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Effect of NAA and IAA on Stem Cuttings of *Dalbergia Sissoo* (Roxb)

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Abstract

The plant cuttings is one of the most common methods of vegetative reproduction which is, today, used extensively due to low cost. In order to study the effect of various concentrations of Naphthalene acetic acid (NAA) and Indole acetic acid (IAA) on the rooting of semi-hardwood cuttings of *Dalbergia sissoo* , an experiment was carried out in a private field in Koya city in 2014. In this research, the treatments were prepared to include hormone of Naphthalene acetic acid in four levels of: (0, 100, 300 and 500 ppm) and Indole acetic acid in four levels of: (0, 100, 300 and 500 ppm), and the bottom part of the cutting was dipped into above solutions for 30 seconds. The results showed that the maximum percentage of the shooted cuttings, shoot length, number of main branch, diameter of main branch, leaf area, number & length of root, dry weight & biomass &dry matter of shoot, fresh &dry weight of root, biomass &dry matter of root and chlorophyll a belonged to IAA treatment with concentration of 500 ppm, NAA treatment with concentration of 500 ppm. Nitrogen and protein increased with concentration 300 ppm for IAA amd NAA auxins. The highest length of root belonged to IAA treatment with concentration of 500 ppm. All growth parameters were increased up to the highest concentrations of IAA 500 ppm. IAA was the most effective in promoting growth of *Dalbergia sissoo* cuttings.

Keywords: Naphthalene acetic acid (NAA), Indole acetic acid (IAA), Rooting, Vegetative propagation, Stem cuttings, *Dalbergia sissoo.*

1. Introduction

Shisham *Dalbergia sissoo* (Roxb.) belongs to family Fabaceae, sub-family Faboideae (Saha *et al*., 2013 and Bhattacharya, *et al*., 2014). It growths along river banks below 900 meters elevation, but can range naturally up to 1500 m above sea level. The temperature in its native range averages10 – 40 ℃ but varies from just below freezing to nearly 50 ℃. It can withstand average annual rainfall up to 2000 millimeters and droughts 3 – 4 months. (Dhakal, 2008; Keshta, 2011; Shaltout and Lal and Singh, 2012 and Bharath,*et al*.,2013). *D. sissoo is* one of the most common multipurpose species with value for its timber. Wood is used for fuel and charcoal source, and the wood oil is used as a lubricant for heavy machinery. Leaves, young shoots and green pods, are an important source of fodder. *D. sissoo* is widely used in urban and roadside plantings for the habit of developing root suckers and runners make it useful for erosion control. These shade-loving crops also benefit from improved soil fertility under *D. sissoo. D. sissoo* plants are one of the important sources of medicines. The roots contain tectoridin, which is used medicinally (Orwa, *et al.*, 2009; Shaltout and Keshta, 2011 and Lal and Singh, 2012).

Vegetative propagation is extensively used in agriculture, horticulture and forestry for multiplying elite plants selected from natural populations or obtained in breeding programs .The formation of adventitious roots is an essential step in vegetative propagation and therefore if cuttings do not form roots, losses occur. Researchers developed new rooting treatments, examining the effects of plant growth regulators, by a short exposure to a solution with a high auxin concentration. The formation of adventitious roots is a process induced and regulated by environmental and endogenous factors, such as temperature, light, hormones (especially auxin), sugars, mineral salts and other molecules.(Pop, *et al*.,2011) .

Stem cuttings are the most important cutting types that based on the nature of the wood is used for making cuttings, are divided to four groups: hardwood, semi-hard wood cuttings, softwood and herbal cuttings. The chemical composition of upper and lower cuttings of a plant is different. It has been observed the changes in production of root in the cuttings of different part of shoot. In many cases, the highest root has been produced in the cuttings which have been made from lower parts of the shoot but in some species that soft wood cuttings are used, the upper shoots have better rooting. Probably the rooting ingredients have more concentration in the buds and also cell differentiation in lower cutting is less. Although different components such as CO, Acetylene and Ethylene have been used for rooting of stem cuttings but commercial derivations of Auxin such as IAA and NAA have much influence on rooting of cuttings.(Rahbin,et al.,2012).

