Physiological basis of propagation studies in commercially important difficult to root ornamental shrub *Thuja orientais*

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**Abstract**

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.

**Keywords:** Physiological basis, propagation studies, root ornamental shrub, *Thuja orientais*

**Introduction**

Vegetative propagation understands the propagation of plant which is produced with the aid of some parts drewed 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) [13]. *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 monocious, 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) [15].

**Material and Method**

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 portraits containing growing media soil + sand + cocopeat and soil + sand + cocopeat + VAM (the VAM culture used in the study is Acualospore 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) [10]. Similar reports on shoot characters were also noted by Soga et al. (2018) [20] in Thuja orientalis and Chowdhuri et al. (2017) [7] 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) [10] in Thuja orientalis and Chowdhuri et al. (2017) [7] 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 spraying of roots were also noted by Deshmukh and Barad (2002) in Bougainvillea and (Singh et al., 2009) [19] 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) [11] in Jasmine and Torkashv and Shadparvar (2011) [21] 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) [13] 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) [14] in Bougainvillea and Shadparvar et al. (2011) [17] in Hibiscus.

Root characters
Highest number of primary roots per cutting (5.70) and rooting percent (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) [18] in Poinsettia.

Interaction effect of type of cuttings and growing media
Shoot characters
Significantly minimum days taken for sprout initiation (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) [6] 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) [6] 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) [3] in

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*Dalbergia melanoxylon* and Adams *et al.* (2018) [2] 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 conformity with Parmar *et al.* (2010) [14] in *Bougainvillea*; Abidin and Metali (2015) [1] in *Martelli Shrub* and Adams *et al.* (2018) [2] in *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 | T₀ (control) | T₁ (1000) | T₂ (2000) | T₃ (3000) | T₄ (4000) | Mean |
|-----------------|-------------|-----------|-----------|-----------|-----------|------|
| C₁ - Tip        | 15.73       | 15.20     | 14.03     | 11.60     | 13.87     |      |
| C₂ - Semi hardwood | 16.86   | 16.50     | 14.76     | 13.66     | 15.26     |      |
| C₃ - Hardwood   | 19.30       | 18.16     | 16.96     | 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      |           |           |           |      |
| CxB             | 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 | M₁ (Soil + Sand + Cocopeat) | M₂ (Soil + Sand + Cocopeat + VAM) | Mean |
|-----------------|------------------------------|----------------------------------|------|
| C₁ - Tip        | 14.29                        | 13.45                            | 13.87|
| C₂ - Semi Hardwood | 15.69                      | 14.82                            | 15.26|
| C₃ - 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                             |      |
| CxM             | 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) | M₁ (Soil + Sand + Cocopeat) | M₂ (Soil + Sand + Cocopeat + VAM) | Mean |
|----------------------|-----------------------------|----------------------------------|------|
| T₀ (control)         | 17.64                       | 16.95                            | 17.30|
| T₁ (1000)            | 17.06                       | 16.17                            | 16.62|
| T₂ (2000)            | 15.57                       | 14.93                            | 15.25|
| T₃ (3000)            | 14.88                       | 14.08                            | 14.48|
| T₄ (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                             |      |
| TxM                 | 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<sub>1</sub> (Soil + Sand + Cocopeat) | M<sub>2</sub> (Soil + Sand + Cocopeat + VAM) |
|--------------------------------------|------------------------------------------|
| T<sub>0</sub> (control) | T<sub>1</sub> (1000 ppm) | T<sub>2</sub> (2000 ppm) | T<sub>3</sub> (3000 ppm) | T<sub>4</sub> (4000 ppm) | T<sub>0</sub> (control) | T<sub>1</sub> (1000 ppm) | T<sub>2</sub> (2000 ppm) | T<sub>3</sub> (3000 ppm) | T<sub>4</sub> (4000 ppm) |
| T<sub>0</sub> | 16.13 | 15.73 | 14.26 | 13.26 | 12.06 | 15.33 | 14.66 | 13.80 | 12.33 | 11.13 |
| T<sub>1</sub> | 16.17 | 16.86 | 15.26 | 14.93 | 14.26 | 16.60 | 16.13 | 14.26 | 14.06 | 13.06 |
| T<sub>2</sub> | 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 x T x M: 0.06; 0.18

