Scientific Propagation of Sandalwood (*Santalum album L.*): A Review

Abstract

Vegetative propagation is a fantastic way to improve the quality of the forest tree planting stock. It is often used in seed orchards and clone banks as a method of genotype preservation. Vegetative propagation is the greatest option when low quality seed and poor germination rates limit the availability of planting stock and quality. This review article discusses the many vegetative propagation methods, including as macro-propagation by cuttings, micropropagation through tissue culture, and grafting. Having insufficient knowledge and experience is the biggest obstacle to employing vegetative propagation. Therefore, an effort was made to outline several techniques together with their history and significance.

Keywords: sandalwood, propagation, planting and yield

Introduction

Due to its high economic worth and reputation as the best indigenous species in the world, sandalwood (Santalum album L.) is one of the fancy wood species in Indonesia. (Pareira *et al*., 2019).Sandalwood is a source of essential oils and a potential non-timber forest product; due to the particular quality of its core wood and the aroma-specific oil it provides, it's also classified as a luxury good. Sandalwood oil may be made from the hardwood of sandalwood trees' trunks, branches, roots, and branches. Sandalwood's uniquely fragrant oil content gives the wood its economic significance (santalol). The sesquiterpenoid chemical family that comprises α -santalol and β -santalol makes up sandalwood essential oil.(Ariyanti&Asbur, 2018).Since sandalwood has desirable properties, it has been over-harvested without regard for sustainability, which has caused a sharp fall in the population of sandalwood in its native habitat. Sandalwood is a valuable kind of wood that has to be preserved and protected. This is demonstrated by the fact that sandalwood has been listed as vulnerable (vurnarable) on the International Union for the Conservation of Nature (IUCN) Redlist since 1998, signifying a high risk of extinction in the wild. There hasn't been enough focus on establishing sandalwood plantations. Since its numbers have dropped, it has been designated as an endangered species. (Kumar *et al.* 2019).Because there were fewer adult individuals, the sandalwood's mating system, which had previously been dominated by outcrossing and later growing inbreeding in some populations, underwent alterations. (Indriorko*et al*. 2015),(Nurchahyani*et al*. 2017), (Ratnaningrum*et al*. 2021). For instance, a decline in the genetic quality of the seeds produced, inbreeding depression, and even reproductive failure might result from it.

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(Ratnaningrum*et al.*2015). As a result, a new technique for vegetative propagation is required to produce more certified seedlings in less time. Different outcomes were seen in earlier sandalwood vegetative propagations. While root sucking, grafting, and tissue culture techniques show promise, air layering and stem cutting were not very successful. (Das *et al.* 2021). Advanced techniques and an aseptic environment are needed for the tissue culture. (Swamy *et al.* 2021), whereas root suckers require more time to create new seedlings (Batabyal*et al.* 2015). Grafting is a form of vegetative growth that involves joining sections of plant tissue known as the scion with other plant components known as the rootstock. As the newly created parenchyma cells intermingle, interlock, and fill the gap between the rootstock and scion (Hartmann *et al.* 2014). scion and rootstock Successful grafting propagation depends on compatibility. Thus, they are able to develop into a single plant. Grafting is often used to conserve certain genetic resources or to grow better plants in clonal seed orchards rather than to produce forest tree seedlings in large quantities. (Sukendro*et al.* 2010).Since the planting programme for sandalwood is currently only available in a small area, the rate of sandalwood harvest from wild populations typically exceeds the rate of planting. This illustrates that rescuing sandalwood is a big issue that requires assistance from efficient culture techniques as a step toward broad regeneration. (Herawan*et al.*, 2015).Due to the incapacity of forest plants to regenerate naturally, human intervention is required to create artificial regeneration, which may be achieved by environmental modification or vegetative propagation.

