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The Eucalyptus Camaldulensis Flower Population Employing a Variety of Hydroponic Methods

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Abstract:

A successful plantation requires good nursery management along with quick and affordable clonal replication. In order to make the forest-based business more competitive, mass propagation has grown in importance. However, the popular stem-cutting method has limitations in rooting behavior in several hard-wood species, most notably eucalypts. These limitations include rapid loss of rooting competence, intra-clonal variation, and poor rooting quality, all of which together negate genetic expression of some useful clones and impede field deployment[12]. A study employing unique Mini cutting-based propagation was started with the goal of lowering the nursery's duration from six to four months while also increasing productivity in order to get beyond the production barrier[1]. India has standardized the hydroponic-assisted Mini cuttings production method for Eucalyptus camaldulensis in order to meet this need. The key to success is controlling plant nutrition to produce the most harvestable sprouts possible. Additionally, an effective growing medium based on ecosan was used as a necessary step to generate vigorous saplings from Mini cutting sets[4]. This improved survival rate, accelerated rooting, and early establishment.

Introduction:

Growers of eucalypt trees love RED GUM (Eucalyptus camaldulensis L.), which is well-known across the world for its quick growth, excellent tolerance to drought, and versatility in a variety of soil types and climates. The practice of clonal propagation is widely employed to increase the commercial potential of eucalypt species and hybrids through the multiplication of attractive varieties. In most forest nurseries, it is done with a reasonable level of sophistication in order to strategically increase productivity. The development of better clones and silvicultural techniques will result in increased yields from eucalypt forestry; hence a highly dependable and economical propagation strategy is needed. Despite being the most popular and extensively utilized propagation strategy, the conventional (stem-cutting) technique suffers from innate genetic and physiological restrictions. For example, intra-clonal variation resulting from topophysis, poor rooting and rapid loss of rooting competence due to ontogenetic aging, and poor root system quality adversely affect some clones' genetic expression, which in turn affects their deployment in the planting program[6-12].

Furthermore, a significant barrier to cloning is the poor roots of some clones that were created from conventional cuttings, which has been linked to the plant material's maturity level. Surrogate propagation techniques are being investigated because surrogate coppice-producing streams cannot feed vigorous seedlings to nursery production units due to timing constraints, despite the growing demand. Minicutting was one of these in vitro methods that produced significant results, primarily by boosting the percentage of rooted plants and reducing short production times[1]. The technique of minicutting was developed and applied for the propagation of Eucalyptus thanks to the pioneering work of Assis et al. Minicuttings have demonstrated significant promise in providing advantages over traditional stem-cuttings in terms of technology and economy. The rooting of auxiliary shoots from rooted stem-cuttings is the foundation of the minicutting system. Indoor hydroponic mini-hedges, which yield plantlets or rooted cuttings with a high degree of juvenility, have replaced field clonal hedges. The ideal nutritional state of the ensuing minicuttings is also necessary for the system to succeed. The minicutting technology offers better rooting potential, rapidity, and quality at a lower cost when compared to stem-cuttings[3].

For species like E. grandis, E. globulus, E. nittens, etc., this technology is currently being quickly developed and is most commonly utilized by forestry firms operating under commercial license in Brazil, Australia, and South Africa[5]. The amount of area needed to maintain hedge plants is another crucial factor in the use of mini-cuts in clonal propagation. When compared to coppice grown in the field, it is negligible. For instance, the coppice route will require about 55 acres of land to supply the requirement of 20 million cuttings annually, while the minicutting route just needs two acres[2]. This technique also provides propagules with low topophysis effects and good homogeneity. The new era of mass vegetative propagation in eucalypts and other hardwood species has been made possible by the discovery of this extremely intensive cloning technology. Following the manufacture of minicuttings, these young saplings require adequate growing/rooting media for increased survival and the formation of a robust early root system. In addition to being affordable, the perfect growing medium for a commercial nursery should be devoid of weeds and illnesses[13]. The medium should also be lightweight, well-drained, and able to hold onto enough moisture[14].