Auxins are a class of plant growth substance (often called phytohormone or plant hormone). Auxins play an essential role in coordination of many growth and behavioral processes in the plant life cycle, they and the behavior they played in plant growth. They were the first of the major plant hormones to be discovered and are a major coordinating signal in plant development. Knowing IAA and NAA and chemical analogues synthesized and examined for auxin-like activity. Auxin enters cuttings mostly via the cut surface. Role of some auxins, indol-3-acitic acid (IAA) and naphthalene acetic acid (NAA) has been examined for their stimulatory effects on adventitious root formation in stem cuttings of *D.sissoo* as well as on subsequent growth and survival of these cutting raised plantlets, commonly applied to stimulate root growth when taking cuttings of plants. However, high concentrations of auxin inhibit root elongation and instead enhance adventitious root formation. Removal of the root tip can lead to inhibition of secondary root formation.It induces shoot apical dominance; the axillary buds are inhibited by auxin. When the apex of the plant is removed, the inhibitory effect is removed and the growth of lateral buds is enhanced as a high concentration of auxin directly stimulates ethylene synthesis in lateral buds causes inhibition of its growth and potentiation of apical dominance.(Kenney *et al.*, 1969; Pop, *et al*.,2011 and Gehlot,*et al*.,2014).

2. Materials and Methods

An experiment was conducted in a private field in Koya city located at 44^{o}38 E, 36 ^{o}4N and 570 m of altitude above sea level, at *D.sissoo* trees aged about 10 years. A factorial experiment using randomized complete block design (R.C.B.D.) with three replications was conducted to study the combination effect of two auxin NAA (naphthalene acetic acid) and IAA (indole-3-acetic acid) with four concentrations (0, 100, 300 and 500 ppm), denoted as (C_0, C_1, C_2 and C_3). Stem cuttings without lateral shoots by removing leaves and leaving intact leaf buds in each cutting. The cuttings were selected for this study and putting the stem cutting in water until planting time.

Auxin solutions were prepared by dissolving each of 0.1 g of NAA in 1ml of acetone and completed to 100 ml by (50 ml ethanol and 50 ml distilled water). Also dissolving 0.1 g of IAA with 5 drop of ethanol in 100 ml distilled water to obtain concentrations (0, 100, 300 and 500 ppm). 30 cm long stem cutting with 1 cm diameter were treated by dipping their basal 3.0 cm portions for 30 second, control cuttings were dipped in distilled water. The treated carried out in the late evening to avoiding auxin reaction. After treating the cuttings were planted vertically in polythene bags sized 10x10x 30 cm containing sandy clayey soil at 9 March 2014. The cuttings were watered regularly when needed.

2.1 Meteorological Data

Maximum and Minimum temperature, the relative humidity and the amount of rain fall in the open field during the planting season are shown in table (1), as recorded by Agro-Meteorological Station in Koya city.

Table 1. Maximum and minimum temperature, the relative humidity and the amount of rain fall during the growing season (2014).

Month (2014)	Air Temp. C^o		Relative Humidity%		Rain fall (mm)
	Maximum	Minimum	Maximum	Minimum	
March	19.4	11.7	70.6	61	141.0
April	24.6	15.1	57.4	47.2	30.3
May	32.9	22.4	39.0	30.6	3.9
June	37.6	26.6	32.3	26.7	0
July	40.6	29.8	34.6	23.9	0
August	42.5	29.5	27.9	22.2	0
September	36.0	24.5	32.9	25.2	0.1

2.2 At 20 September 2014 the following Characteristics were Studies

2.2.1 Vegetative Growth Included

Shooting percentage, Shoot length, Number of main and sub branches. cutting^{-1} , Root length and Number roots per cutting were measured as it mentioned in Abdul,2009, Diameter of main branches was measured by vernier caliper, Leaf area (cm^2.cutting^{-1}) was measured by planometer instrument, Fresh & dry weight of shoots, Fresh & dry weight of roots and Dry matter of shoots and roots were measured as it mentioned in Al-Sahaf 1989, Biomass of shoots and roots were measured as it mentioned in Godbold, *et al*.(1988).

