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RESEARCH ARTICLE

PROPAGATION OF WHITE SANDAL WOOD: *SANTALUM ALBUM* L.

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Abstract: *Santalum album* L. is native to India and a member of the Santalaceae family. The Red Data Book classifies it as a vulnerable species. Sandalwood is in high demand due to the high value of its essential oil and wood. The oil derived from sandal's heartwood is used as a fragrance enhancer and in the creation of expensive fragrances. It was closely linked to Indian religion and culture. *Santalum album* is the most attracted species and they exhibited wider variations in its natural range of occurrence. So clonal selection and vegetative propagation through rooted cuttings is a greater potential for commercial exploitation of the species. But the root formation of cutting is a complex mechanism and influenced by physiological, environmental and genetic factors. Within this, experiments which consist of three different rooting media viz., Standard nursery mixture 1:1:1 ratio of soil, sand & FYM, Soil: Sand (1: 1) and Sand + Silt were tried with the hormonal treatments of IAA (1000 to 10000 ppm), IBA (1000 to 10000 ppm) and NAA (1000 to 10000 ppm) at different concentrations and two types formulation *viz*., powder and liquid formulation of rooting media. Among these treatments, IBA 8000 ppm and NAA 8000 ppm treated cuttings showed slow response in shoot induction. The rooting percentage of cuttings is Zero. Therefore it is necessary to find combination of some factors that will support root cutting formation and produce new seedlings with root induction.

Keywords: Sandal, Cuttings, Rooting induction, Growth hormones

INTRODUCTION

Santalum album L. belongs to the santalaceae family, a medium-sized evergreen hemi root parasitic tree, highly valued for its fragrant heartwood, which contains sandal oil that is used in perfumes, cosmetics, and also in Agarbathi (incense sticks) industries. *Santalum album* has the highest oil content (about 6%) of the species of the genus *Santalum*. The sandalwood and its oil demand (80%-90%) in the international market have been fulfilled by Indian sandalwood for decades. Production of Sandalwood has fallen sharply over the past decades due to the mushrooming of illegal sandalwood processing units.

The sandalwood is traded both locally and globally due to its importance in perfumery and pharmaceutical industry. India produced nearly about 1000 tonnes of sandalwood (Anon, 2006) and 40 tonnes of oil (Jain *et al*, 2003) annually over several years and contributed 25% of the revenue from essential oils exported. The price of heartwood and oil was at Rs.12 lakh per tonne and Rs. 22000 per kg respectively during the year 2003. However the price of sandal wood has been steadily increasing which currently ranged between Rs.5000 and Rs. 12000 per kg based on quality (Tewari *et al.,* 2014). The market trend indicated that the sandal prices have increased from Rs. 6.5 lakh per tonne (1999 -2000), Rs. 37 lakhs per tonne (2007), Rs. 56.5 lakh per tonne (2012) to Rs.52.97 lakh per tonne (2013) (Krishnakumar *et al.*, 2016; Tewari *et al.*, 2014). This indicated that the price of sandal wood has steadily increased due to increased market potential. *Santalum album* is the most attracted species among the *Santalum sp.* and they exhibited wider variations in its natural range of occurrence. However there is no systematic evaluation of *Santalum album* improvement programme in order to utilize the existing genetic variation, which warrants a systematic investigation.

MATERIALS AND METHODS

The experiment was conducted at Forest College and Research Institute, Mettupalayam which is situated at 11'9'N latitude and 77'56'E longitude at an altitude of 300 m above MSL. It occupies a 200 hectares area and is located at the base of the Western Ghats. With hot summers and chilly winters, the climate is of the semi-arid tropical variety. Beginning in early February and lasting until mid-June are the dry and wet seasons, respectively. The north east monsoon contributes 60% of the region's average annual

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rainfall, which falls during 49 rainy days. The remaining 40% is made up of summer showers and the southwest monsoon. The mean maximum and minimum temperature are 30^0c and 20^0 c respectively.

Three different rooting media viz., Standard nursery mixture 1:1:1 ratio of soil, sand & FYM, Soil : Sand (1 : 1) and Sand + Silt were tried with the hormonal treatments of IAA (1000 to 10000 ppm), IBA (1000 to 10000 ppm) and NAA (1000 to 10000 ppm) at different concentrations and two types formulation viz., powder and liquid formulation of rooting media. The treated cuttings were housed in the recommended climatic conditions of temperature, light and relative humidity.

