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Growth and propagation aspects of some medicinally important trees in Chandigarh, India: a review

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Abstract
Seed germination improves with scarification, gibberellic acid treatments and seasonal variations in tree species viz. *Aegle marmelos, Madhuca indica, Michelia champaca* and *Terminalia chebula*. Seed scarification with hot water and conc. H_2SO_4 and, pre-sowing GA_3 treatment significantly increase percentage germination. The Success of adventitious rooting of stem cuttings depends upon the physiological status of mother stock plant, its nutrient status and general growth conditions; type of cutting, pre-planting treatments and environmental conditions including season. Easy-to-root species have a higher concentration of promoters while difficult-to-root have more inhibitors. Strong and deep plant root system of the parent plant is essential to establish air layers in a sound condition supplying enough nutrients and required moisture.

Keywords: Propagation, Air-layering, Scarification, PGRs, Bael, Mahua, Champa, Harar.

1. Introduction

Since ancient times trees have been an integral part of human life and a vital component of biodiversity. Forest trees are renewable sources of food, fodder, fuel wood, fiber, timber and other valuable non-timber products. Due to rapid deforestation, depletion of genetic resources coupled with escalating human needs the forest cover is being reduced tremendously from the earth's surface. There are alarming threats to forests in particular and biodiversity in general. To maintain and sustain the forest vegetation, conventional approaches have been exploited for propagation and improvement, but tree breeding efforts are restricted to the most valuable and fast growing tree species. However, trees are generally slow growing, long lived, sexually self-incompatible and highly heterozygous plants. As a result, recessive deleterious alleles are retained within populations, resulting in high genetic load and inbreeding depression [1]. Thus conventional breeding has its own limitations for efficient genetic improvement programs. Giri *et al*. [2] overviewed the progress made in the last decade concerning tissue culture, genetic transformation, mass propagation and applications of biotechnology to trees.

Clonal fidelity is a major consideration in commercial propagation, including both macro- and micro-propagation methods for forestation programs, woody-biomass production and conservation of elite and rare germplasm [3]. In general woody trees are difficult to regenerate under *in vivo* conditions. As trees grow and attain maturity the ability of vegetative propagules to root declines [4]. Most of the trees can be propagated by vegetative means during juvenile phase.

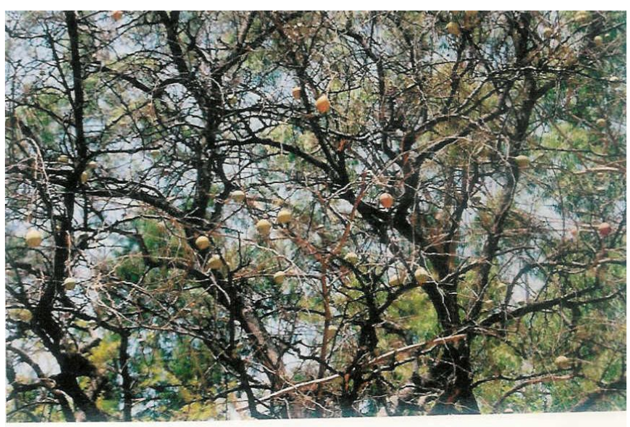
A conscious aesthetic planning, including flora, fauna and architecture, ultimately decides the establishment of a beautiful city. Chandigarh is an example of such systematic, orderly and wise landscaping with beautiful ornamental trees and shrubs. The scenic beauty is supported by artistic foliage and colourful flowerings planted as avenue trees alongside the roads, N-choe, on the bank of ponds and in public places, *viz.*, gardens, parks, schools/colleges, hospitals, temples, municipal corporation buildings, courts etc. A total of approximately 225 tree species are growing in and around Chandigarh. These species were introduced and established during 1962-66. The seed raised saplings were brought from Saharanpur, Dehradun and Maliabad (UP) and Patiala (Punjab) [5]. Twenty six tree species namely, *Acer oblongum, Adenanthera pavonina, Aegle marmelos, Aesculus indica, Agathis robusta, Cinnamomum camphora, Crataeva religiosa, Dillenia indica, Diospyros embryopteris, Elaeocarpus sphaericus, Erythrina indica, E. suberosa, Eucalyptus robusta, Ficus krishnae,* *Ginkgo biloba, Homalium tomentosum, Lagerstroemia tomentosa, Madhuca indica, Melaleuca leucadendron, Michelia champaca, Peltophorum ferrugineum, Platanus orientalis, Podocarpus gracilior, Sapindus trifoliatus, Terminalia chebula* and *T. myriocarpa* were categorized as difficult to grow tree species by the Horticulture Department after years of long experience of raising and maintaining localized flora. Out of these plants four species, namely *Aegle marmelos, Madhuca indica, Michelia champaca* and *Terminalia chebula* have been selected as model tree species for standardizing their propagation techniques. Their important taxonomical and morphological descriptions; origin, spreading, habitat, economic importance, medicinal uses etc. are summarized:

