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Physiological Basis of Propagation studies in Commercially Important Difficult to Root Ornamental Shrub *Thuja orientais*

Aishwarya Kundargi[1], Sateesh R. Patil[1], S. G. Gollagi[2]*, B. C. Patil and G. K. Seetharamu

[1]*Department of Floriculture and Landscape Architecture, Kittur Rani Chanamma College of Horticulture, Arabhavi, University of Horticultural Sciences Bagalkot, India*
[2]*Department of Crop Physiology, College of Horticulture Bagalkot, India*

**Corresponding author*

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A B S T R A C T

Among different types of cutting, tip cuttings showed early sprouting, highest number of sprouts per cutting per cutting and length of longest sprout. Subsequently, highest number of primary roots per cutting, secondary roots and length of longest root were found with same type of cutting. Among different levels of IBA, IBA at 4000 ppm resulted in early sprouting, maximum number of sprouts per cutting per cutting and length of longest sprout. Subsequently, highest number of primary roots per cutting, secondary roots and length of longest root were found with same treatment. Among two different media used soil + sand + cocopeat + VAM media recorded early sprouting, maximum number of sprouts per cutting per cutting and length of longest sprout. Subsequently, highest number of primary roots per cutting, secondary roots and length of longest root were found with same treatment.

Introduction

Vegetative propagation understands the propagation of plant which is produced with the aid of some parts drawed from vegetative organs of plant, so named cuttings. The specimens obtained by that way conserve the biomorphological characters and the heredity peculiarities of the species. For that reason, vegetative propagation found a large implementation in modern horticulture with a view of producing decorative planting material (Leakey *et al.*, 1990).

Thuja orientalis, commonly known as white cedar or arborvitae or northern white cedar, a member of Cupressaceae family, is native to North America. In ornamental arrangements it

is usually found as shrub reaching up to 12-20 m height. The trees are characteristically coniferous and monoecious, have a pyramid-shaped with monopodial branchings to the trunk, which is erect with a reddish-brown cortex. The branches are flattened, short, horizontals and covered with small rigid leaves, which overlap one another. The leaves are oval-shaped, persistent, green in color with scales crossing from opposite sides. *T. orientalis* is widely used as an ornamental tree, particularly for screens and hedges, in gardens, parks and cemeteries. *Thuja* plants are planted in parks and gardens, due to its decorative aspect and can be easily modeled into different and desired shapes. Occasionally *Thuja* shrubs are propagated through seeds, but can also be easily propagated using vegetative methods, the most common being heel cuttings (Posta and Hernea, 2008).

Materials and Methods

Preparation of rooting hormone solution

A 4000 ppm IBA solution was prepared by dissolving one gram of IBA in little quantity of 0.1 N NaOH solution, simultaneously 250 g of talc powder paste is made by adding 250 ml of water and IBA solution and later the paste was allowed to dry. After drying it was powdered and sieved. Similarly 1000, 2000 and 3000 ppm powder was prepared by taking 0.25 g, 0.5 g and 0.75 g of IBA respectively.

Treating cuttings and planting

The method adopted for treating of cuttings with rooting hormone powder, in which, the basal end of the prepared cuttings were kept standing in powder of rooting hormone to a depth of 2.5-3.0 cm. Twenty five cuttings for each treatment were treated with the rooting hormone and repeated thrice in Completely Randomized Design with Factorial concept. The treated cuttings were planted in portrays containing growing media soil + sand + cocopeat and soil + sand + cocopeat + VAM (the VAM culture used in the study is *Acualospors laevis*) and placed under mist house as per the treatment. Watering was given through misters for two minutes at an interval of 30 minutes.

Results and Discussion

Effect of type of cutting

Shoot characters

Type of cuttings showed prominent influence on various shoot characters. Minimum days for sprouting (13.87 days) and number of sprouts per cutting (11.34) was observed in tip cuttings. This might be due to active leaf is necessary to provide energy for the growth of stem cuttings, as there is little reserves in the stem Reuveni and Raviv (1980). Similar reports on shoot characters were also noted by Soga *et al.* (2018) in *Thuja orientalis* and Chowdhuri *et al*. (2017) in Cape jasmine.

