



Rooting Response of *Thuja occidentalis* L. to Different Soilless Media and Stem Propagation Techniques in Ghana

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Authors' contributions

This work was carried out in collaboration between all authors. Authors DDDS, IAI and LA designed the study. Author DDDS performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors IAI and LA managed the analyses of the study. Author DDDS managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Studies were carried out to ascertain a suitable soilless medium which would enhance root development in *Thuja occidentalis* using stem cuttings and air-layered propagules.

Economically, the demand for these ornamentals necessitates that the difficult-to-root phenomenon should be solved.

Study Design: A 2 x 6 factorial in a randomised complete block design replicated three times was the experimental design used for the stem cutting experiment. While a complete randomised design with 6 treatments which were replicated three times used for the air-layering experiment.

Place and Duration of Study: Department of Horticulture, KNUST, Ghana, between June 2009 and August, 2009.

Methodology: In the stem cutting propagation experiment, six media types; 100% topsoil, 100% palm-mix, a mix of 50% teak sawdust and 50% coconut coir, a mix of 50% palm-mix and 50% coconut coir, a mix of 50% palm-mix and 50% teak sawdust and a mix of 50% palm-mix, 25% teak

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sawdust and 25% coconut coir and two stem cuttings being straight and heel stems giving twelve (12) treatment combinations was used and replicated three (3) times. For the air-layering experiment, air-layers were made on the selected branches of the plant. Different media were colour-tagged.

Results: Results from the study showed that, a mix of 50% teak sawdust and 50% coconut coir was the most suitable soilless medium, with regards to its physico-chemical properties, and promoted the highest number of rooting. With respect to the root length, the mix of 50% palm-mix and 50% coconut coir recorded the longest root. The best soilless medium that promoted rooting in the air-layered propagule was a mix of 50% palm-mix and 50% teak sawdust.

Conclusion: Thus for propagation works in Ghana, the 50% teak sawdust+50% coconut coir and 50% palm mix + 50% coconut coir and their variations be experimented on other difficult-to-root ornamental plants to validate its use as the best soilless medium for most difficult-to-root ornamental plants.

Keywords: *Thuja occidentalis* L.; difficult-to-root; soilless media; rooting; propagules.

1. INTRODUCTION

Thuja occidentalis L. belongs to the family Cupressaceae and it is native to North America and also widely established in Europe [1]. The common name Arborvitae which means 'tree of life' is due to its unchanging evergreen nature in cold dry climates [2]. Arborvitae, is a tree that grows slowly to a height of 6m to 38m. It has a symmetrical canopy with a smooth dense outline and it is pyramidal in shape. The small scale-like leaves are simple, fragrant when crushed and arranged in alternate forms on the stem. It prefers well-drained loam or sand soils and requires full sun or partial sun/shade to grow [3]. Ornamentally, it is best used as a screen or narrow hedges, background to flowerbeds, in rock gardens, for guard strips around parking lots or for median planting in the highway, in parks and as a reclamation plant [1,2].

In Ghana, *Thuja occidentalis* L. is commonly used as a specimen plant in most residential and institutional landscapes. However, the plant has a potential of diverse use in Ghana, as indicated by Anado' n A et al. [1], Gilman EF and Watson DG [2], if challenges associated with its propagation is adequately resolved and thereby made affordable for many.

The success of any ornamental industry begins with proper nursery activities in terms of relevant methods, effective and efficient use of materials [4]. In the tropics, most of the ornamental nursery operators use topsoil for their operations even though it is bulky, heavy and very inconsistent in quality. Thus, developing alternatives to topsoil as a medium that would mimic the environment that natural soil would provide in order to promote high rooting success is critical. This will

make production of Arborvitae liners less expensive and reliable [5]. An economically important ornamental plant such as Arborvitae which is a narrow-leaved plant requires rooting under moist conditions that will prevent excessive drying as they have minimal genetic and physiological ability for adventitious root development [6] and thus limit their commercial production in Ghana. Therefore, these narrow-leaved upright plants has been commonly referred to as "difficult-to-root" [7].