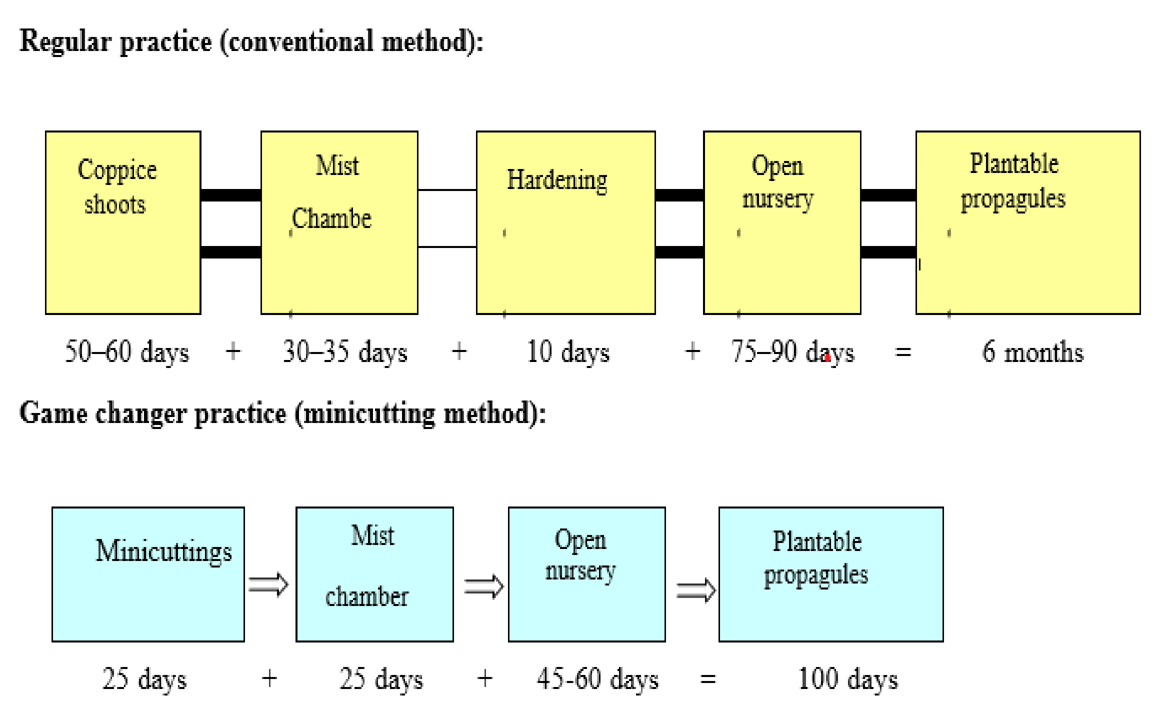
High-yielding clones can be mass-produced and used for commercial forestry, where a consistent and reliable supply of stock is essential, after a new and suitable growing medium has been developed. A comprehensive study was carried out in selected clones and hybrids of Red Gum species at the Clonal Production Centre, PSPD Unit, ITC Ltd, Bhadrachalam, Andhra Pradesh, India, with the aim of improving the nursery production and reducing its cycle (length) [1-14].

Meterials and Methods:

First, 25 days were spent in a nutrient (mix) tank for 60–65-day-old eucalyptus plants from the open nursery (grown using the traditional coppice shoot method). The plants were housed in a polythene enclosure with air temperature of 33–35 C, relative humidity (RH) of 60–65%, and natural sunlight with a 30% cut-off. Minicuttings essentially originate from these hedge stumps. Using a motorized pump, the nutrient mix (NM) was continually fed (cycled and re-cycled) to produce aeration (Figure 1). Using portable DO, pH, and EC meters, the dissolved oxygen (DO), pH, and electrical conductivity (EC) of the NM were continuously regulated to allow for appropriate ion exchange, nutrient uptake, and root respiration.

One replacement of the NM was made every two weeks. Minicuttings from these hedge plants were harvested/cut on the 25th day, and this process continued until the 30th day, depending on when the sets were ready to be harvested. Twenty nutrient tanks held 25,000 hedge plants in order to generate 1.5 lakh minicuttings over the course of five months. These sets were immediately placed in rooting trays with a combination of ecosand €, vermiculite (V), and compost ©. They were then kept in a mist chamber for a further 25 days, with controlled misting to maintain a temperature of 32–35°C and a RH of 80–85%. These seedling trays were then moved to a hardening environment for ten days, where they were covered by controlled water sprinklers and kept in a 50:50 shade. The hardened seedlings were transferred to an open nursery area, fully immersed in their natural surroundings, and received twice-daily irrigation until they were ready to be hoisted for field planting. Following 60–70 days in the open nursery, 100 seedlings from coppice and minicutting sources were planted in the wild to study their growth patterns and acclimation[15].