C1: Tip cutting; C2: Semi hardwood cutting; C3: 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 |
|-----------------|-----------------------|------|
|                 | 60 DAP | 90 DAP | 120 DAP | 60 DAP | 90 DAP | 120 DAP | 60 DAP | 90 DAP | 120 DAP |
| C<sub>1</sub>   | 0.70   | 1.50   | 2.30   | 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<sub>2</sub>   | 0.60   | 1.30   | 2.30   | 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<sub>3</sub>   | 0.50   | 1.00   | 1.50   | 2.20   | 1.63   | 2.46   | 3.30   | 2.30   | 4.36   | 4.20   | 2.90   | 3.90   | 4.63   | 1.66   | 2.48   | 3.19   |
| Mean            | 0.60   | 1.30   | 2.12   | 1.93   | 2.72   | 2.04   | 2.91   | 3.87   | 2.75   | 3.83   | 4.55   | 3.30   | 4.15   | 4.93   | 0.06   | 0.06   | 0.10   |

Sources: S.Em±; C.D (5%)
C x T x M: 0.02; 0.02; 0.03

C1: Tip cutting; C2: Semi hardwood cutting; C3: Hardwood cutting

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

| Growing media | Type of cutting | M<sub>1</sub> (Soil + Sand + Cocopeat) | M<sub>2</sub> (Soil + Sand + Cocopeat + VAM) | Mean |
|---------------|-----------------|--------------------------------------|------------------------------------------|------|
|               | 60 DAP | 90 DAP | 120 DAP | 60 DAP | 90 DAP | 120 DAP | 60 DAP | 90 DAP | 120 DAP |
| C<sub>1</sub>-Tip | 2.05   | 2.97   | 3.86   | 2.50   | 3.32   | 4.16   | 2.27   | 3.14   | 4.01   |
| C2-Semi hardwood | 1.90   | 2.75   | 3.48   | 2.10   | 2.92   | 3.74   | 2.00   | 2.84   | 3.61   |
| C3-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   | 1.04   | 1.84   | 2.66   |

Sources: S.Em±; C.D (5%)
C x T x M: 0.01; 0.01

C1: Tip cutting; C2: Semi hardwood cutting; C3: Hardwood cutting

Table 7: Number of sprouts as influenced by rooting hormone and growing media and their interaction effect in Thuia orientalis

| Rooting hormone (ppm) | Type of cutting | M<sub>1</sub> (Soil + Sand + Cocopeat) | M<sub>2</sub> (Soil + Sand + Cocopeat + VAM) | Mean |
|-----------------------|-----------------|--------------------------------------|------------------------------------------|------|
|                       | 60 DAP | 90 DAP | 120 DAP | 60 DAP | 90 DAP | 120 DAP | 60 DAP | 90 DAP | 120 DAP |
| T<sub>0</sub> (control) | 0.46   | 1.20   | 1.82   | 0.73   | 1.40   | 2.14   | 0.60   | 1.30   | 1.93   |
| T<sub>1</sub> (1000)   | 1.06   | 1.80   | 2.53   | 1.35   | 2.06   | 2.91   | 1.21   | 1.93   | 2.72   |
| T<sub>2</sub> (2000)   | 1.88   | 2.37   | 3.68   | 2.20   | 3.08   | 4.00   | 2.04   | 2.91   | 3.87   |
| T<sub>3</sub> (3000)   | 2.53   | 3.60   | 4.39   | 2.98   | 4.06   | 4.59   | 2.75   | 3.83   | 4.55   |
| T<sub>4</sub> (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   | 1.04   | 1.84   | 2.66   |

Sources: S.Em±; C.D (5%)
C x T x M: 0.01; 0.01

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

| Type of cutting | M<sub>1</sub> (Soil + Sand + Cocopeat) | M<sub>2</sub> (Soil + Sand + Cocopeat + VAM) | Mean |
|-----------------|--------------------------------------|------------------------------------------|------|
| T<sub>0</sub> (control) | 0.60   | 1.20   | 2.00   | 2.80   | 3.67   | 0.80   | 1.47   | 2.40   | 3.00   | 4.00   |
| T<sub>1</sub> (1000 ppm)  | 0.53   | 1.20   | 2.20   | 2.60   | 3.13   | 0.80   | 1.40   | 2.40   | 2.73   | 3.20   |
| T<sub>2</sub> (2000 ppm)  | 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 x T x M: 0.02; 0.07
Table 9: Interaction effect of type of cutting, rooting hormone and growing media on number of sprouts in *Thuja orientalis* at 90 DAP

|          | M1 (Soil + Sand +Cocopeat) | M2 (Soil + Sand +Cocopeat VAM) | Mean          |
|----------|-----------------------------|--------------------------------|---------------|
|          | T0 (control) 1000 ppm       | T1 (2000 ppm)                  | T2 (3000 ppm) | T3 (4000 ppm) | T0 (control) 1000 ppm | T1 (2000 ppm) | T2 (3000 ppm) | T3 (4000 ppm) |
| C1       | 1.40                       | 2.20                           | 2.87          | 3.80          | 4.33                   | 1.60           | 2.40           | 3.27           | 4.00           | 4.80           |
| C2       | 1.20                       | 1.80                           | 3.00          | 3.60          | 4.20                   | 1.40           | 2.20           | 3.40           | 3.87           | 4.40           |
| C3       | 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%)                       |               |               |                        |               |               |               |               |               |
|         | CxT×M                      | 0.07                           |               |               |                        |               |               |               |               |               |