Root characters

Number of primary roots per cutting (4.06) and rooting percentage (51.00%) was significantly influenced by type of cuttings. As rooting is stimulated by high levels of available carbohydrates provided by the leaves. The findings were in accordance with Griffin *et al.* (1998) in *Thuja orientalis* and Chowdhuri *et al*. (2017) in Cape jasmine.

Effect of rooting hormone

Shoot characters

The result observed that minimum days taken to sprouting (13.47 days) and highest number of sprouts per cutting (10.53) was significantly noted with 4000 ppm IBA

application. This might be due to early rooting and favorable environment showed different response based on concentration of plant growth regulators, *viz*. IBA 4000 ppm was found best optimum concentration for root initiation. Similar reports on sprouting of roots were also noted by Deshmukh and Barad (2002) in Bougainvillea and (Singh *et al.,* 2009) in Guggal.

Root characters

Among the different IBA treatment, 4000 ppm IBA was the most effective as it enhanced the maximum number of primary (4.87) and rooting (51.33%). The better rooting and root growth with auxin might be ascribed due to greater metabolic activity and maximum utilization of sugar and starch after hydrolysis from stem has been experimentally substantiated by various researcher like Hirapara *et al.* (2007) in Jasmine and Torkashv and Shadparvar (2011) in Hibiscus.

Effect of growing media

Shoot characters

Among two growing media, minimum days for sprouting (15.03 days) and highest number of sprouts per cutting (7.71) was recorded in soil + sand + cocopeat + VAM. This might be due to Arbuscular mycorrhizal fungi are well known to improve the nutritional status and thereby aid in increased growth of plants. Similar findings were noticed by Bhatti *et al.* (2013) in Carnation.

Root characters

Soil + sand + cocopeat + VAM media recorded significantly highest number of primary roots per cutting (3.64) and rooting (38.57%) which was primarily due to correlation of root parameters with mycorrhizal inoculation amount of root is probably related to suitable ventilation of soil that is the result of hypha network of mycorrhizal fungi that connects particles of soil and as result the rootspreads into deep soil and produce more of roots. Similar reports were noted by Davies (1987) in Rose and Kerur and Lakshman (2009) in Carnation.

Interaction effect of type of cuttings and rooting hormone

Shoot characters

Application of 4000 ppm of IBA to tip cuttings resulted in minimum days taken for sprout initiation (11.60 days) and highest number of sprouts per cutting (15.56). This may be due to greater stability and low mobility of IBA which induces all growth responses. These results came in conformity with the findings of Parmar *et al.* (2010) in Bougainvillea and Shadparvar *et al.* (2011) in Hibiscus.

Root characters

Highest number of primary roots per cutting (5.70) and rooting per cent (66.00%) was observed in tip cuttings with application of 4000 ppm of IBA. The initiation and development of roots on stem cuttings is controlled by complex ecophysiological and biochemical processes, as well as anatomical factors and exogenous application of IBA helps in enhancing these factors as well mobilize sucrose or its derivative to the site of root formation. The results were in agreement with Shirol *et al.* (1992) in Poinsettia.

Interaction effect of type of cuttings and growing media

Shoot characters

Significantly minimum days taken for sprout intiation (13.45 days) was noticed in tip

cuttings planted in soil + sand + cocopeat + VAM media which was due to mycorrhizal fungi can enhance qualification and quantification characteristics in cuttings. This was in accordance with the reports of Bhatti *et al.* (2012) in Carnation and Bidarnamani and Mohkami (2014) in Rosemary.

Root characters

From the data it is evident that highest number of primary roots per cutting (4.16) and rooting (52.80) were observed in tip cuttings planted in soil + sand + cocopeat + VAM media which was due to mycorrhizal fungi can enhance qualification and quantification characteristics in cuttings. This was in conformity with the results of Bhatti *et al.* (2012) in Carnation and (Bidarnamani and Mohkami, 2014) in Rosemary.