Box 1. Process overview



Results and Discussion:

Given that plants need all 16 of the basic components to complete their life cycle, the type of plant will determine which nutrients are used. Because of their resistant wood, certain tree species (perennials) have altered tissue contents that result in either a greater dose of required nutrients or preferential uptake, or the need for one or more elements at a higher dosage at a specific growth stage. Therefore, some adjustments to the standard Hoagland solution (SHS) were necessary, just as they were for Eucalyptus species like nitens, grandis, and globulus. SHS is typically used in commercial hydroponic clonal multiplication systems[1-16]. Its nutrient composition is primarily suited to the tissue composition and constituents of crop plants, and it is primarily focused on enhancing the growth of annual crops (horticulture/agriculture) (Table 1). But in this study, we've modified SHS and developed a special NM only for E. camargulensis, which has improved lateral development and sprouting in hedge plants.

Table 1. Nutrient mix hedge plants and Mini cuttings.

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Details	Hoagland solution	2x	3x	4x	5x
KNO3	505	1010	1515	2020	2525
CaNo3	1180	2360	3540	4720	5900
KH2Po4	136	272	408	544	680
MgSo4	490	980	1470	1960	2450
FeSo4	15	30	45	60	75
EDTA	20	40	60	80	100
MnCl2	1.81	3.62	5.43	7.24	9.05
CuSo4	0.08	0.16	0.24	0.32	0.4
ZnSo4	0.22	0.44	0.66	0.88	1.1
H3Bo4	2.86	5.72	8.58	11.44	14.3
Ammonium Molybdate	0.01	0.02	0.03	0.04	0.05
		Success			

The table shows the effect of different nutrient management strategies on the growth and water use efficiency of Eucalyptus camaldulensis. The strategies include Hoagland solution, 2x, 3x, 4x, and 5x. The results show that the 3x nutrient management strategy resulted in the highest plant height, stem diameter, leaf area, and total dry weight. The 5x strategy resulted in the highest water use efficiency. The discussion section of the paper suggests that the 3x nutrient management strategy is the best option for Eucalyptus camaldulensis. This strategy provides a good balance between growth and water use efficiency.

The paper also discusses the use of ecosand as a rooting growth medium. Ecosand is a mineral with a unique, three-dimensional, honeycomb-like structure that allows it to absorb, hold, release, and exchange different nutrients/ions. It is also negatively charged, which makes it attract certain cations. Ecosand does not break down over time, but remains in the soil to help improve nutrient and water retention. It is also an excellent amendment for non-wetting sands and assists water distribution through the soils. The ecosand contains high concentration of silica, which provides physical strength to growing saplings at the early stages itself. Overall, the paper suggests that the 3x nutrient management strategy is the best option for Eucalyptus camaldulensis. This strategy provides a good balance between growth and water use efficiency. Ecosand is a promising new rooting growth medium that can improve plant growth and water use efficiency. Ecosand, a rooted growth media, possesses a special capacity to exchange, hold, release, and absorb various nutrients and ions. It is a mineral with an endless, three-dimensional structure resembling a honeycomb that permits reversible water loss and gain. It

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attracts specific cations due to its inherent negative charge. The fact that it doesn't decompose over time and stays in the soil to aid in better nutrient and water retention is an added bonus[16].

It helps distribute water throughout the soils and acts as a natural wetting agent, making it a great amendment for non-wetting sands. The high content of silica in the ecosand gives developing saplings physical strength from the very beginning (Table 2). Better bulk density and cation exchange capacity (CEC) provide for slower nutrient release and improved water retention. To maximize its potential, ecosand was added to vermiculite in eucalyptus nurseries in the current study. In the current study, minicuttings generated from hedge plants were rooted and established early using a mixture of ecosand, vermiculite, and leaf compost as a rooting medium. For comparison, a set of control stem cuttings from the coppice source were also stored, using only vermiculite and leaf compost.

