 7, it is evident that maximum fresh biomass of shoot (30.18 g) was recorded in S_3T_7 (basal × 6000ppm), while the minimum (7.87 g) was recorded in S_1T_1 (apical cutting without any treatment). Also, maximum dry biomass of shoot (13.20 g) was recorded in S_3T_7 (basal × 6000ppm), while the minimum (3.53 g) was recorded in

S_1T_1 (apical cutting without any treatment), interaction between cutting section and IBA concentration being significant.

CONCLUSIONS

The current study is the first of its kind in which effect of different concentrations of growth hormone and types of cutting sections on rooting ability of *Platanus orientalis* L. branch cuttings has been conducted. The best concentration of auxin for vegetative propagation of *Platanus orientalis* L. is IBA@6000ppm since it greatly improved all growth parameters recorded as compared to control. IBA@6000ppm was most effective for rooting of *Platanus orientalis* L. cuttings. The best section of cutting for vegetative propagation of *Platanus orientalis* L.is basal as it performed better in all characters recorded than apical and middle section of cuttings. In order to gain maximum rooting, a combination of IBA@6000ppm and basal cuttings should be used.

FUTURE SCOPE

Platanus orientalis L. are very difficult to propogate asexually, using this study genetic makeup of superior plants can be propagated easily on vast programme.

Acknowledgement. The authors wish to express their gratitude to the scientists of Division of FBT, SKUAST-K for facilitating the use of equipment and for technical help.
Conflict of Interest. None.

REFERENCES

Abidin, M. and Baker, A. (1984). Effect of growth substance on rooting of cocoa cuttings. *Acta Horticulturae, 137,* 95-102.

Al-Bebewat, G. B. A. (2001). Effect of cutting type, planting depth and NPK fertilizer on growth of Oriental plan tree (*Platanus orientalis* L.) sapling in Sumel-Duhok. *M.Sc. Thesis*, University of Duhok. Duhok. Iraq.

Ali, Y. H. and El-Tigani, S. (2003). Vegetative Propagation of *Acacia senegal* (Willd.) by Stem Cuttings. *Sudan Silva, 9*(2), 36-34.

Ali, M., Malik, A. R. and Sharma, K. R. (2008). Vegetative propagation of *Berberis aristata* DC. An endangered Himalayan shrub. Journal of *Medicinal Plant Research, 2*(12), 374-377.

Al-Ma'athid, A. F., Angam, A. K. and Adeeb, J. A. (2009). Influence of medium culture and treated cutting with Seradix root cutting of *Pelargonium zonale*. *Tikrit Journal for Agriculture Sciences, 9*(2), 226-235.

Aminah, H., Dick, J. M., Leakey, R., Grace, J. and Smith, R. (1995). Effect of indole butyric acid (IBA) on stem cuttings of *Shorea leprosula*. *Forest Ecology and Management, 72*(2), 199–206

Anonymous (2008). IUCN Red List of Threatened species. www.iucnredlist.org cited on March 02, 2008.

Bhattacharjee, S. K. and Balakrishna, M. (1991). Studies on propagation of ornamental trees through stem cuttings. *Indian Journal of Horticulture, 48* (1), 87-94.

Chandra, J. P and Verma, S. D. (1989). Rootability of softwood cuttings of individual mother trees of Eucalyptus. *Proceedings of Seminar on Vegetative Propagation*, held on Coimbator, India, 27 to 28 July.

Chauhan, K. S. and Maheshwari, L. D. (1970). Effect of certain plant growth regulators, season and types of the cuttings on root initiation and vegetative growth in stem cutting of Peach var. Sharbati. *Indian Journal of Horticulture, 27,* 136-40.

Couvillon, G. A. (1988). Rooting responses to different treatments. In: International *Symposium on Vegetative Propagation of Woody Species, 227*, 187-196.

Dar, S. A. and Wani, A. B. (2017c). Plant secondary metabolites. In Book INSECT. International Research Publication House; B-2/84, Ground Floor, Rohini Sector-16, Delhi-110089, Chapter: 20, pp: 236-264

Das, P., Basak, U. C. and Das, A. B. (1997). Metabolic changes during rooting in pre-girdled stem cuttings and air-layering of *Heritiera*. *Botanical Bulletin of Academia Sinica, 38*(2), 91-95.