2.2.2 Chemical analysis of Leaves Included

Chlorophylls and carotene content were measured by (Tang, 2004), Total nitrogen was measured by kjeldahl method as (Allen, *et al.*, 1974)), Total protein was measured as it mentioned in Dalaly and Al-Hakim, 1987; Total potassium was measured by Flame photometer as (Kalra, 1998).

Number, length and width of stomata in upper and lower leaves surface and type of stomata were measured as it mentioned in Rai and Mishra, 2013.

2.2.3 Statistical Analysis

Comparisons between means were made by using Duncan's Multiple Range test at 5% level (Reza, 2006). The statistical analysis was carried out by using SAS Program (2000).

3. Result and Discussions

3.1 Effect of different concentrations of (NAA and IAA) on shoot percentage and some vegetative growth characteristics of D. sissoo stem cuttings.

Results in table (2 and 3) shows the significant difference of different auxin on the survive percentage of stem cuttings (shoot percentage), number of main branches, diameter of main branches, root length, number of main roots, leaf area, fresh and dry weight of shoot, fresh and dry weight of root, dry matter of shoot and root, biomass of shoot and root especially in IAA as compare to NAA. Auxin with different concentrations and their interactions shows significant effects on these parameters. The highest value was obtained from IAA with 500 ppm, while the lowest value was obtained from control, except shoot length, number of sub-branches which recorded high values in 300 ppm of NAA and IAA as compared with control treatment. The adventitious root formation is regulated by optimal environmental conditions (cutting origin and environment) to achieve good rooting; optimal morphological and physiological condition of the cutting material, which in turn, affected by stockplant physiology and management (Dick et al. 2004; Leakey 2004).

It appears from the results there were significant differences between different concentration of NAA and IAA on survival percentage and vegetative growth of stem cuttings, the highest value was recorded in IAA, while, the lowest value was recorded in NAA. The application of auxins to induce root formation on leafy stem cuttings is widely recognized (Leakey et al. 1990; Husen 2003; Husen et al. 2003; Husen and Pal 2006, 2007a). IAA was superior to stem cutting in stimulating the morphological growth.Tables (2 and 3) showed that IAA increased all growth parameters significantly compared to the NAA, this effect may be attributed to the physical and chemical properties of the plant. The results agree with Khan, *et al*., 2006 ; Pandey, *et al.*, 2011; Singh, *et al.*,2012; Parvaiz,*et al*,2013; Gehlot,*et al*., 2014 and Mohana, *et al.*,2014). Because auxins coordinate development at all levels in plants, from the cellular level to organs and ultimately the whole plant. The plant cell wall is made up of cellulose, protein, and, in many cases, lignin. It is very firm and to growth, affecting both cell division and cellular expansion. Depending on the specific tissue, auxin may promote axial elongation (as in shoots), lateral expansion (as in root swelling). In some cases (coleoptile growth) auxin-promoted cellular expansion occurs in the absence of cell division. In other cases, auxin-promoted cell division and cell expansion may be closely sequenced within the same tissue (root initiation). (Taiz and Zeiger ,1998).The widely used sources of growth hormones for cuttings rooting are the NAA, IAA and commercialization root promoters (root-growing powders). The successful formation of adventitious roots is an obligatory prevents any sudden expansion of cell volume and without contribution of auxins any expansion at all. On the cellular level, auxin is essential for cell phase of vegetative propagation in many woody plants; this being related the presence of auxin. IAA was the first used to stimulate rooting of cuttings was discovered and was considered even more effective (Cooper, 1935).

Table 2. Effect of type of auxin treatment and different concentrations and their interactions on survival shoot percentage and some vegetative growth characteristics of *Dalbergia sissoo* stem cuttings.