1.1 *Aegle marmelos* (Linn.) Correa. Ex Roxb.

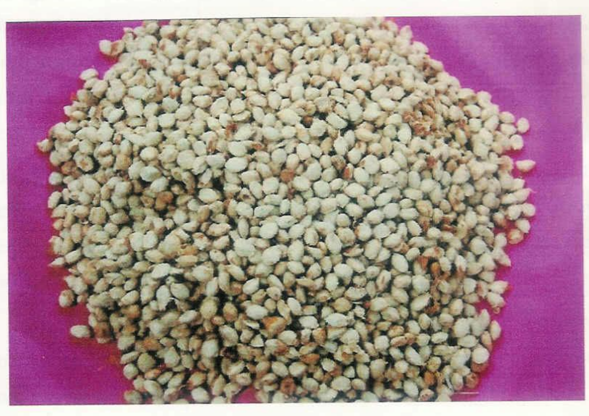
It belongs to the family Rutaceae with a common name bael. It is moderate sized, slender, aromatic spinous tree distributed in the Indo Malaysian region. Only one species is found in India in the wild form and is often cultivated. It commonly occurs in sub Himalayan tract and in the dry deciduous forests of central and southern India. The tree has branches armed with straight, sharp, axillary spines. Its bark is soft, corky and light grey in color. Leaves are trifoliate, leaflet ovate, acuminate, lateral sessile and have terminal petioles. Flowers are large greenish white and sweet scented, fruit globose and yellowish. The fruits have numerous seeds which are oblong, compressed covered with thick orange sweet pulp (Plate 1).

It can withstand various types of soil, climatic conditions and a pH range of 5 to 10. It is drought hardy and ordinarily found in dry localities unfavorable to the majority of tree species. It is fairly frost resistant and can withstand low temperature -7 °C. In its wild state, the tree occurs in regions where the temperature varies from 40–46 °C. Due to its ability to grow in poor, stony and alkaline soils, it is recommended for reclamations of waste lands, and also for wind breaks in northern India. Generally, bael is propagated by seeds, although it seldom produces a plant true-to-type. The seeds have short viability and are much liable to insect attack. The seedlings are prone to die back in frosty localities, but have a good power of recovery. At one year age, the seedlings are fit for transplanting in the field. The plants can also be propagated through root cuttings, air layering, inarching or budding. Under natural conditions, the plant produces root suckers copiously. Successful micro-propagation can be achieved in bael by using various seed-derived explants [6, 7, 8, 9].

The bael fruits are used in the preparation of several ayurvedic medicines to cure chronic diarrhea and dysentery. Its fruit is said to be a good tonic for the heart and brain and also help to remove constipation by the healing of ulcerated surfaces of the intestine. Clinical experiments of unripe fruit show antiviral effect against several viruses. Its juice added with sugar and tamarind, forms a delicious cooling drink. The timber of bael is used for making tool handles, agricultural equipment and also for railway key and brake blocks.



AEGLE MARMELOS (CLOSE UP)
(ROSE GARDEN SECTOR -16



AEGLE MARMELOS (SEEDS)

Plate 1

1.2 *Madhuca indica* J.F. Gmel.