Densmore, R. and Zasada, J. C. (1978). Rooting potential of Alaskan Willow cuttings. *Canadian Journal of Forest Research, 8*(4), 477-479.

Digby, J. and Wanerman, E. (1965). A note on the effect of shoot and root apex secondary thickening in pea radical. *New Phytoharmones, 46,* 168-170.

Dirr, A. M. and Heuser, C. W. (2006). The Reference Manual of Woody Plant Propagation: From Seed to Tissue Culture. Varsity Press, Inc. North Carolina, (USA), p. 417.

Doud, S. L. and Carlson, R. F. (1972). Propagation methods of fruit tree cultivars from hardwood cuttings. *Horticultural Abstracts, 43*(7), 4178.

Gehlot, A., Gupta, R. K., Arya, I. D., Arya, S. and Tripath, A. (2014). Vegetative propagation of *Azadirachta indica*: effect of auxin and rooting media on adventitious root induction in minicuttings. *Advances in Forestry Science, 1* (1), 1-9.

Grolli, P.R., Morini, S. and Loreti, F (2005). Propagation of *Platanus acerifolia* Willd. by cutting. *Journal of Horticulture Science and Biotechnology, 80*(6), 705-710.

Guoqiang, F., Jianping, J., Yaoqing, H. and Feng, L. (2003). In vitro efficient plant regeneration with *Platanus orientalis* L. leaves as explants. *Acta Horticulturae Sinica, 30*(2), 236-238.

Gurumurti, K. and Bhandari, H. S. (1988). Induction of rooting in cladode cuttings of *Casuarina equistifoli*. *Current Science, 57*(3), 1-2.

Howard, B. H. (1972). Factors affecting the rooting response of plants to growth regulator application. In: Symposium *on growth Regulators in Fruit Production, 34*, 93-106.

Hussein, B. A. and Khurshid, Y. G. M. (2017). Effect of Different Concentrations of IBA on Rooting Ability and Shooting in Olive (*Olea europaea* L., cv. Dgel) Cuttings. In *International Conference and Workshop on Basic and Applied Sciences*.

Hussian, A., Wani, S., Lone, A., Mir, Z. A., Malik, Z. A. and Jaan, N. (2016). Distribution pattern, population density and conservation by vegetative propagation of *Ulmus villosa* in temperate conductions of Kashmir. *International Quarterly Journal of Life Science, 11*(4), 2471-2474.

Ibironke, O. A. (2013). The effect of cutting types and length on rooting of *Duranta repens* in the nursery. *Global Journal of Human Social Science, 13*(3), 1-5.

Khan, M. S., Khan, R. U. and Waseem, K. (2006). Effect of some auxin on growth of damask rose cutting in different cutting media. *Journal of Agriculture and Social Sci*ences, *2*(1), 13-16.

Kozgar, I. and Khan, S. (2011). Fiery Chinar. *Science Reporter*. pp. 54-55.

Kumar, K., Tanuja, D. K. and Chandra, D. N. (2017). Influence of different concentrations of IBA on the shooting and rooting of hardwood cuttings of pomegranate (*Punica granatum* L.) cv. Ganesh under valley condition of Garhwal Himalaya. *Plant Archives, 17*(1), 375-379.

Lebrun, A. and Roggemans, J. (1998). Description of *Syzygium paniculatum* Gaertn: Verlaine and propagation by stem cuttings. *Scientia Horticulture, 75,* 103-111.

Longman, K. A and Jenik, J. J. (1990). Tropical Forest and its Environment (2^{nd} Ed.) Co Published in the United States with John Wiley and sons Inc., New York. Pp 51-56.

Mahmood, K. A., Ali, O. O. and Rahman, N. M. A. (2017). Effect of cutting type and Seradix 3 on the rooting percentage and some characteristics of produced Paulwonia's saplings *Paulwonia tomentosa*. *Tikrit Journal for Agricultural Sciences, 17* (3), 1-10.

Nanda, K. K. (1979). Adventitious root formation in stem cuttings in relation to hormones and nutrition. In: S.S.Bir, Ed. Recent researches in plant sciences. pp. 461-492.

Nanda, K. K., Gurumurti, K. and Chibber, R. N. (1975). An-evidence for the allosteric nature of IAA oxidase system in *Phaseolus mungo* hypocotyls. *Experimentia, 31,* 635.