Vegetative propagation through tissue culture

The development of plant cultivation technology calls for the use of tissue culture or micropropagation for vegetative propagation. (Jayusman, 2015).Growing plant components such as protoplasts, cells, cell groups, tissues, and organs in sterile or aseptic conditions is known as tissue culture. This method offers the advantages of yielding plants that are mature relatively quickly, using the least amount of land possible, and not being impacted by the time of year. (Harahap*et al.*, 2019; Mastuti, 2017).The axillary branches of sandalwood plants can therefore be stimulated as a way to quickly accomplish mass regeneration. The advantage of axillary shoot proliferation is that there is little to no genetic diversity and the shoots are genetically more stable. (Ngezahayo& Liu, 2014).The success of tissue culture is greatly influenced by the body's regulatory substances that are introduced to the growing media. Auxins and cytokinins are two often utilized growth regulators. The cytokinin family member benzyl amino purine (BAP) is a growth regulator that is often used since it is easily available, moderately priced, and particularly effective at promoting shoot and leaf production. (George *et al.*, 2007).NAA, a growth regulator from the auxin group, promotes callus formation, cell division, and elongation in plants. (Wattimena, 1988).

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Vegetative propogation through Grafting

Grafting joins pieces of plants to create a new individual and aims to preserve the genes of superior and/or unique plants. (Page *et al*. 2020, 2021), RATNANINGRUM*et al*. – Sandalwood grafting compatibility in GunungSewu, Indonesia 3489 enhancing stem performance (Huang *et al*. 2019), Accelerating the development of sexual maturity and delivering mature plants that are ready to blossom for breeding purposes (Page *et al*. 2020; Pullaiah*et al*. 2021). Grafting is also said to increase plant productivity, tolerance, and fruit quality. (Kumar *et al*. 2017; Belmonte-Urena *et al*. 2020). Grafting has a substantial impact on the parameters of Solanum spp. survival, plant morphology, plant growth, reproductive, and yield in India. (Kumar *et al*. 2017). In the developed graftings, various characteristics were reported to have been passed from rootstock to scion in the Greek Solanum melongena plant. In addition to passing on their resistance to fusarium wilt to the fruits, rootstocks control the nutrient deposition that influenced the composition and nutritional content of the fruits. (Krommydas*et al*. 2018). The genotypes, age, and size of the rootstocks and scions both had a significant impact on the survival rate in the grafted sandalwood. (Page *et al* 2012, 2020; Pullaiah*et al*. 2021). The first study on sandalwood grafting in WanagamaGunungSewu revealed that the seedlings grown from a red-big flower variant are the healthiest for rootstock. (Prastyo*et al*. 2022). Wild saplings and root-suckers are commonly used as rootstock materials in numerous Pacific Island locations. (Page *et al*. 2012, 2021). In Tanzania, the Allanblackiastuhlmannii grafting technique may also be used with in-situ rootstocks, either on farms or in the open countryside. (Munjuga*et al*. 2013). Grafting joins pieces of plants to create a new individual and aims to preserve the genes of superior and/or uncommon plants. (Page *et al*. 2020, 2021), (RATNANINGRUM *et al*. 2015) – Grafting compatibility of sandalwood in GunungSewu, Indonesia 3489 improving the stem performance (Huang *et al*. 2019), accelerating the achievement of reproductive age, and providing ready-to-flower mature plants for breeding purpose (Page *et al*. 2020; Pullaiah*et al*. 2021). Grafting is also reported to improve plant resistance, productivity, and fruit quality (Kumar *et al*. 2017). The survival rate, plant morphology, plant growth, reproductive and yield parameters of Solanum spp. in India were significantly affected by grafting (Kumar *et al*. 2017). Within the developed graftings, several traits were transferred by rootstock to scion, as was reported in Solanum melongena in Greece. Rootstocks controlled the nutrient deposition which affected the composition and nutritional value of the fruits; as well as transferred the resistance of fusarium wilt from the rootstocks to the fruits (Krommydas*et al*. 2018). The survival rate in the grafted sandalwood was mostly affected by the genotypes, as well as the age and size of both rootstocks and scions (Page *et al* 2012, 2020; Pullaiah*et al*. 2021). The initial study on sandalwood grafting in WanagamaGunungSewu showed that the seedlings raised from a red-big flower variant are the best for rootstock (Prastyo*et al*. 2022). In several sites on