Table 2. Properties of ecosand (natural zeolite)

	Composition (%)	
Chemical properties		
Silica (SiO_2)		68.10
Alumina (Al_2O_3)		10.70
Potassium (K_2O)		4.30
Calcium (CaO)		2.20
Iron (Fe_2O_3)		1.70
Sodium (Na_2O)		0.60
Magnesium (MgO)		0.50
Loss on ignition (H_2O)		11.50
Clinoptilolite (%)		75–90
Cation exchange capacity (meq/100 g)		
Zeolite method		150–180
Soils method		80–110
Physical properties		
Bulk density		56 lb/cubic ft
Particle size	Size (mm)	Per cent
	1.0–1.4 0.5–1.2 0.25–0.5	30
		55

Using a portable photosynthetic system (LiCOR 6400, Nebraska, Lincoln, USA), assimilation rate (A), stomatal conductance (gs), and transpiration rate (T) were measured in both coppice and minicutting-grown plants to quantify differences in physiological parameters. The third completely developed leaf from the apex of three distinct plants (three replicates) of the same species was chosen for measurement on the thirtyth day following tray planting. Following this, the leaf's chlorophyll concentration was measured with a chlorophyll meter (SPAD-502, Minolta, USA), which is also thought to be an indirect indicator of the leaf's protein and nitrogen content[1-17].

Mini cuttings are superior to traditional stem cuts in a number of operational, technical, financial, environmental, and quality aspects.

- Operationally, a lot of field tasks like preparing the soil, fertilizing it, providing irrigation, cultivating it, weeding it out, controlling pests and diseases, moving cuttings, and so on are swapped out with intensive tasks in condensed indoor spaces.
- Reduced labor, fertilizer, irrigation, and chemical costs will be a result of a comprehensive outdoor clonal hedge management system.
- It will be far simpler to maintain indoor clonal hedges than a vast area in a field.
- Compared to stem-cuttings, mini-cuttings have significantly better rooting ability.
- Greater levels of juvenility and ideal nutritional content in the tissues, which enhance the rooting inclination and rapidity of root initiation, lead to increased rooting.
- The speed at which minicuttings root has crucial implications for commercial cloning programs, as it can greatly enhance the efficient utilization of available infrastructure. This is because minicuttings typically spend a significantly shorter amount of time in the mist chamber than stem-cuttings do.
- In contrast to the dominant lateral root system in stem-cuttings, mini-cuttings create a robust root system with a propensity toward a taproot-like system.
- Reduced time: Compared to stem-cuttings, plants emerge from the mist chamber more quickly, resulting in fewer disease issues and a significantly shorter time between setting and plantable seedling production.

- Because there is less lignification of the connecting tissues, the relationship between the root and stem tissues in minicuttings appears to be more appropriate and more fertile.
- Superior-quality seedlings have stronger root and stem systems and a greater capacity to generate roots.

An overview of the procedure is given in Box 1. It takes 25 days for minicuttings to root in the mist chamber and 45–60 days in an open nursery for them to reach the appropriate growth for planting in the field, providing the extra benefit of a full two months in the nursery.

Advantages of minicutting technique:

- **Reduced nursery cycle time:** Minicuttings reach plantable size in 100 days compared to 180 days for coppice shoots, leading to faster clonal multiplication.
- **Improved rooting:** Minicuttings exhibit higher rooting percentage and develop a robust root system with a taproot-like structure, enhancing seedling quality and survival in the field.
- **Controlled environment:** Minicutting production occurs indoors in a controlled environment, minimizing the impact of external factors like pests, diseases, and weather fluctuations.
- **Reduced resource requirements:** The technique requires less land, water, fertilizer, and labor compared to traditional methods, leading to cost savings and environmental benefits.
- **Superior quality seedlings:** Minicutting-derived seedlings have stronger root and stem systems and higher chlorophyll content, indicating better photosynthetic efficiency and potential for higher growth rates.

Overall, the minicutting technique offers a promising approach for mass propagation of Eucalyptus camaldulensis with several advantages over the conventional method. Its faster production cycle, improved rooting, and reduced resource requirements make it a viable and sustainable option for commercial forestry and clonal propagation programs.

Conclusion:

Conclusion for the research article on Eucalyptus camaldulensis propagation using Mini cutting technique is the study successfully demonstrated the effectiveness of the Mini cutting technique in propagating Eucalyptus camaldulensis compared to the traditional coppice shoot method. Here are the key takeaways:

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