Type of auxin	Shoot Percentage(%)	Shoot length(cm)	Number of main-branches	Number of sub-branches	Diameter of main branches(mm)	Leaf area $cm^{2-}cuttings^{-1}$	Number of main root per cuttings	Root length of cuttings(cm)
Control	22.220 c	18.000 c	1.5000 b	1.7333 b	1.7333 b	5.2567 b	1.0000 c	13.5000 c
NAA	38.888 b	28.500 b	2.7500 a	2.0033 b	2.0033 b	5.5442 b	2.0000 b	15.8958 b
IAA	55.557 a	36.153 a	2.7917 a	3.5433 a	3.5433 a	6.7633 a	2.3750 a	20.7500 a
Concentrations ppm								
0	22.220 b	18.000 c	1.5000 c	5.0000 c	1.7333 b	5.2567 b	1.0000 d	13.5000 c
100	37.036 ab	30.333 ab	2.1667 b	8.0000 b	2.1533 b	5.2656 b	1.5000 c	16.3333 b
300	44.444 a	32.500 a	2.7222 a	10.6667 a	2.8811 a	6.1789 a	2.0000 b	17.5000 b
500	51.852 a	29.371 b	3.0000 a	7.5000 b	2.9389 a	6.7178 a	2.6667 a	19.5278 a
Interaction between NAA & IAA								
Control 0	22.22 d	18.000 d	1.5000 c	5.000 d	1.7333 c	5.2567 cd	1.0000 f	13.500 e
Control 100	33.33 cd	18.000 d	1.5000 c	5.000 d	1.7333 c	5.2567 cd	1.0000 f	13.500 e
Control 300	44.44 cd	18.000 d	1.5000 c	5.000 d	1.7333 c	5.2567 cd	1.0000 f	13.500 e
Control 500	55.56 abc	18.000 d	1.5000 c	5.000 d	1.7333 c	5.2567 cd	1.0000 f	13.500 e
NAA 0	22.22 d	18.000 d	1.5000 c	5.000 d	1.7333 c	5.2567 cd	1.0000 f	13.500 e
NAA 100	33.33 cd	30.000 c	2.5000 b	7.500 c	1.4767 c	4.6900 d	1.5000 e	14.500 e
NAA 300	44.44 bcd	38.500 b	3.5000 a	14.500 a	2.2200 bc	5.7300 cd	2.5000 c	17.000 d
NAA 500	55.56 abc	27.500 c	3.5000 a	8.500 c	2.5833 bc	6.5000 bc	3.0000 b	18.583 cd
IAA 0	22.22 d	18.000 d	1.5000 c	5.000 d	1.7333 c	5.2567 cd	1.0000 f	13.500 e
IAA 100	55.56 abc	43.000 a	2.5000 b	11.500 b	3.2500 b	5.8500 bc	2.0000 d	21.000 bc
IAA 300	66.67 ab	41.000 ab	3.1667 ab	12.500 ab	4.6900 a	7.5500 ab	2.5000 c	22.000 b
IAA 500	77.78 a	42.613 ab	4.0000 a	9.000 c	4.5000 a	8.3967 a	4.0000 a	26.500 a

* Means with the same letter or letters are different not significantly ($P \leq 0.05$).

Table 3. Effect of type of auxin treatment and different concentrations and their interactions on fresh and dry weight shoot & root, dry matter shoot & root and biomass shoot & root of *D. sissoo* stem cuttings.