In Horticulture and Agronomy, adventitious root development has numerous practical inferences which has generated a lot of commercial interest due to several plant species that are considered difficult-to-root [8-9]. Economically, the interest for such ornamentals requires that the difficult-to-root phenomenon be resolved. Rooting cuttings can be challenging and creative [10]. Further research states that each year many people make their living raising plants in greenhouses for people to buy [11]. Implying that, various soilless media and stem cutting kinds need to be discovered to enhance the rooting of the ornamentals.

The objectives of the study were, therefore, to ascertain a suitable soilless medium and stem cutting type that would promote root development in *Thuja occidentalis* L. plant.

2. MATERIALS AND METHODS

To determine the rooting response of *Thuja occidentalis* L. to different soilless media and stem propagation techniques, a study was carried out at the Department of Horticulture, KNUST, Ghana between June 2009 and August, 2009.

The stem cutting experiment utilised a 2 x 6 factorial in a randomised complete block design (RCBD) and was replicated three times. The stem cuttings served as the first factor with 2 levels (straight stem and heel stem) whereas the different media used served as the second factor with 6 levels (100% topsoil, 100% palmix [mixture of oil palm waste], 50% composted teak sawdust + 50% coconut coir, 50% palmix + 50% coconut coir, 50% palmix + 50% composted teak sawdust and 50% palmix + 25% composted teak sawdust + 25% coconut coir). For each perforated black polythene bag of dimension 15 cm x 10 cm used, three cuttings per treatment were inserted into the bag filled with the required medium. Each treatment was watered with 200 ml of water then placed under a polythene frame propagator of dimension 1.5m x 0.6m x 0.6m. Weekly data were recorded on temperature of medium (ThermoTrace Infrared Thermometer Model No. 15030), humidity of polythene frame propagator (Micronta LCD Indoor/Outdoor Thermometer/Hygrometer Model No. 63-867), days to sprouting, number of fully developed leaves per cutting, number of rooted cuttings, root length per cutting and number of survived cuttings.

In the air-layering experiment, a complete randomised design (CRD) with six treatments (different media) was used and was also replicated three times. A strip of bark 2 cm wide was completely removed from six stems on the plant to expose the inner woody tissue. A transparent polythene sheet of size 12 cm x 10 cm was fastened securely about the stem using a raffia string below the first ring mark for each stock plant and filled with the six different moistened media as treatments (as in the stem cutting experiment) and fastened above the second ring mark. Different coloured polythene tags were used to differentiate the various treatments. Weekly data were collected on temperature of the medium and humidity of the surroundings (same instruments as were used for cutting experiment), days to root emergence, number of rooted air-layers, root length per air-layer and number of survived air-layers.

Data collected from both experiments were square-root transformed and analysed using Analysis of Variance (ANOVA) with the Statistix Statistical Package, Version 9. Differences between treatment means were separated using the Least Significant Difference (LSD) test at 5% probability level.

3. RESULTS AND DISCUSSION

3.1 Propagation of *Thuja occidentalis* L. Propagules

3.1.1 Microclimatic conditions in the polythene frame propagator and its effect on rooting

Temperatures in the media and polythene frame propagator were similar (Fig. 1) over the 10-week period while the relative humidity fluctuated between 82.0% and 90.0% (Fig. 2) in the polythene frame propagator. Temperatures within the polythene frame propagator were between 26.0°C and 31.0°C and that of the various media ranged from 23.0°C to 34.0°C. The temperature recorded across the media was higher than that of the polythene frame propagator from the 3rd to the 4th week. This was as a result of higher ambient temperatures and low relative humidity which caused a rise in the polythene frame propagator temperatures and subsequent increase in media temperatures. Readings for the temperature in the polythene frame propagator and media was done once a day thus more heat was retained in the latter. The black colour of the polythene bags used also encouraged the heat been retained in the media while further decomposition and microbial activity in the media also promoted higher media temperatures. Halfway through the experimental period, temperatures of the various media dropped to that of the 1st week observations and below that of the polythene frame propagator due to onset of heavy rains which occurred during the data collection. Further temperature drop were observed up to the 10th week across the media and the polythene frame propagator as a result of the rainy season in the months of July to August.