RESULTS AND DISCUSSION

Effect of rooting hormone on adventitious root induction in juvenile *Santalum album* leafy shoot cuttings

The effects of various rooting hormone *viz*., IBA, IAA and NAA on adventitious root development were evaluated in leafy shoot cuttings of *Santalum album*. The leafy shoot cuttings were collected from fully matured trees and root suckers and coppice of selected individuals of *Santalum album*. The leafy shoot cuttings were collected and prepared as one and two node cuttings. Among the various treatments *viz*., IBA -1000 ppm to 10000 ppm, IAA – 1000 ppm to 10000 ppm and NAA – 1000 ppm to 10000 ppm leafy shoot cuttings no response was observed in shoot and root induction. In leafy shoot stem cuttings, carbohydrate production through photosynthesis is important in supporting the induction and development of adventitious roots. The level of photosynthesis and thus the capacity of stem cuttings to produce adventitious roots can be influenced by the level of irradiance in the propagation environment. However, higher light levels are not directly associated with improved root induction. Root induction in cuttings exposed to high light intensity may be inhibited, reduced or delayed due to the effects of water stress and stomata closure with an associates reduction in photosynthesis.

Effects of rooting hormone on adventitious root induction in *Santalum album* stem cuttings

Effect of different auxins IBA, IAA & NAA, their concentration were studied for rooting of stem cuttings. Rooting response was recorded in terms of rooting percentage, average number of roots produced and average root length.

Auxin is one of the major endogenous hormones known to be intimately involved in the process of adventitious rooting and the physiological stages of rooting are correlated with changes in endogenous auxin concentrations. High endogenous auxin concentration is normally associated with a high rooting rate at the beginning of the rooting process. Auxins have been shown to be effective inducers of adventitious roots in many woody species and are usually synthesized in the stem tip and tender leaves of aerial parts of plants and then transported to the action site. When applying exogenous auxin on cuttings, the endogenous auxin concentration reaches a peak after wounding coinciding with the initiation of the rooting process. The widely used sources of growth hormones for rooting of cuttings are the IBA (indole-3-butyric acid), IAA (indole-3-acetic acid) and NAA (α - naphthalene acetic acid) and commercialized root promoters (root-growing powders). IAA was the first to be used to stimulate rooting of cuttings and soon after another (IBA) auxin which also promoted rooting. The application of exogenous plant growth regulators, as the auxins group, can increase the success of adventitious rooting in vegetative propagules collected from selected genotypes of various tree species indole-3-butyric acid (IBA) is the widely used. The objective of the present study is to investigate the effect of different auxin and their concentrations on root induction in stem cuttings of *Santalum album*.

Within this background, the semi hard wood and hard wood cuttings were collected from selected individuals with one or two nodes. The stem cuttings of length 15 to 20 cm were selected and trimmed properly. The cuttings were treated with various treatments *viz*., IBA -1000 ppm to 10000 ppm, IAA – 1000 ppm to 10000 ppm and NAA – 1000 ppm to 10000 ppm. Among these treatments, IBA 8000 ppm and NAA 8000 ppm (Powder formulation) treated cuttings showed slow response in shoot induction. Among the various factors of treatments *viz*., type of cuttings, potting media and rooting hormone, shoot induction was observed on 23 days and 30 days after planting but due to non rhizogensis factor all the cuttings were dried.

Cutting propagation in the genus Santalum

Several species of santalum can be reproduced clonally by cuttings, although success is moderated by ontogenetic effect, such that cuttings are produced more readily using juvenile than mature plants and optimum conditions required for successful cutting propagation vary between species. Collins (2000) conducted cuttings studies with tropical sandalwood species (*Santalum yasi*, Santalum *austrocaledonicum, Santalum lanceolatum* and *Santalum macgregorii)* and reported substantial variation in the percentage of rooting between experiments, genotypes and species. Differences between experiments were recorded for *S. album* (9.5 and 0% rooting), Santalum *austrocaledonicum* (63.5 and 20.2%) and *Santalum yasi* (46.1 and 0.1%). Srimathi (1995) reported that clonal propagation of *S.album* was problematic with less than 3 % rooting success in stem cuttings propagated under intermittent mist. They reported that this method resulted in the most shoots per branch, but they failed to report rooting percentages between the treatments.

Biological factors affecting cutting performance

Stock plant management

Stock plants are the source plants from which cuttings are collected and these may be raised either as seedlings, clones or coppice. The survival and performance of cuttings is influenced by stock plant physiology, which can be manipulated through its management. So, to promote suitable shoot material from the stock plant it is essential to understand and appropriately, modify the environmental conditions of the plant. While cuttings may be collected from natural forest, successful mass propagation of majority of tree species usually requires stock plants to be managed as pruned hedges or coppice stools. Stock plant hedges may be established, the managed intensively *viz*., soil water availability, nutrition, light and juvenile vigour. The aim of stock plant management is to maintain the health and vigour of the shoots, in order to maximize the number cuttings produced and to optimize their rooting ability.