Type of auxin	Fresh weight of shoot (g)	Dry weight of shoot (g)	Dry matter of shoot (%)	Biomass of shoot(g)	Fresh weight of root (g)	Dry weight of root (g)	Dry matter of root (%)	Biomass of root (g)
Control	19.2150 b	9.1000 b	47.267 a	3.0300 b	0.52667 c	0.31667 c	59.880 b	0.106667 c
NAA	36.2250 a	13.8075 a	39.253 b	4.6008 a	0.7367 b	0.50000 b	67.518 a	0.168333 b
IAA	37.0100 a	13.6900 a	38.552 b	4.5633 a	1.34250 a	0.55917 a	45.144 c	0.187500 a
Concentration ppm								
0	19.2150 c	9.1000 c	47.267 a	3.0300 c	052667c	0.31667 b	59.880 a	0.106667 b
100	26.1900 b	9.9733 c	39.353 bc	3.3233 c	0.87889 b	0.49667 a	60.119 a	0.166667 a
300	38.1167 a	13.6567 b	38.052 c	4.5511 b	0.98444 ab	0.49778 a	57.812 a	0.167778 a
500	39.7450 a	16.0667 a	42.089 b	5.3544 a	1.07778 a	0.52333 a	52.244 b	0.175556 a
Interaction between NAA & IAA								
Control 0	19.215 e	9.100 d	47.267 a	3.0300 d	0.52667 e	0.31667 e	59.880 b	0.10667 e
Control 100	19.215 e	9.100 d	47.267 a	3.0300 d	0.52667 e	0.31667 e	59.880 b	0.10667 e
Control 300	19.215 e	9.100 d	47.267 a	3.0300 d	0.52667 e	0.31667 e	59.880 b	0.10667 e
Control 500	19.215 e	9.100 d	47.267 a	3.0300 d	0.52667 e	0.31667 e	59.880 b	0.10667 e
NAA 0	19.215 e	9.100 d	47.267 a	3.0300 d	0.5267 e	0.31667 e	59.880 b	0.10667 e
NAA 100	20.775 e	7.570 d	36.410 b	2.5200 d	0.7500 d	0.55667 bcd	73.893 a	0.18667 bcd
NAA 300	46.910 b	17.330 b	36.847 b	5.7767 b	0.8000 d	0.65000 b	81.250 a	0.22000 b
NAA 500	58.000 a	21.230 a	36.487 b	7.0767 a	0.8500 d	0.47667 d	55.047 b	0.16000 d
IAA 0	19.215 e	9.100 d	47.267 a	3.0300 d	0.5267 e	0.31667 e	59.880 b	0.10667 e
IAA 100	38.580 d	13.250 c	34.383 bc	4.4200 c	1.3600 c	0.61667 bc	46.583 c	0.20667 bc
IAA 300	48.225 b	14.540 c	30.043 c	4.8467 c	1.6267 b	0.52667 cd	32.307d	0.17667 cd
IAA 500	42.020 c	17.870 b	42.513 a	5.9567 b	1.8567 a	0.77667 a	41.807 c	0.26000 a

* Means with the same letter or letters are different not significantly ($P \leq 0.05$).

3.2 Effect of different concentrations of NAA and IAA on chemical characteristics and nutrient content and some stomata characteristics of Dalbergia sissoo stem cuttings leaves.

The result shown in table (4) explains that the different concentration and level application of auxin were affected significantly on chlorophyll a, total nitrogen and total protein of stem cuttings leaves, while the interaction between then affected significantly chlorophyll a, total nitrogen and total protein The highest values were recorded from each of IAA and NAA with 300 and 500 ppm.While the lowest value was recorded from control. These results also shows non significant effect of different concentration auxin with NAA and IAA and their interactions on chlorophyll b, total chlorophyll and total carotenoid of leaf content.

To produce genetically superior trees, vegetative propagation is one of the more successful techniques in many economically important tree species, including *D. sissoo.* Auxins coordinate development at all levels in plants, from the cellular level to organs and ultimately the whole plant. It is evident that rooting of stem cuttings of *D. sissoo* depends upon a number of factors , such as age of plants, type of cuttings, season of planting, size of cuttings and planting media. Several investigators reported that a number of extemal factors such as season, temperature, light, water, humidity, aeration, composition and pH of rooting media and internal factors, i.e., nutrients, genetic constitution, exogenously applied rooting co-factors and hormones, affect rooting behavior of a species. The present investigation reveals that length of cuttings significantly ($p < 0.05$) affected the rooting of *D. sissoo* stem cuttings. The 25- and 30-cm-long cuttings gave the best performance in terms of rooting as well as in other parameters studied (Puri S, Verma R C. 1996. And Singh, *et al*., 2011). This species can survive at sites where nitrogen levels are low and also on saline and alkaline soils. It is widely adaptable, drought resistant, hard and has nitrogen fixing properties. *D. sissoo* is arapidly disappearing species due to indiscriminate removal. (Singh,*et al*.,2012). These results agree partially with Parvaiz,*et al*,2013 and Gehlot,*et al*., 2014 who confirm that auxin increased vegetative growth .