3.1.2 Bud sprouting and survival of *Thuja occidentalis* L. propagules

Prolific bud sprouts was observed after the 3rd week of setting out the cuttings. This occurrence could be attributed to the high temperatures recorded in the various media over polythene frame propagator. The high relative humidity in the polythene frame propagator from the 4th week also promoted further growth in root development which also provided the cuttings with nutrients for further prolific sprouting. Maintaining air temperatures lower than medium temperature delays shoot growth and encourages root development [12]. The different

media, stem cutting kinds and their respective interactions did not significantly affect the number of survived cuttings. As a trend, the 50% teak sawdust + 50% coconut coir and 50% palmix + 25% teak sawdust + 25% coconut coir both had 18% of the cuttings that survived. Heel stem cuttings also had 51% more survived

cuttings than the straight stem cuttings. Although sprouting was prolific in the straight stem cuttings, the cuttings may not have directed their energies into rooting but utilised most ATP into the sprouting. Therefore less survival and scanty roots to support further growth.

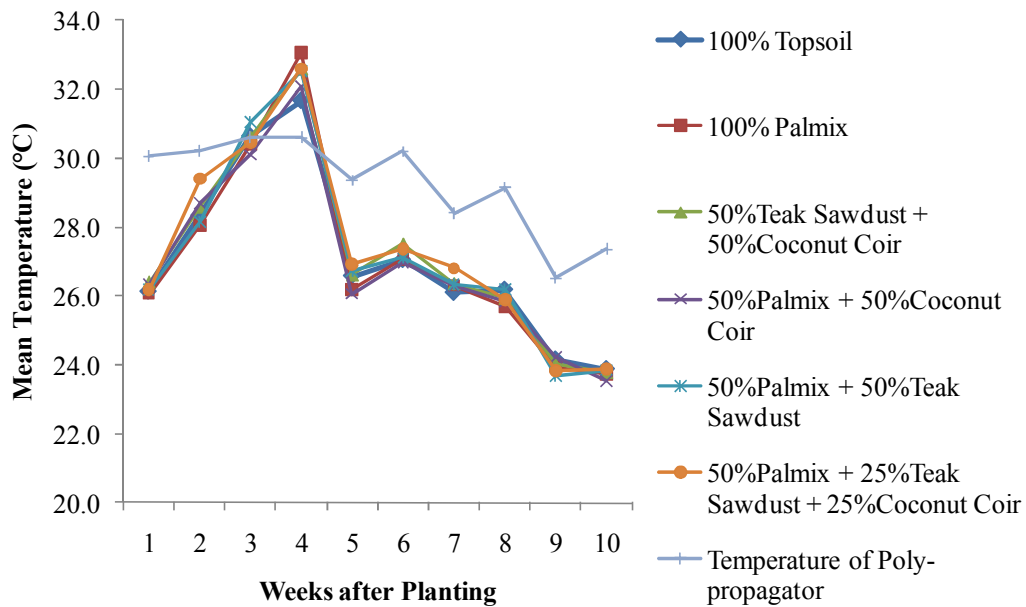


Fig. 1. Mean media and polythene frame propagator temperature over time

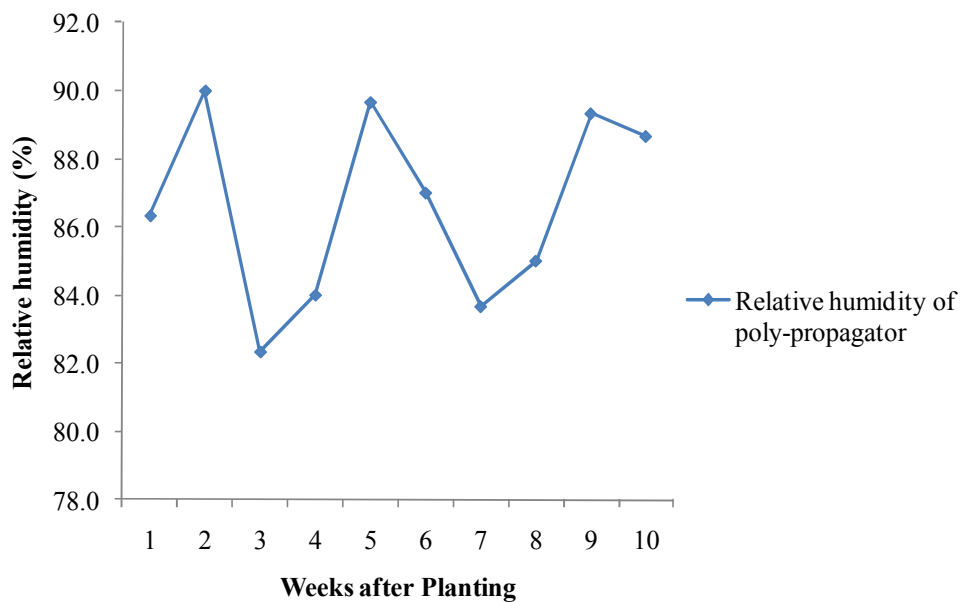


Fig 2. Relative humidity in polythene frame propagator over time

3.1.3 Rooting of *Thuja occidentalis* L. propagules

The different media significantly ($P = 0.0086$) affected the number of rooted cuttings of the *Thuja* propagules (Table 1). The highest mean percentage of rooting (21%) was recorded in the 50% teak sawdust + 50% coconut coir whilst the minimum rooting (11%) was observed in 100% palmix. This can be attributed to 50% teak sawdust + 50% coconut coir having adequate air porosity (90%) which provided enough oxygen to the roots coupled with the presence of adequate water for further growth. The high organic matter content (88%) enabled the medium to have high water holding capacity thus providing sufficient uptake of water and nutrients to the stem cuttings for root development. The low pH (5.8) of 50% teak sawdust + 50% coconut coir also made more available nutrients for absorption by the cuttings. Coniferous shrubs and trees prefer lower pH levels about 5.0-5.5 [13].