It is commonly known as Mahua. The other related species of the family Sapotaceae are *Madhuca latifolia* Macob., *Bassia latifolia* Roxb. Leaves are elliptical oblong and appear in clusters, pubescent when young and on maturity become glabrous. Flowers are cream colored, scented, greenish turning reddish yellow or orange when ripe. The seeds are brown shinning 2.5-3.75 cm long (Plate 2). It is medium sized to large deciduous tree and grows up to an altitude of 12,000 m. *Madhuca indica* is found in mixed deciduous forests, often growing on rocky and sandy soil. It is common throughout central India. It is generally planted in the plains of northern India and Deccan Peninsula. Mahua is ordinarily drought and frost hardy, but suffers under severe conditions. Natural reproduction takes place by seeds which germinate early in the rainy season, soon after falling from a tree. Nursery raised seedlings have to be planted with utmost care.

The wood is valued for ship's keels and used in the construction of carts and for bridges. Bark yields tannin (17%) which is used for dyeing. Leaves are used as fodder to feed cattle and for making cups and plates to serve food. Flowers are a rich source of nutrients and can be used to yield alcohol. Fruits are eaten raw/cooked, and have medicinal value; fruit pulp is used as a source of sugar for making alcohol; yield essential oil (0.3%). Seeds are used in the preparation of washing soaps; proper refined oil finds use in cooing, confectionary, chocolate making, in the manufacture of lubricating greases, candle making, production of alcohols and stearic acids. Besides, mahua oil is used in medicine to cure skin diseases, rheumatism and headaches. Seed cake is useful for making biofertilizers. *Madhuca indica* is an ornamental tree with beautiful flowers and is recommended for planting under social forestry programs, particularly in community waste lands.

***MADHUCA INDICA* (CLOSE UP)**
P.G.I. SECTOR - 12

***MADHUCA INDICA* (SPROUTING SEEDS)**

Plate 2

1.3 *Michelia champaca* Linn.

It belongs to the family Magnoliaceae with a common name champak. It is a tall evergreen tree usually growing up to 30 m in height and 3.5 m in girth, with a clean cylindrical bole up to 20 m long. It is found in the eastern Himalayas, North East India and Western Ghats. However, it is cultivated throughout India in gardens and near the temples and handsome foliage. Leaves ovate to lanceolate, flowers-usually axillary, solitary, yellow or orange and highly fragrant; fruit 5-10 cm long, woody; seeds-brown, angular with pink fleshy aril (Plate 3). The trees thrive in a damp climate and require deep moist soil and are sensitive to frost. The flowers are produced in hot and rainy weather and seeds in August. The plants can be propagated by fresh seeds and shoot cuttings.

The wood is used for posts, boards, furniture, decorative fittings and ship building, toys and beads. It is also suitable for making pencils, aircraft constructions, battery separators, tea chest plywood. Champaca oil is used in perfumery which is extracted from flowers. Champak flowers are used in India in the preparation of 'Attars' and perfumed hair oil. The leaves yield volatile oil. Seeds of the common Champa are produced in abundance; in fact the tree can exhaust itself with the prodigality of its output and may take two to three years to gather enough strength to flower again. The fruit clusters need to be removed before they develop.

The Champa tree has medicinal value also. Stem bark is considered stimulant and diuretic, dried roots and root bark are purgative and the juice of the leaves is used in colic. Flowers and fruits are stimulant, antispasmodic, stomachic and are considered useful in dyspepsia, fever, renal diseases and healing of cracks in the feet.

MICHELIA CHAMPACA (CLOSE UP)
ROSE GARDEN SECTOR – 16

MICHELIA CHAMPACA (Fruit) *MICHELIA CHAMPACA* (SEEDS)

Plate 3

1.4 *Terminalia chebula* Retz.

It is a member of the family Combretaceae with a common name Harar. The tree grows up to 15-24 m in height and 1.5-2.4 m in girth, with a cylindrical bole of 4.9 m; a rounded crown with spreading branches. It is found throughout the greater parts of India. bark-dark brown, often longitudinally cracked; leaves ovate or elliptic with a pair of large glands at the top of the petiole; flowers yellowish white, in terminal spike; drupes ellipsoidal, ovoid, yellow or orange-brown 3.5 cm long; seed hard, pale, yellow (Plate 4).

Harar is found in the sub-Himalayan tracts to West Bengal and Assam up to an altitude of 1500 m in rocky and dry places in the outer Himalayas and in the hills of Deccan and South India. It is a small tree. It grows on clay as well as sandy soils. The species requires strong light and cannot tolerate shade or a cramped situation. The lack of natural regeneration may be attributed to some extent to the poor germination capacity of seed and the destruction of the seed by insects, rats, squirrel and other rodents. The seedlings are poor in growth and often killed by heavy and continuous rain. Establishment of the young seedlings requires considerable care and tending.