Plant development is modulated by genetic and environmental factors, which have effects on auxin biosynthesis, metabolism, transport, and signaling pathway. Adventitious roots can arise naturally from stem tissue under stressful environmental conditions; they may also be induced by mechanical damage or following tissue culture regeneration of shoots. They are postembryonic roots which arise from the stem and leaves and from nonpericycle tissues in old roots. There are at least two pathways by which adventitious roots form: by direct organogenesis from established cell types such as the cambium or from callus tissue following mechanical damage (e.g. cuttings). Auxins were the first of the major plant hormones to be discovered and are a major coordinating signal in plant development. Their pattern of active transport through the plant is complex. They typically act in concert with (or opposition to) other plant hormones. Phytohormones have direct (involved in cell division or cell growth) or indirect (interacting with other hormones or molecules) effects on plants. (Kenney *et al.*, 1969 and Taiz and Zeiger ,1998). Auxin metabolism studies on adventitious rooting have been done on cuttings exposed for a prolonged period to auxin, but in other studies cuttings have been exposed to auxin for short periods) an optimal auxin concentration for one of the three phases may be supraoptimal or suboptimal for the next. (Liu and Reid, 1992 and Diaz-Sala *et al.*, 1996). Throughout the plant's life, auxin helps the plant maintain the polarity of growth and recognize where it has its branches (or any organ) connected. The plant hormone stimulates cell elongation. It stimulates the wall loosening factors, for example, elastins, to loosen the cell walls.It participates in phototropism, geotropism, hydrotropism and other developmental changes. The uneven distribution of auxin, due to environmental cues (for example, unidirectional light and gravity force), results in uneven plant tissue growth. It also induces sugar and mineral accumulation at the site of application. It induces formation and organization of phloem and xylem. When the plant is wounded, the auxin may induce the cell differentiation and regeneration of the vascular tissues. In a living plant it appears that auxins and other plant hormones nearly always interact to determine patterns of plant development. Growth auxin effects in intact plants, and is the most potent native auxin.(Taiz and Zeiger ,1998).

3.3 Effect on some Stomata Characteristics

On examining the stomata structure in *Dalbergia sissoo* stem cuttings leaves, we saw that type of stomata were paracytic type. Both adaxial(upper) and abaxial(lower) epidermis have stomata. The anatomical study (table 5) indicated to non significant differences between different concentration, auxin with NAA and IAA and their interaction on each of who says that stomata number on lower surface is more than stomata number on upper surface. These results agree with Artik (2005) who says that stomata number on lower surface is more than stomata number on upper surface. These results also agree with Ricciardi, *et al.* (1986) who mentioned that stomata characteristics like number, length and width is affected by genetic constitution , season, leaf position and leaf surface (upper or lower).

Table 4. Effect of type of auxin treatment and different concentration and their interactions on chemical characteristics and nutrient concentration of *D. sissoo* leaves.

Type of auxin	Chlorophyll a	Chlorophyll b	Total chlorophyll	Total Carotenoids	Total nitrogen %	Total protein %	Total potassium%
	mg/100g wet weight						
Control	5.9500 b	6.8100 a	12.773 a	1.6833 a	0.210000 d	1.32667 c	37.083 a
NAA	6.3858 b	6.5200 a	12.921 a	1.7375 a	0.272500 a	1.70667 a	46.396 a
IAA	7.5667 a	6.8317 a	14.413 a	2.0425 a	0.253333 b	1.58500 b	49.646 a
Concentration ppm							
0	5.9500 a	6.8100 a	12.773 a	1.8300 a	0.210000 d	1.32667 d	37.083 a
100	6.7289 a	6.9978 a	13.741 a	1.9800 a	0.235556 c	1.47778 c	42.028 a
300	6.8633 a	6.5456 a	13.423 a	1.8533 a	0.280000 a	1.75000 a	47.694 a
500	6.9944 a	6.5289 a	13.538 a	1.6211 a	0.255556 a	1.60333 b	50.694 a
Interaction between NAA & IAA							
Control 0	5.9500 b	6.810 a	12.773 a	1.6833 a	0.21000 f	1.32667 f	37.083 a
Control 100	5.9500 b	6.810 a	12.773 a	1.6833 a	0.21000 f	1.32667 f	37.083 a
Control 300	5.9500 b	6.810 a	12.773 a	1.6833 a	0.21000 f	1.32667 f	37.083 a
Control 500	5.9500 b	6.810 a	12.773 a	1.6833 a	0.21000 f	1.32667 f	37.083 a
NAA 0	5.9500 b	6.810 a	12.773 a	1.6833 a	0.21000 f	1.32667 f	37.083 a
NAA 100	6.3767 ab	7.013 a	13.407 a	1.8767 a	0.23000 ef	1.45000 ef	36.500 a
NAA 300	6.6333 ab	6.010 a	12.660 a	1.7067 a	0.34333 a	2.14333 a	55.500 a
NAA 500	6.5833 ab	6.247 a	12.843 a	1.6833 a	0.30667 b	1.90667 b	56.500 a
IAA 0	5.9500 b	6.810 a	12.773 a	2.1233 a	0.21000 f	1.32667 f	37.080 a
IAA 100	7.8600 ab	7.170 a	15.043 a	2.3800 a	0.26667cd	1.65667 cd	52.500 a
IAA 300	8.0067 ab	6.817 a	14.837 a	2.1700 a	0.28667 bc	1.78000 bc	50.500 a
IAA 500	8.4500 a	6.530 a	14.997 a	1.4967 a	0.25000 de	1.57667 de	58.500 a