Results from Table 1 again shows that, there were highly significant ($P = 0.0005$) differences in root length amongst the media where stem cuttings in 50% palmix + 50% coconut coir was the longest (2.38 cm) followed by 50% teak sawdust + 50% coconut coir with length of 2.19 cm whilst the shortest root length (0.71 cm) was recorded by stem cuttings in 100% palmix. The longer root lengths in 50% palmix + 50% coconut coir and 50% teak sawdust + 50% coconut coir (Fig. 3) was due to its high air-porosity and water holding capacities which made the roots have sufficient supply of oxygen for root growth and also travel longer distances in the medium to absorb the nutrients and water thus an increase in the root length. When the total pore space in the medium increases, it often causes a reduction in water retention, an increase in oxygen transport and further increase in root penetration. This will in turn stimulate plant growth [14].

Table 1. Effect of media on number of rooted cuttings and root length (cm) of cuttings of *Thuja occidentalis* L.

Media	Rooted cuttings	Root length (cm)
100% Topsoil	1.05 ± 0.52^{abc}	1.50 ± 1.03^{bc}
100% Palmix	0.71 ± 0.00^a	0.71 ± 0.00^a
50% Teak sawdust+50% Coconut coir	1.39 ± 0.14^c	2.19 ± 0.58^{cd}
50% Palmix+50% Coconut coir	1.36 ± 0.48^c	2.38 ± 1.21^d
50% Palmix+50% Teak sawdust	0.94 ± 0.57^{ab}	0.89 ± 0.56^{ab}
50% Palmix+25% Teak sawdust+25% Coconut coir	1.16 ± 0.57^{bc}	1.56 ± 1.02^{bc}
<i>P-value</i>	0.0086	0.0005

Values with different superscripts letters in the same column represent significant differences.



Fig. 3. Picture showing rooted stem cuttings in 50% palmix + 50% coconut coir (a) and 50% teak sawdust + 50% coconut coir (b)

3.2 Air-Layering of *Thuja occidentalis* L. Propagules

3.2.1 Microclimatic conditions and its effect on rooting of *Thuja occidentalis* L. air-layers

In the first four weeks after the air layers were done, the ambient temperature was between 28.0°C and 33.0°C while that of the media was between 25.0°C and 32.0°C (Fig. 4). In the same manner, the relative humidity in the ambience was between 67.0% and 86.0% (Fig. 5). High initial ambient and media temperatures encourages cell division which therefore aids in the formation of roots [15].