Interaction effect of rooting hormone and growing media

Shoot characters

Minimum days taken for sprout initiation (13.00 days) and highest number of sprouts per cutting (10.73) was found in cuttings planted in soil + sand + cocopeat + VAM treated with 4000 ppm of IBA this might be due to mycorrhizal fungi has symbiotic association and improves the growth of plants through enhanced uptake of macro and micronutrient as well as improves plant resistance against biotic and abiotic stress. Similar findings were reported by Amri (2015) in *Dalbergia melanoxylon* and Adams *et al.* (2018) in *Thuja orientalis.*

Root characters

Highest number of primary roots per cutting (5.02) and rooting (53.33%) was seen soil + sand + cocopeat + VAM treated with 4000 ppm of IBA this might be due to IBA assist the colonization of a host (mycorrhiza fungi) by increasing the number of lateral roots as preferred colonization sites for the fungi during early growth development. Similar results were also obtained by Amri (2015) in *Dalbergia melanoxylon* and Adams *et al.* (2018) in *Thuja orientalis*.

Interaction effect of type of cutting, rooting hormone and growing media

Shoot characters

Minimum days taken for sprout initiation (11.13 days) and number of sprouts per cutting (15.93) was found in tip cuttings planted in soil + sand + cocopeat + VAM treated with 4000 ppm of IBA this is due to interaction effect enhance the utilization of carbohydrates at the base of cuttings through creation of sink and better utilization of photosynthesis and enhance uptake of nutrients leading to early growth. The results were in accordance with Parmar *et al*. (2010) in Bougainvillea; Abidin and Metali (2015) in Martelli Shrub and Adams *et al.* (2018) in *Thuja orientalis.*

Root characters

Highest number of primary roots per cutting (5.80) and rooting (68.00%) was found in tip cuttings planted in soil + sand + cocopeat + VAM treated with 4000 ppm of IBA this is due to mycorrhizal fungi influence on rooting ability of auxin treated stem cuttings. The results were in conformity with Bidarnamani and Mohkami (2014) in Rosemary; and Bhattacharjee and Balakrishana (1992) in *Hamelia patens*.

Based on the results of the present investigation, it can be concluded that tip cutting is most effective for rooting of cuttings whereas, 4000 ppm IBA is the most effective for rooting of cuttings. Soil + sand + cocopeat + VAM media is more beneficial for rooting of cuttings of *Thuja orientalis*.

Table.1 Days taken for sprout initiation as influenced by type of cuttings and rooting hormone and their interaction effect in *Thuja orientalis*

Type of cutting	Rooting hormone (ppm)					Mean
	T_0 (control)	T_1 (1000)	T_2 (2000)	T_3 (3000)	T_4 (4000)	
C_1 –Tip	15.73	15.20	14.03	12.80	11.60	**13.87**
C_2 -Semi hardwood	16.86	16.50	14.76	14.50	13.66	**15.26**
C_3 -Hardwood	19.30	18.16	16.96	16.16	15.16	**17.15**
Mean	**17.30**	**16.62**	**15.25**	**14.48**	**13.47**	
Sources	**S.Em±**			**C.D (5%)**		
C	0.02			0.06		
T	0.02			0.07		
C×T	0.04			0.13		

Table.2 Days taken for sprout initiation as influenced by type of cuttings and growing media and their interaction effect in *Thuja orientalis*

Type of cutting	Growing media		Mean
	M_1 (Soil + Sand +Cocopeat)	M_2 (Soil + Sand + Cocopeat +VAM)	
C_1 –Tip	14.29	13.45	**13.87**
C_2 -Semi hardwood	15.69	14.82	**15.26**
C_3 –Hardwood	17.49	16.81	**17.15**
Mean	**15.82**	**15.03**	
Sources	**S.Em±**	**C.D (5%)**	
C	0.02	0.06	
M	0.02	0.06	
C×M	0.03	0.09	

Table.3 Days taken for sprout initiation as influenced by rooting hormone and growing media and their interaction effect in *Thuja orientalis*

Rooting hormone (ppm)	Growing media		Mean
	M_1 (Soil + Sand Cocopeat)	M_2 (Soil + Sand +Cocopeat+VAM)	
T_0 (control)	17.64	16.95	**17.30**
T_1 (1000)	17.06	16.17	**16.62**
T_2 (2000)	15.57	14.93	**15.25**
T_3 (3000)	14.88	14.08	**14.48**
T_4 (4000)	13.95	13.00	**13.47**
Mean	**15.82**	**15.03**	
Sources	**S.Em±**	**C.D (5%)**	
T	0.02	0.07	
M	0.02	0.06	
T×M	0.04	0.12	

Table.4 Interaction effect of type of cutting, rooting hormone and growing media on days taken for sprout initiation in *Thuja orientalis*