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

|          | M1 (Soil + Sand +Cocopeat) | M2 (Soil + Sand +Cocopeat VAM) | Mean          |
|----------|-----------------------------|--------------------------------|---------------|
|          | T0 (control) 1000 ppm       | T1 (2000 ppm)                  | T2 (3000 ppm) | T3 (4000 ppm) | T0 (control) 1000 ppm | T1 (2000 ppm) | T2 (3000 ppm) | T3 (4000 ppm) |
| C1       | 3.53                       | 4.07                           | 4.53          | 5.23          | 6.33                   | 3.80           | 4.27           | 4.87           | 5.73           | 6.93           |
| C2       | 2.20                       | 2.20                           | 4.27          | 5.13          | 4.20                   | 2.60           | 3.73           | 4.73           | 5.47           | 6.00           |
| C3       | 3.33                       | 3.75                           | 4.00          | 4.20          | 5.14                   | 5.93           | 3.73           | 4.20           | 4.73           | 5.60           | 6.20           |
| Sources  | S.Em±                      | C.D (5%)                       |               |               |                        |               |               |               |               |               |
|         | CxT×M                      | 0.03                           |               |               |                        |               |               |               |               |               |

Table 11: Number of primary roots as influenced by type of cutting and rooting hormone and their interaction effect in *Thuja orientalis* Rooting hormone (ppm)

| Type of cutting | M1 (Soil + Sand +Cocopeat) | M2 (Soil + Sand +Cocopeat VAM) | Mean          |
|----------------|-----------------------------|--------------------------------|---------------|
|                | T0 (control) 1000 ppm       | T1 (2000 ppm)                  | T2 (3000 ppm) | T3 (4000 ppm) | T0 (control) 1000 ppm | T1 (2000 ppm) | T2 (3000 ppm) | T3 (4000 ppm) |
| C1 - Tip       | 2.30                        | 3.10                           | 4.10          | 5.10          | 5.70                   | 4.06           |               |               |               |               |
| C2 - Semihardwood | 2.06                      | 2.90                           | 3.53          | 3.93          | 4.56                   | 3.40           |               |               |               |               |
| C3 - 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                        |                                |               |               |                        |               |               |               |               |               |
| T              | 0.01                        |                                |               |               |                        |               |               |               |               |               |
| CxT            | 0.02                        |                                |               |               |                        |               |               |               |               |               |

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 | M1 (Soil + Sand +Cocopeat) | M2 (Soil + Sand +Cocopeat VAM) | Mean          |
|----------------|-----------------------------|--------------------------------|---------------|
|                | T0 (control) 1000 ppm       | T1 (2000 ppm)                  | T2 (3000 ppm) | T3 (4000 ppm) | T0 (control) 1000 ppm | T1 (2000 ppm) | T2 (3000 ppm) | T3 (4000 ppm) |
| C1 - Tip       | 3.96                        |                                | 4.16          | 4.06          |                        |               |               |               |               |               |
| C2 - Semihardwood | 3.26                      |                                | 3.53          | 3.40          |                        |               |               |               |               |               |
| C3 - Hardwood  | 3.00                        |                                | 3.24          | 3.12          |                        |               |               |               |               |               |
| Mean           | 3.40                        |                                | 3.64          |               |                        |               |               |               |               |               |
| Sources        | S.Em±                       | C.D (5%)                       |               |               |                        |               |               |               |               |               |
| C              | 0.01                        |                                |               |               |                        |               |               |               |               |               |
| T              | 0.008                       |                                |               |               |                        |               |               |               |               |               |
| CxT            | 0.01                        |                                |               |               |                        |               |               |               |               |               |