Nautiyal, S. and Rawat, M. S. (1994). Macropropagation of teak (*Tectona grandis* L.). *Indian Forester, 120*(2), 146-151.

Nautiyal, S., Nautiyal, D. P., Bhandari, H. C. S., Kumar, P. and Prakash, R. (2007). Mass propagation protocol for *Podocarpus nerifolius* D. Don. through juvenile shoot cuttings. *Indian Forester, 133*(2), 262-265.

Ochoa, J., Bañon, S., Fernández, J. A., González, A. and Franco, J. A. (2002). Influence of cutting position and rooting media on rhizogenesis in oleander cuttings. In: International *Symposium on The Horizons of Using Organic Matter and Substrates in Horticulture.* pp. 101-106.

Pain, S. K. and Roy, B. K. (1981). A comparative study of the root forming effect of IAA, IBA and NAA on the stem cuttings of *Dalbergia sissoo* Roxb. *Indian Forester, 107*(3), 151-154.

Pal, M. (1992). Clonal propagation for yield improvement in forest plantations. *Indian Pulp & Paper Technical Association, 4,* 61-64.

Pilloti, M., Brunneti, A., Tizzani, L. and Marrani, O. (2009). *Platanus acerifolia* genotypes surviving to inoculation with *Ceratocystis platani* (the agent of cancer stain): first screening and molecular characterization. *Euphytica, 169*(1), 1-17.

Ragonezi, C., Klimaszewska, K., Castro, M. R., Lima, M., de Oliveira, P. and Zavattieri, M.A. (2010). Adventitious rooting of conifers: influence of physical and chemical factors. *Trees*24(6):975–992.

Ramesh, K. R. and Khurana, D. K. (2007). Standardization of vegetative propagation techniques for rooting of *Populus alba* Linn. Cuttings. *Indian Forester*, 133(4), 464-474.

Sadhu, M. K. (1999). Plant propagation. New Age Internantional,New Delhi. 287p.

Sarkisova, M. M. (1964). The effect of growth substances on the root formation in vine cutting. *Horticultural Abstracts, 35*, 625-635.

Sert, S., Kutahyali, C., Inan, S., Talip, Z., Cetinkaya, B. and Eral, M. (2008). Biosorption of lanthanum and cerium from aqueous solutions by *Platanus orientalis* L. leaf powder. *Hydrometallurgy, 90*(1), 13-18.

Soni, S. L. (1970). Use of growth regulator in horticulture. *Farmers and Parliament, 5*(2), 7.

Swamy, S. L., Puri, S. and Singh, A. K. (2002). Effect of auxin (IBA and NAA) and season on rooting of Juvenile and mature hardwood cutting of *Robinia psudoacacia* and *Grewia optiva.New Forests, 23*(2), 143- 157.

Wadoo, M. (2007). *The Trees of Our Heritage*, pp. 54-58.

Zalensy, R. S., Hall, R. B., Bauer, E. O. and Riemenschneider, D. E. (2003). Shoot position affects root initiation and growth of dormant unrooted cuttings of Populus. *Silvae Genetica, 52* (3), 273-279.

Zarad, S. S. and Saleh, M. A. (1994). Response of coffee stem cutting to different auxin treatment in Spring and Fall season. *Annals of Forest Research, 39* (2), 771-780.

Zencirkiran, M. (2010). Determination of native woody landscape plants in Bursa and Uludag. *African Journal of Biotechnology, 8*(21), 5737-5746.

Zencirkiran, M. and Erken, K. (2012). The effect of different times collecting cutting and auxin treatments of the rooting in *Platanus orientalis* L. *The Journal of Animal and Plant Sciences, 22*(3), 764-767.

Zsuffa, L, Anderson, H. W. and Jaciw, P. (1997). Trends and Prospects in Ontario's poplar plantation management. *Forestry Chronicle, 53*(4), 195-220.

How to cite this article: Midhat Bilal, Parvez Ahmad Khan, Ashfaq Ahmad Mir, Nageena Nazir, Amir Bashir Wani, Sajad Ahmad Gangoo, Immad Ahmad Shah and Asnain Khateeb (2024). Effect of various Concentrations of Growth Hormone (IBA) and Types of Cutting Sections on Rooting and Growth of *Platanus orientalis* L. Branch Cuttings. *Biological Forum – An International Journal, 16*(7): 44-52.