	M_1 (Soil + Sand + Cocopeat)					**M_2 (Soil + Sand + Cocopeat + VAM)**				
	T_0 (control)	**T_1 (1000 ppm)**	**T_2 (2000 ppm)**	**T_3 (3000ppm)**	**T_4 (4000 ppm)**	**T_0 (control)**	**T_1 (1000 ppm)**	**T_2 (2000 ppm)**	**T_3 (3000 ppm)**	**T_4 (4000 ppm)**
C_1	16.13	15.73	14.26	13.26	12.06	15.33	14.66	13.80	12.33	11.13
C_2	17.13	16.86	15.26	14.93	14.26	16.60	16.13	14.26	14.06	13.06
C_3	19.66	18.60	17.20	16.46	15.53	18.93	17.73	16.73	15.86	14.80
Sources	**S.Em±**					**C.D (5%)**				
C×T×M	0.06					0.18				

C_1 : Tip cutting; **C_2:** Semi hardwood cutting; **C_3:** Hardwood cutting

Table.5 Number of sprouts as influenced by type of cutting and rooting hormone and their interaction effect in *Thuja orientalis*

Type of cutting	Rooting hormone (ppm)															Mean		
	T_0 (control)			T_1 (1000)			T_2 (2000)			T_3 (3000)			T_4 (4000)					
	60 DAP	90 DAP	120 DAP	60 DAP	90 DAP	120 DAP	60 DAP	90 DAP	120 DAP	60 DAP	90 DAP	120 DAP	60 DAP	90 DAP	120 DAP	60 DAP	90 DAP	120 DAP
C_1	0.70	1.50	2.30	1.33	2.30	3.36	2.20	3.06	4.20	3.29	4.30	5.00	3.83	4.56	5.23	**2.27**	**3.14**	**4.01**
C_2	0.60	1.30	1.90	1.30	2.00	2.60	2.30	3.20	4.13	2.66	3.73	4.46	3.16	4.00	4.94	**2.00**	**2.84**	**3.61**
C_3	0.50	1.10	1.60	1.00	1.50	2.20	1.63	2.46	3.30	2.30	3.46	4.20	2.90	3.90	4.63	**1.66**	**2.48**	**3.19**
Mean	**0.60**	**1.30**	**1.93**	**1.21**	**1.93**	**2.72**	**2.04**	**2.91**	**3.87**	**2.75**	**3.83**	**4.55**	**3.30**	**4.15**	**4.93**			
Sources					**S.Em±**									**C.D (5%)**				
	60 DAP			90 DAP			120 DAP			60 DAP			90 DAP			120 DAP		
C	0.009			0.009			0.01			0.02			0.03			0.04		
T	0.01			0.01			0.02			0.03			0.03			0.06		
C×T	0.02			0.02			0.03			0.05			0.06			0.10		

C_1 : Tip cuttings; **C_2 :** Semi hardwood cutting; **C_3** Hardwood cutting

Table.6 Number of sprouts as influenced by type of cutting and growing media and their interaction effect in *Thuja orientalis*

Type of cutting	Growing media								
	M_1 (Soil + Sand + Cocopeat)			M_2 (Soil + Sand + Cocopeat + VAM)			Mean		
	60 DAP	90 DAP	120 DAP	60 DAP	90 DAP	120 DAP	60 DAP	90 DAP	120 DAP
C_1–Tip	2.05	2.97	3.86	2.50	3.32	4.16	**2.27**	**3.14**	**4.01**
C_2 -Semi hardwood	1.90	2.75	3.48	2.10	2.92	3.74	**2.00**	**2.84**	**3.61**
C_3-Hardwood	1.53	2.29	3.02	1.80	2.66	3.36	**1.66**	**2.48**	**3.19**
Mean	**1.83**	**2.68**	**3.45**	**2.13**	**2.95**	**3.75**			
Sources	**S.Em±**			**C.D (5%)**					
	60 DAP	90 DAP	120 DAP	60 DAP	90 DAP	120 DAP			
C	0.009	0.009	0.01	0.02	0.03	0.04			
M	0.007	0.008	0.01	0.02	0.02	0.04			
C×M	0.01	0.01	0.02	0.03					