3.2.2 Survival and rooting of *Thuja occidentalis* L. air-layers

Significant ($P = 0.0011$) differences were observed among the media used, such that air-layers in 50% palmix + 50% teak sawdust (Table 2) took 7 longer days for its roots to emerge than layers in 50% teak sawdust + 50% coconut coir with 3 shorter days. There were highly significant ($P = 0.0000$) differences for the root length of air-layers among the different media used. Air-layers in 50% palmix + 50% teak sawdust recorded the

longest root length (2.56cm) as seen in Fig. 6 while 50% teak sawdust + 50% coconut coir recorded root lengths of 0.88cm amongst the soilless media as seen from Table 2. There was an early development of roots for air-layers in 50% teak sawdust + 50% coconut coir medium than 50% palmix + 50% teak sawdust because it provided higher initial medium temperatures from which may have initiated the early root development but developed shorter root length than 50% palmix + 50% teak sawdust because it could not provide enough stored energy. Root initiation in cuttings is temperature-driven but subsequent root growth is strongly dependent on available carbohydrates [15]. An important component of the capacity for a stem to root is the nutritional status of the plant. In general, high carbohydrates levels are associated with vigorous root growth [16]. Carbohydrates translocated from the leaves undoubtedly contribute to root formation. This could mean that the branch on which the air layers were done had less stored food for further root growth. Yet again, when root primordia are formed, there is a comparable time frame (seven to eight days) between root primordia elongation (emergence) and maximum rooting for both easy and difficult-to-root plants [17].