The dried fruit constitutes one of the most important vegetable tanning material. In addition to its use in tanning, the extract is used on a very large scale for the internal treatment of locomotive feed waters. The fruit is credited with laxative, stomachic, toxic and alternative properties. The bark is endowed with both diuretic and cardio tonic properties. The gum produced by the trees has also medicinal properties. In South India, its timber is used for construction and as posts and shafts and very suitable for the manufacture of good quality tool handles etc.

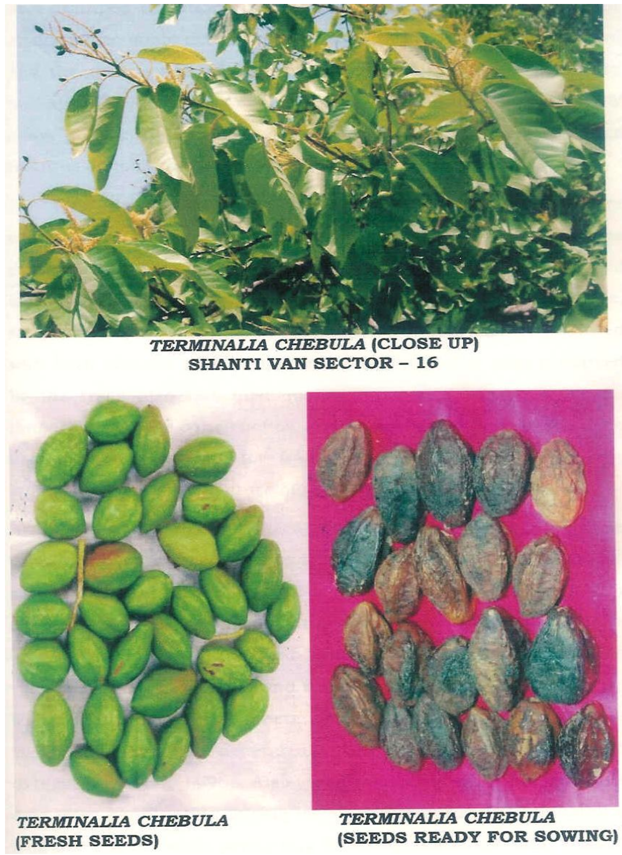


Plate 4

2. Areas of Concern

Tropical dry forests comprises tree communities growing in a warm to hot climates with a pronounced seasonal variation in rainfall and the ratio of potential evaporation to rainfall (E/R) is greater than one. Knowledge of seed viability, seed germination and seedling growth is required for the success of efforts in reforestation programs. The proportion of viable seeds might depend on the time of seed collection. Also, seed coat dormancy prevents the seed germination during isolated showers in the middle of a long dry season while permitting it during sustained rainy season [10]. Size of the seed influences the dispersal and seed water relations, and emergence, establishment, survival and growth of seedlings [11]. The large seeded primary forest species are relatively immobile because of low dispersal efficiency [12]. Seed size is genetically determined and there exists a wide inter-generic and inter-specific variation. Soil moisture availability is a key factor influencing the growth and survival of plant communities in tropical dry forests [13]. Increased water stress lessens the percentage and rate of seed germination [14]. A requirement of detailed study with immediate concerns on seed longevity, nature of seed dormancy, optimal temperatures for germination and conditions for storage of seeds reducing viability loss have been felt since long. Pre-treatment of seeds along with post seedling vigour carry considerable hope due to intra-specific diversity in traits of commercial importance [15].

Another method of mass production of good quality stocks is vegetative propagation to provide an uninterrupted supply of high quality planting stocks for forests. In general, woody trees are difficult to regenerate under *in vitro* conditions. Cloning of mature trees is generally preferred over seedling explants because it is often not possible to determine whether the embryos or seedlings have the genetic potential to develop the desired qualities later in their life cycle. Vegetative propagation ability varies between and within species, and even within an individual, depending upon the life stage [16]. Vegetative propagation was recommended as one of the main methods for the deployment of improved genetic forest tree species by detecting Quantitative Trait Loci (QTL) in *Quercus robur*, the pedunculate oak [17].