Stock plant nutrition and water management

The positive effect of stock plant nutrition on adventitious rooting of cuttings is generally known, but the specific role of various nutrients in stimulating adventitious rooting has yet to be fully understood for many species (Hartmann *et al*., 1997). A vital part of nutrition management is to ensure that stock plant health and vigour is maintained. The application of fertilizers to stock plants may have both positive and negative effects on adventitious rooting. So, the effect of nutrient application may not be stand alone factor, but may interact with other factors including light, water and physiological condition of the stock plant. Therefore the effect of nutrients can be modified by other environmental factors such as water availability, light quality, photoperiod and temperature to impact on physiological and morphological condition of the stockplant and root formation in its cuttings. The rooting capacity of cuttings is intimately related to the water balance between transpiration and absorption. Rooting capacity is reduced when the plant is affected by water stress. This may due to produce gas bubbles in the xylem tissues which may block water vessels from the transportation of water, carbohydrates and mineral nutrition.

Age of the plant

The age of the plant brings with it cellular and physiological changes, which include lignifications of shoots resulting in difficulties in vegetative propagation. Two possible causes may be attributed to the negative influence of a mature physiology on cutting success. Firstly, various types of endogenous rooting inhibitors have been found in higher concentration in mature compared with juvenile stems. Secondly the increasing complexity of a tree as it matures leads to lignifications of mature tissues, with the reduction in endogenous auxins and a high concentration of rooting inhibitors.

The root formation of cutting is a complex mechanism and influenced by physiological, environmental and genetic factors. Physiologically, the cutting becomes stressed after severance from the stock plant, and if there is little water or nutrient uptake, the cutting usually reduces stomatal conductance, until the root formation has been developed. Environmental factors, especially temperature, light, and relative humidity also affect the root formation. When environmental factors do not support the cutting, it will be unable to promote root formation. From the genetic aspect, individual cutting has its own ability to form the adventitious root because this phenomenon is related to gene activation after cutting process.

In this view the cutting propagation studies have elucidated some basic requirements for successfully cloning *Santalum album* by cuttings. The results demonstrated that phyto-hormones *viz*., IAA, IBA and NAA did not have any significant effect on root induction. The study found that good management of cutting hedges is required to achieve high quality, less lignified softwood cuttings that root better than semi-hardwood and hardwood cuttings. Leaf retention during propagation is critical for success, since cuttings that shed all their leaves remain alive during the propagation period but only rarely produce roots. Light is important for root induction, so the optimum mean daily photon flux density of between 56 and 86 µmol m^2 s^{-1} induced root induction of cuttings. Therefore it is necessary to study the physiological activity and find combination of some factors that will support root cutting formation and produce new seedlings with root induction.

Table 1. Effect of growth regulators and rooting media on rooting of *Santalum album* cuttings

Treatments	Days to initial shoot induction (Days)	% of Shoot induction	% of root induction
IBA 1000 ppm	--	--	--
IBA 2000 ppm	--	--	--
IBA 3000 ppm	--	--	--
IBA 4000 ppm	--	--	--
IBA 5000 ppm	--	--	--
IBA 6000 ppm	--	--	--

IBA 7000 ppm	--	--	--
IBA 8000 ppm	23	6.8 %	--
IBA 9000 ppm	--	--	--
IBA 10000 ppm	--	--	--
NAA 8000 ppm	30	8.0%	--
NAA 9000 ppm	--	--	--
NAA 10000 ppm	--	--	--

CONCLUSION

Sandalwood is a commercially important forest product that has been traded for many countries. The trade has been based on the exploitation of wild stands of the wood, but as supplies have dwindled interest in its cultivation has been increasing within agroforestry systems, both as an industrial crop and small scale product. In this studies, Effect of different auxins IBA, IAA & NAA, their concentration were studied for rooting of stem cuttings. Among these treatments, IBA 8000 ppm and NAA 8000 ppm (Powder formulation) treated cuttings showed slow response in shoot induction. The shoot induction was started after 23 days of planting but dried. The rooting percentage of cuttings is Zero. The root formation of cutting is a complex mechanism and influenced by physiological, environmental and genetic factors. Physiologically, the cutting becomes stressed after severance from the stock plant, and if there is little water or nutrient uptake, the cutting usually reduces stomatal conductance, until the root formation has been developed. Environmental factors, especially temperature, light, and relative humidity also affect the root formation. When environmental factors do not support the cutting, it will be unable to promote root formation. From the genetic aspect, individual cutting has its own ability to form the adventitious root because this phenomenon is related to gene activation after cutting process. Therefore it is necessary to find combination of some factors that will support root cutting formation and produce new seedlings with root induction.

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