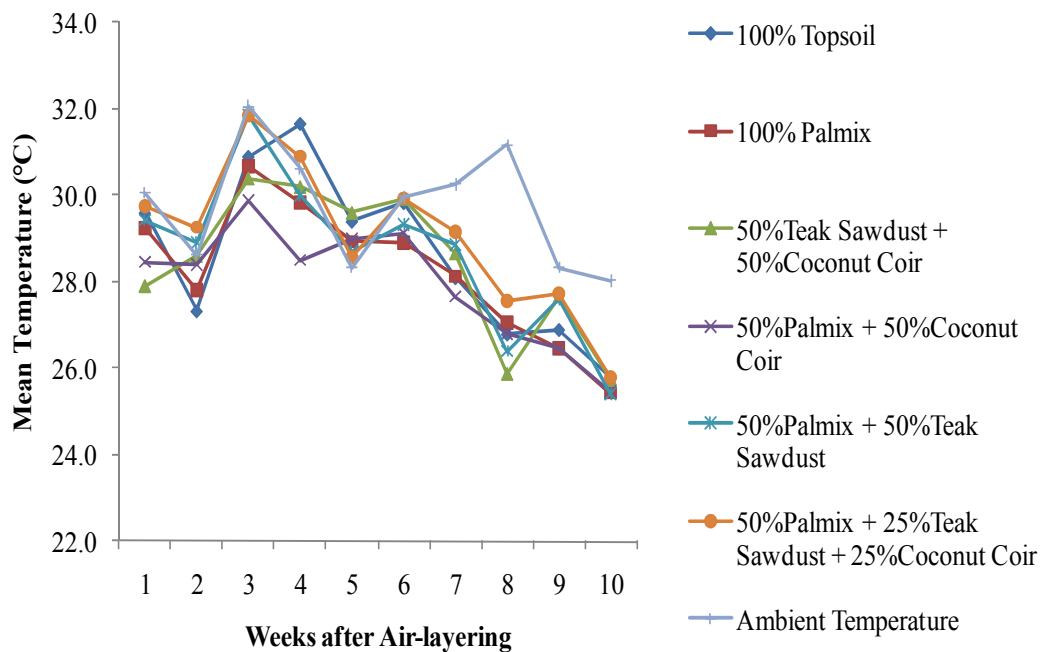


Fig. 4. Mean media and ambient temperature over time

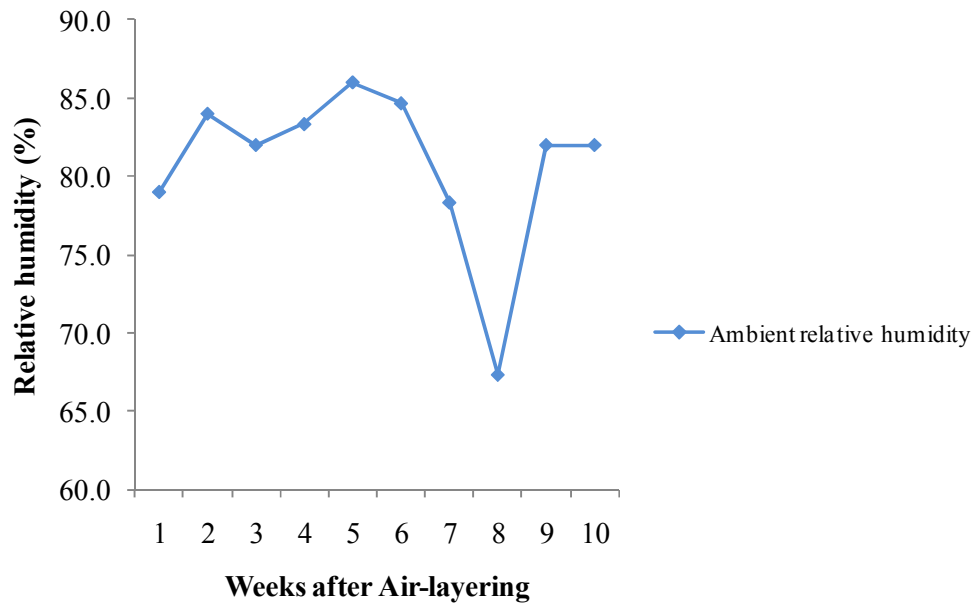


Fig. 5. Ambient relative humidity over time

Table 2. Effect of media on number of days to root emergence and root length (cm) of *Thuja occidentalis* L. air-layers

Media	Days to root emergence	Root length (cm)
100% Topsoil	0.71 ± 0.00 ^a	0.71 ± 0.00 ^a
100% Palmix	0.71 ± 0.00 ^a	0.71 ± 0.00 ^a
50% Teak sawdust+50% Coconut coir	2.96 ± 4.28 ^a	0.88 ± 0.58 ^a
50% Palmix+50% Coconut coir	0.71 ± 0.00 ^a	0.71 ± 0.00 ^a
50% Palmix+50% Teak sawdust	7.49 ± 0.31 ^b	2.56 ± 0.68 ^b
50% Palmix+25% Teak sawdust+25% Coconut coir	0.71 ± 0.00 ^a	0.71 ± 0.00 ^a
<i>P-value</i>	0.0011	0.0000

Values with different superscripts letters in the same column represent significant differences.

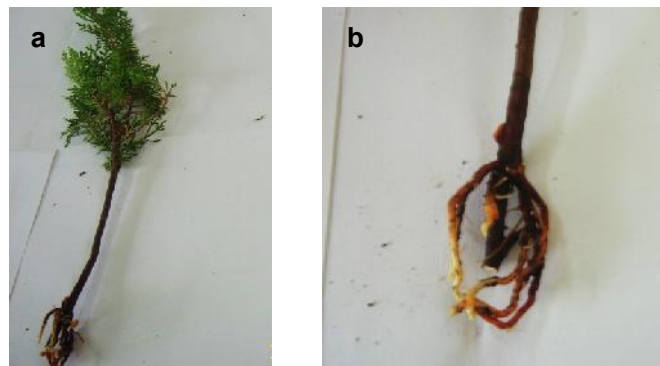


Fig. 6. Picture showing rooted air layer in 50% palmix + 50% teak sawdust (a) and closer view of rooted air layer (b)