Table.7 Number of sprouts as influenced by rooting hormone and growing media and their interaction effect in *Thuja orientalis*

Rooting hormone (ppm)	Growing media								
	M_1 (Soil + Sand + Cocopeat)			M_2 (Soil + Sand + Cocopeat +VAM)			Mean		
	60 DAP	90 DAP	120 DAP	60 DAP	90 DAP	120 DAP	60 DAP	90 DAP	120 DAP
T_0 (control)	0.46	1.20	1.82	0.73	1.40	2.14	**0.60**	**1.30**	**1.93**
T_1 (1000)	1.06	1.80	2.53	1.35	2.06	2.91	**1.21**	**1.93**	**2.72**
T_2 (2000)	1.88	2.73	3.68	2.20	3.08	4.00	**2.04**	**2.91**	**3.87**
T_3 (3000)	2.53	3.60	4.39	2.98	4.06	4.59	**2.75**	**3.83**	**4.55**
T_4 (4000)	3.20	4.11	4.82	3.40	4.19	5.10	**3.30**	**4.15**	**4.93**
Mean	**1.83**	**2.68**	**3.45**	**2.13**	**2.95**	**3.75**			

Sources	S.Em±			C.D (5%)		
	60 DAP	90 DAP	120 DAP	60 DAP	90 DAP	120 DAP
T	0.01	0.01	0.02	0.03	0.03	0.06
M	0.007	0.008	0.01	0.02	0.02	0.03
T×M	0.01	0.01	0.03	0.03	0.03	0.09

Table.8 Interaction effect of type of cutting, rooting hormone and growing media on number of sprouts in *Thuja orientalis* at 60 DAP

	M_1 (Soil + Sand + Cocopeat)					M_2 (Soil + Sand + Cocopeat + VAM)				
	T_0 (control)	T_1 (1000 ppm)	T_2 (2000 ppm)	T_3 (3000 ppm)	T_4 (4000 ppm)	T_0 (control)	T_1 (1000 ppm)	T_2 (2000 ppm)	T_3 (3000 ppm)	T_4 (4000 ppm)
C_1	0.60	1.20	2.00	2.80	3.67	0.80	1.47	2.40	3.00	4.00
C_2	0.53	1.20	2.20	2.60	3.13	0.80	1.40	2.40	2.73	3.20
C_3	0.40	0.80	1.47	2.20	2.80	0.60	1.20	1.80	2.40	3.00
Sources	**S.Em±**					**C.D (5%)**				
C×T×M	0.02					0.07				

C_1 : Tip cuttings; C_2 : Semi hardwood cutting; C_3 Hardwood cutting

Table.9 Interaction effect of type of cutting, rooting hormone and growing media on number of sprouts in *Thuja orientalis* at 90 DAP

	M_1 (Soil + Sand + Cocopeat)					**M_2 (Soil + Sand + Cocopeat + VAM)**				
	T_0 (control)	**T_1 (1000 ppm)**	**T_2 (2000 ppm)**	**T_3 (3000 ppm)**	**T_4 (4000 ppm)**	**T_0 (control)**	**T_1 (1000 ppm)**	**T_2 (2000 ppm)**	**T_3 (3000 ppm)**	**T_4 (4000 ppm)**
C_1	1.40	2.20	2.87	3.80	4.33	1.60	2.40	3.27	4.00	4.80
C_2	1.20	1.80	3.00	3.60	4.20	1.40	2.20	3.40	3.87	4.40
C_3	1.00	1.40	2.33	3.40	3.80	1.20	1.60	2.60	3.53	4.00
Sources	**S.Em±**					**C.D (5%)**				
C×T×M	0.07					0.21				

Table.10 Interaction effect of type of cutting, rooting hormone and growing media on number of sprouts in *Thuja orientalis* at 120 DAP

	M_1 (Soil + Sand + Cocopeat)					**M_2 (Soil + Sand + Cocopeat + VAM)**				
	T_0 (control)	**T_1 (1000 ppm)**	**T_2 (2000 ppm)**	**T_3 (3000 ppm)**	**T_4 (4000 ppm)**	**T_0 (control)**	**T_1 (1000 ppm)**	**T_2 (2000 ppm)**	**T_3 (3000 ppm)**	**T_4 (4000 ppm)**
C_1	3.53	4.07	4.53	5.23	6.33	3.80	4.27	4.87	5.73	6.93
C_2	2.20	3.20	4.27	5.13	5.80	2.60	3.73	4.73	5.47	6.00
C_3	3.33	4.00	4.20	5.14	5.93	3.73	4.20	4.73	5.60	6.20
Sources	**S.Em±**					**C.D (5%)**				
C×T×M	0.03					0.09				