* Means with the same letter or letters are different not significantly ($P \leq 0.05$).

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Table 5. Effect of type of auxin treatment and different concentration and their interactions on some stomata characteristics on upper & lower leave surfaces of *D.sissoo*.

Type of auxin	**Stomata number /mm²**		**Stomata length (μm)**		**Stomata width (μm)**	
	Upper leaf surface	**Lower leaf surface**	**Upper leaf surface**	**Lower leaf surface**	**Upper leaf surface**	**Lower leaf surface**
Control	80.000 b	327.00 b	29.6000 b	24.0000 b	17.2000 b	14.800 b
NAA	87.250 ab	472.00 a	31.9000 a	26.5000 a	18.1000 ab	19.600 a
IAA	94.083 a	494.25 a	30.1000 b	25.6000 ab	18.5000 a	16.200 ab
Concentration ppm						
0	80.000 b	327.00 c	29.6000 b	24.000 b	17.2000 b	14.800 b
100	87.000 ab	435.00 b	30.4000 ab	26.933 a	17.7333 b	19.600 a
300	87.222 ab	470.00 ab	30.4000 ab	24.400 b	17.0667 b	15.733 ab
500	94.222 a	492.33 a	31.7333 a	26.133 ab	19.7333 a	17.333 ab
Interaction between NAA & IAA						
Control 0	80.000 b	327.00 c	29.600 b	24.000 b	17.200 c	14.800 b
Control 100	80.000 b	327.00 c	29.600 b	24.000 b	17.200 c	14.800 b
Control 300	80.000 b	327.00 c	29.600 b	24.000 b	17.200 c	14.800 b
Control 500	80.000 b	327.00 c	29.600 b	24.000 b	17.200 c	14.800 b
NAA 0	80.000 b	327.00 c	29.600 b	24.000 b	17.200 c	14.800 b
NAA 100	86.000 ab	454.00 b	32.000 ab	30.800 a	18.400 bc	27.600 a
NAA 300	85.000 ab	548.00 a	32.000 ab	25.200 b	16.800 c	17.600 b
NAA 500	98.000 ab	559.00 a	34.000 a	26.00 b	20.000 ab	18.400 b
IAA 0	80.000 b	327.00 c	29.600 b	24.000 b	17.200 c	14.800 b
IAA 100	95.000 ab	524.00 ab	29.600 b	26.000 b	17.600 c	16.400 b
IAA 300	96.667 ab	535.00 a	29.600 b	24.000 b	17.200 c	14.800 b
IAA 500	104.667 a	591.00 a	31.600 ab	28.400 ab	22.000 a	18.800 b

* Means with the same letter or letters are different not significantly ($P \leq 0.05$).

4. Conclusions

Application of both growth regulators IAA and NAA had a significant effect on the growth and development parameters of *D.sissoo*. IAA had more strong beneficial effect than NAA on root growth and development. The effective levels of IAA was 500 ppm, all growth parameter were increased up to the highest concentration of IAA (500 ppm).

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