4. CONCLUSION

In absence of pre-wintering conditions in the tropics, Arborvitae stem cuttings rooted better in a mix of decomposed teak sawdust and coconut coir at a ratio of 1:1. However, due to the porous nature of palmix medium, it promoted root length. All media mixes with some amount of coconut coir made significant impact on rooting stem cuttings. Media mix of decomposed teak sawdust and palmix at a ratio of 1:1 performed best for air-layers. Thus for propagation works in Ghana, it is suggested that the 50% teak sawdust+50% coconut coir and 50% palmix + 50% coconut coir and their variations should be experimented on other difficult-to-root ornamental plants to validate its use as the best soilless medium for most difficult-to-root ornamental plants.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Anado´ n A, Martı´nez-Larran˜ aga MR, Ares I, Martı´nez MA. Poisonous plants of the Europe. In: Gupta RC, editor. Veterinary Toxicology, Basic and Clinical Principles. 3rd ed. Academic Press, Cambridge, Massachusetts; 2018.
2. Gilman EF, Watson DG. *Thuja occidentalis* L. 'White Cedar'. University of Florida, Cooperative Extension Service, Institute of Food and Agricultural Sciences, Fact Sheet ENH-787; 2006.
(Accessed 28 September 2008)
Available:<http://hort.ufl.edu/trees/THUOCCA.pdf>
3. Nesom G. Northern White Cedar. United States Department of Agriculture (USDA) and Natural Resources Conservation Service; 2002.
(Accessed 28 November 2008)
Available:https://plants.usda.gov/plantguide/pdf/cs_thoc2.pdf
4. Kessler JR. Greenhouse Potting Media. Auburn University, College of Agriculture, Horticulture; 2002.
(Accessed 30 September 2008)
Available:<http://www.ag.auburn.edu/hort/landscape/pottingmedia.html>
5. Acquaah G. Horticulture: Principles and practices, 3rd ed. Upper Saddle River, Pearson Education Incorporated Hall New Jersey; 2005.
6. Hartmann HT, Kester DE, Jr. Davies FT. Plant propagation: Principles and practices 5th ed. Pearson Prentice Education Incorporated Hall, Upper Saddle River, New Jersey; 1990.
7. Hamilton DF, Midcap JT. Propagation of woody ornamentals by Cuttings University of Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, CIR 415; 2003.
(Accessed 28 September 2008)
Available:<http://edis.ifas.ufl.edu/pdffiles/EP/EP03000.pdf>
8. Davies FT, Jr. Davis TD, Kester DE. Commercial importance of adventitious rooting to horticulture. In: Davis TD, Haissig BE, editors. Biology of Adventitious Root Formation; 1994.
9. Kovar JL, Kuchenbuch RO. Commercial importance of adventitious rooting to agronomy. In: Davis TD, Haissig BE, editors. Biology of Adventitious Root Formation; 1994.
10. Rothenberger RR. Home propagation of landscape plants, Department of Horticulture, College of Agriculture; 2000.
(Accessed 28 September 2008)
Available:<http://www.growit.com>
11. Herren RV. Exploring Agriscience. Delmar Publishers; 1997.
12. Lopez RG. OFA fact sheet: Cutting propagation, OFA Grower Bulletin, January/February, 2008, Number 906.
(Accessed 5 December 2008)
Available:<https://sharepoint.agriculture.purdue.edu/agriculture/flowers/Shared%20Documents/04%20Cutting%20propagation.pdf>
13. Handreck K, Black N. Growing media for ornamental plants and turf. University of South Wales Press; 1999.
14. Michael R, Lieth JH. Soilless culture: Theory and practice. Elsevier; 2007.
15. Hartmann HT, Kester DE, Jr. Davies FT, Geneve RL. Plant Propagation: Principles and Practices 7th ed. Pearson Prentice Education Incorporated Hall, Upper Saddle River, New Jersey; 2002.

16. Janick J. Horticultural Science, 4th Ed. W. H. Freeman and Company, 41 Madison Avenue. New York; 1986. juvenile and mature leaf bud cuttings of *Ficus pumila* L. Am J Bot. 1982;69:804-811.
17. Davies FT, Jr. Lazararte JE, Joiner JN. Initiation and development of roots in DOI: 10.2307/2442971

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