C_1 : Tip cuttings; **C_2 :** Semi hardwood cutting; **C_3** Hardwood cutting

Table.11 Number of primary roots as influenced by type of cutting and rooting hormone and their interaction effect in *Thuja orientalis*

Type of cutting	Rooting hormone (ppm)					Mean
	T_0 (control)	T_1 (1000)	T_2 (2000)	T_3 (3000)	T_4 (4000)	
C_1 –Tip	2.30	3.10	4.10	5.10	5.70	**4.06**
C_2 -Semi hardwood	2.06	2.90	3.53	3.93	4.56	**3.40**
C_3 -Hardwood	1.50	2.30	3.53	3.90	4.36	**3.12**
Mean	**1.95**	**2.76**	**3.72**	**4.31**	**4.87**	
Sources	**S.Em±**			**C.D (5%)**		
C	0.01			0.03		
T	0.01			0.03		
C×T	0.02			0.06		

Table.12 Number of primary roots as influenced by type of cutting and growing media and their interaction effect in *Thuja orientalis*

Type of cutting	Growing media		
	M_1 (Soil+Sand+Cocopeat)	M_2 (Soil + Sand +Cocopeat+VAM)	Mean
C_1 –Tip	3.96	4.16	**4.06**
C_2 –Semi hardwood	3.26	3.53	**3.40**
C_3 -Hardwood	3.00	3.24	**3.12**
Mean	**3.40**	**3.64**	
Sources	**S.Em±**	**C.D (5%)**	
C	0.01	0.03	
M	0.008	0.02	
C×M	0.01	NS	

Table.13 Number of primary roots as influenced by rooting hormone and growing media and their interaction effect in *Thuja orientalis*

Rooting hormone (ppm)	Growing media		
	M_1 (Soil+Sand+Cocopeat)	M_2 (Soil + Sand +Cocopeat+VAM)	Mean
T_0 (control)	1.84	2.06	**1.95**
T_1 (1000)	2.66	2.86	**2.76**
T_2 (2000)	3.60	3.84	**3.72**
T_3 (3000)	4.22	4.40	**4.31**
T_4 (4000)	4.71	5.02	**4.87**
Mean	**3.40**	**3.64**	
Sources	**S.Em±**	**C.D (5%)**	
T	0.01	0.03	
M	0.008	0.02	
T×M	0.02	0.05	

Table.14 Interaction effect of type of cutting, rooting hormone and growing media on number of primary roots in *Thuja orientalis*

	(Soil + Sand + Cocopeat)					**M_2 (Soil + Sand + Cocopeat + VAM)**				
	T_0 (control)	**T_1)0111 ppp(**	**T_2 (2000 ppm)**	**T_3 (3000 ppm)**	**T_4 (4000 ppm)**	**T_0 (control)**	**T_1 (1000 ppm)**	**T_2 (2000 ppm)**	**T_3 (3000 ppm)**	**T_4 (4000 ppm)**
C_1	2.20	3.00	4.00	5.00	5.60	2.40	3.20	4.20	5.20	5.80
C_2	1.93	2.80	3.53	3.86	4.33	2.20	3.00	3.66	4.20	4.80
C_3	1.40	2.20	3.40	3.80	4.20	1.60	2.40	3.46	4.00	4.53
Sources	**S.Em±**					**C.D (5%)**				
C×T×M	0.03					0.09				

C_1 : Tip cutting; **C_2:** Semi hardwood cutting; **C_3:** Hardwood cutting

Table.15 Rooting percentage (%) as influenced by type of cuttings and rooting hormone and their interaction effect in *Thuja orientalis*