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Pacific Islands, wild seedlings and root-suckers are also common for rootstock materials (Page *et al*. 2012, 2021). In Tanzania, the Allanblackiastuhlmannii grafting might also be applied using in-situ rootstocks, both on-farm or in the natural environment (Munjuga*et al*. 2013). establishing an Indonesian breeding facility for premium sandalwood while protecting the 27 chosen. The grafting compatibility of 27 chosen genotypes of sandalwood grafted onto two different rootstock types is estimated in this study. Scions were chosen in February 2021 during the height of the rainy season from the 27 genotypes descended from the four landraces Imogiri, Bejiharjo, Bleberan, and Petir in GunungSewu. The top-cleft approach was then used to transplant scions onto two different kinds of rootstock. The four Petir genotypes (Pt1, Pt2, Pt3, and Pt4) all received the top ratings for the majority of the measured metrics. Compared to Type 1 rootstock (49%), Type 2 rootstock withstood grafts at a higher rate (57%). For the optimum grafting success, it is strongly advised to utilise the red-big flower variation root-suckers as the rootstocks and the Petir and Imogiri genotypes as the scions. (YENI*et al*., 2022).

Vegetative propogation through cuttings

Any piece of the parent plant that is taken and intended for regeneration is referred to as a cutting. (K T Parthiban *et al*., 2016). Cutting germination and root growth are regulated by ecophysiological, biochemical, and anatomical elements during the complicated process of cutting germination and rooting. (Uniyal*et al*. 1993). Cutting position was a critical factor in rooting success. (Diego Wassner and Damia´nRavetta 2000). The most well-known method of encouraging roots in all types of cuttings is undoubtedly the administration of auxin to draw assimilates to the cutting base and to encourage meristematic differentiation. IBA has a significant role in the growth of adventitious roots, increasing the proportion of cuttings that take root, enhancing the quality of the roots, and ensuring consistency in cutting rooting. (Nagesh, 2002; Teklehaimanot *et al*., 2004; Husen and Pal, 2007a; Opuni-Frimpong *et al*.,2008) Stem cuttings, root cuttings, leaf cuttings, and leaf bud cuttings are the four main forms of cuttings. (K T Parthiban *et al*., 2016). Stem cuttings for vegetative propagation allow for the speedy generation of plants that are true to type and the availability of superior individuals for large-scale commercial plantations with rapid productivity improvements. (Pratap Chandra Panda *et al*., 2019). The simplest and most affordable form of vegetative propagation that is often used in many tree species is rooting stem cuttings. (B H babu *et al.*, 2018). To build industrial plantations, seed orchards, nutritional experiments, etc. and increase forest productivity, macro propagation by induction of rooting in stem cuttings is a practical alternative that is recommended. (Aslam and Rather 2008). There are three types of stem cuttings: hardwood, semi-hardwood, and soft wood cuttings. (Evans, 1999). From mature, dormant stems that are more than a year old, hardwood cuttings are extracted. Typically, semi-hardwood cuttings are made from partially mature wood from the current season's growth, whereas softwood cuttings are

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Conclusion

Vegetative propagation has a great potential to produce high-quality planting material with better phenotypic and genotypic traits in a very short period of time. In this overview, the various vegetative growth techniques are described. All observed sandalwood variation rootstock-scion pairs showed compatibility with various results. The average grafting survival rate with Red as the rootstock and scion was 35.8%. Therefore, the grafting strategy of propagation shows promise for the deployment and conservation of sandalwood variants. Grafting is necessary to establish the stool plant in the hedge orchard, to copy the genetic material for the clonal test, and to establish a clonal seed orchard. Tissue culture or micropropagation is needed for vegetative propagation as plant cultivation technology advances. process of growing plant from a stem or root, that has been cut from another plant is called cutting

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