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

| Growing media | Rooting hormone (ppm) (Soil + Sand +Cocopeat) | (Soil + Sand +Cocopeat VAM) | Mean          |
|---------------|-----------------------------------------------|-----------------------------|---------------|
|               | T0 (control) 1.84                            | 2.06                        | 1.95          |
|               | T1 (1000) 2.66                               | 2.86                        | 2.76          |
|               | T2 (2000) 3.60                               | 3.84                        | 3.72          |
|               | T3 (3000) 4.22                               | 4.40                        | 4.31          |
|               | T4 (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*

| Type of cutting | Rooting hormone (Rooting hormone (ppm)) | Sources | C1 | C2 | C3 | C×T×M | 0.03 | 0.09 |
|-----------------|----------------------------------------|---------|----|----|----|--------|------|------|
| Tip 1           | T0 (control)                           | S.Em±   | 2.20 | 3.00 | 4.00 | 5.00 | 5.60 | 2.40 | 3.20 | 4.20 | 5.20 | 5.80 |
| Semi hardwood   | T1 (1000ppm)                           | C.D (5%)| 2.20 | 4.00 | 5.00 | 5.60 | 4.20 | 3.00 | 3.66 | 4.20 | 4.80 |
| Hardwood        | T2 (2000ppm)                           |         | 1.93 | 2.80 | 3.53 | 3.86 | 4.33 | 2.20 | 3.00 | 3.66 | 4.20 | 4.80 |
|                 | T3 (3000 ppm)                          |         | 1.40 | 2.20 | 3.40 | 3.80 | 4.20 | 1.60 | 2.40 | 3.46 | 4.00 | 4.53 |

C1: Tip cutting; C2: Semi hardwood cutting; C3: Hardwood cutting

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

| Rooting hormone (ppm) | Type of cutting | Sources | C1 | C2 | C3 | C×T×M | 0.03 | 0.09 |
|-----------------------|-----------------|---------|----|----|----|--------|------|------|
| Thuja orientalis      |                 |         |    |    |    |        |      |      |
| Thuja orientalis      |                 |         |    |    |    |        |      |      |
| Thuja orientalis      |                 |         |    |    |    |        |      |      |

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

| Growing media | Type of cutting | M1 (Soil + Sand + Cocopeat VAM) | M2 (Soil + Sand + Cocopeat VAM) | Mean |
|---------------|-----------------|---------------------------------|---------------------------------|------|
|              |                 | T0 (control)                    | T1 (1000ppp)                    | T2 (2000ppm) | T3 (3000 ppm) | T4 (4000 ppm) | Mean |
| C1 – Tip 1   | 49.20 (44.45)   | 51.00 (45.52)                   |                                 | 51.00 (45.52) |
| C2 - Semi hardwood | 30.66 (33.36)   | 31.80 (33.34)                   |                                 | 31.80 (33.34) |
| C3 - Hardwood | 26.93 (30.92)   | 28.80 (32.14)                   |                                 | 28.80 (32.14) |
| Mean         | 35.15 (35.93)   | 38.57 (38.08)                   |                                 | 38.57 (38.08) |

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

| Growing media | Rooting hormone (ppm) | M1 (Soil + Sand + Cocopeat VAM) | M2 (Soil + Sand + Cocopeat VAM) | Mean |
|---------------|-----------------------|---------------------------------|---------------------------------|------|
|              | T0 (control)          | 18.88 (25.46)                   | 22.44 (28.03)                   | 20.66 (26.75) |
|              | T1 (1000)             | 29.33 (32.47)                   | 32.00 (34.16)                   | 30.66 (33.31) |
|              | T2 (2000)             | 36.22 (36.80)                   | 39.77 (38.96)                   | 38.00 (37.88) |
|              | T3 (3000)             | 42.00 (40.29)                   | 45.33 (42.27)                   | 43.66 (41.28) |
|              | T4 (4000)             | 49.33 (44.62)                   | 53.33 (46.96)                   | 51.33 (45.79) |
| Mean         | 35.15 (35.93)         | 38.57 (38.08)                   |                                 | 38.57 (38.08) |

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

| Type of cutting | Rooting hormone (ppm) | Sources | C1 | C2 | C3 | C×T×M | 0.03 | 0.09 |
|-----------------|-----------------------|---------|----|----|----|--------|------|------|
| Tip 1           | T0 (control)          |         | 28.80 (31.9) | 44.00 (41.53) | 52.00 (46.12) | 58.00 (49.58) | 64.00 (53.10) | 12.00 (34.43) | 48.00 (43.83) | 56.00 (48.42) | 60.00 (50.74) | 68.00 (55.52) |
| Semi hardwood   | T1 (1000 ppm)         |         | 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) |
| Hardwood        | T2 (2000 ppm)         |         | 14.00 (21.96) | 20.00 | 28.00 | 32.00 (34.43) | 40.00 (39.21) | 18.00 (25.09) | 24.00 (29.32) | 31.33 | 36.00 | 44.00 |
Conclusion

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.

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