Type of cutting	Rooting hormone					Mean
	T_0 (control)	T_1 (1000)	T_2 (2000)	T_3 (3000)	T_4 (4000)	
C_1–Tip	30.00 (33.18)	46.00 (42.68)	54.00 (47.27)	59.00 (50.16)	66.00 (54.31)	**51.00 (45.52)**
C_2-Semi hardwood	16.33 (23.79)	24.00 (29.32)	30.33 (33.39)	38.00 (38.03)	46.00 (42.68)	**31.80 (33.34)**
C_3-Hardwood	15.66 (23.27)	22.00 (27.93)	29.66 (32.97)	34.00 (35.64)	42.00 (40.37)	**28.80 (32.14)**
Mean	**20.66(26.75)**	**30.66(33.31)**	**38.00(37.88)**	**43.66(41.28)**	**51.33(45.79)**	
Sources	**S.Em±**			**C.D (5%)**		
C	0.08			0.22		
T	0.09			0.28		
C×T	0.17			0.48		

Table.16 Rooting percentage (%) as influenced by type of cuttings and growing media and their interaction effect in Thuja orientalis

Type of cutting	Growing media		
	M_1 (Soil+Sand+Cocopeat)	M_2 (Soil+Sand+Cocopeat+VAM)	Mean
C_1–Tip	49.20 (44.45)	52.80 (46.59)	**51.00 (45.52)**
C_2-Semi hardwood	30.66 (33.36)	32.26 (34.27)	**31.80 (33.34)**
C_3–Hardwood	26.93 (30.92)	29.33 (32.40)	**28.80 (32.14)**
Mean	**35.15 (35.93)**	**38.57 (38.08)**	
Sources	**S.Em±**	**C.D (5%)**	
C	0.08	0.22	
M	0.06	0.17	
C×M	0.11	0.31	

Table.17 Rooting percentage (%) as influenced by rooting hormone and growing media and their interaction effect in Thuja orientalis

Rooting hormone (ppm)	Growing media		
	M_1 (Soil+Sand+Cocopeat)	M_2 (Soil+Sand+Cocopeat+VAM)	Mean
T_0 (control)	18.88 (25.46)	22.44 (28.03)	**20.66 (26.75)**
T_1 (1000)	29.33 (32.47)	32.00 (34.16)	**30.66 (33.31)**
T_2 (2000)	36.22 (36.80)	39.77 (38.96)	**38.00 (37.88)**
T_3 (3000)	42.00 (40.29)	45.33 (42.27)	**43.66 (41.28)**
T_4 (4000)	49.33 (44.62)	53.33 (46.96)	**51.33 (45.79)**
Mean	**35.15 (35.93)**	**38.57 (38.08)**	
Sources	**S.Em±**	**C.D (5%)**	
T	0.09	0.28	
M	0.06	0.17	
T×M	0.14	0.39	

Values in parenthesis indicates arc sine transformation)

Table.18 Interaction effect of type of cutting, rooting hormone and growing media on rooting percentage (%) in *Thuja orientalis*

	M_1 (Soil + Sand + Cocopeat)					**M_2 (Soil + Sand + Cocopeat + VAM)**				
	T_0 (control)	**T_1 (1000 ppm)**	**T_2 (2000 ppm)**	**T_3 (3000 ppm)**	**T_4 (4000 ppm)**	**T_0 (control)**	**T_1 (1000 ppm)**	**T_2 (2000 ppm)**	**T_3 (3000 ppm)**	**T_4 (4000 ppm)**
C 1	28.00 (31.9)	44.00 (41.53)	52.00 (46.12)	58.00 (49.58)	64.00 (53.10)	32.00 (34.43)	48.00 (43.83)	56.00 (48.42)	60.00 (50.74)	68.00 (55.52)
C_2	14.97 (22.49)	24.00 (29.32)	28.67 (32.35)	36.00 (36.85)	44.00 (41.53)	17.33 (24.58)	24.00 (29.32)	32.00 (34.43)	40.00 (39.21)	48.00 (43.83)
C_3	14.00 (21.96)	20.00 (26.55)	28.00 (31.93)	32.00 (34.43)	40.00 (39.21)	18.00 (25.09)	24.00 (29.32)	31.33 (34.02)	36.00 (36.85)	44.00 (41.53)
Sources	**S.Em±**			**C.D (5%)**						
C×T×M	0.24			0.68						

C_1 : Tip cutting; **C_2:** Semi hardwood cutting; **C_3:** Hardwood cutting

(Values in parenthesis indicates arc sine transformation)

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