The Role of auxins and polyamines was also described in adventitious root formation in relation to changes in the duration of different rooting phases namely induction, initiation and expression [18]. Auxins are intimately involved in the process of adventitious root formation [19, 20] and the interdependent physiological stages of the rooting process are associated with changes in endogenous auxin concentrations [21]. Peroxidase activity regulates IAA catabolism and acts as a marker for the successive phases, typically with a minimum level at the induction phase and maximum at the initiation phase [22]. The rooting percentage success for jojoba stem cuttings was highest (75%) in April but the survival of the rooted cuttings was better in February and September trials with a clear indication that rooted stem cuttings had no bearing for their survival upon the best rooting phase [23]. The interaction amongst internal and external factors plays a paramount role in determining the rhizogenetic response of cuttings [24].

3. Interactive Studies on Seed Sowing, Season, Seed Scarification, PGR’s, Air-layering and Adventitious Rooting of Stem Cuttings

Propagation techniques through seed germination, adventitious rooting of stem cuttings and air-layering of tree species; *Aegle marmelos, Madhuca indica, Michelia champaca* and *Terminalia chebula* in relation to various factors [25] have been discussed:

3.1 Seasonal Variations

Highest seed viability observed during July-September when the seeds are fresh. Season of sowing had a significant effect in early and highest seed germination, length of root and shoot etc., and of course, subsequent seedling growth. Higher seed viability and favourable temperature in May-June or July-September could be a possible reason for better results. After this season, the viability of stored seeds reduced drastically in all four tree species. A significant correlation exists between seed germination and number of days elapsed [26]. Preliminary data with different pre-sowing treatments along with various growth regulators i.e., GA_3, NAA, IAA and ABA (0.2–0.5 mM each) substantiated the significance of GA_3 in seed germination of *Aegle marmelos, Madhuca indica, Michelia champaca* and *Terminalia chebula.*

Considering general effect of season on seed sowing, May-June and July- September seasons were optimum with regards to rapid and more germination, number of roots/seedling, length of root, length of shoot and leaf area in *Aegle marmelos Madhuca indica* and *Michelia champaca* and *Terminalia chebula.* However, highest root/shoot ratio and dry weight of seedlings could be obtained in February to March and November to December seasons in few cases. Favorable environmental conditions, i.e. humidity, temperature and photoperiod available during the growth of seedlings in these seasons may have increased absorption, transpiration, respiration and photosynthesis rates resulting in good growth. Among the growth regulators, GA_3 is more effective as compared to NAA, IAA, ABA. Different pre-sowing seed treatments and seasons significantly affect seed germination in tree species. Season of seed sowing played a vital role in germination.

3.2 Seed Scarification

The mechanical means like hot water (60 °C), conc. H_2SO_4 and water soaking in GA_3 (24 h) significantly increase the germination percentage, reduce the duration period for germination and improves growth of seedlings in most of the tree species. Dormancy of seeds resides in the hard seed coat which mainly interferes with water uptake and also acts as a mechanical restraint to radical emergence. It is argued that the scarification treatments improve germination due to removal of physical barrier and degradation of cementing substances in cell walls. Therefore, the beneficial effects of removal/softening of seed coat on seed germination might be due to the removal of hard seed coat itself or the toxic metabolites present in the seed coat [27]. Hard seed coat prevents the absorption of moisture for the solubility of phytohormones, enzymes etc. in the endosperm, nutrient uptake and aeration. Thus, application of GA_3 to the scarified seeds is appropriate to improve the seed germination and further growth of seedlings. GA_3 accelerates the enzyme reaction in the breakdown of starch, which is the first step of seed germination.

3.3 Adventitious Rooting

Success of rooting in stem cuttings depends upon the physiological status of mother stock plant, its nutrient status and general growth conditions; type of cutting, pre-planting treatments and environmental conditions including season. Regeneration of roots in cutting is basically a phenomenon of differentiation and growth at cellular level. The process of regeneration is related to the genetic properties of various tree species and status and activities of endogenous plant hormones. Further, it is influenced by exogenous application of growth regulators and their concentrations and season of propagation. The increase in percentage of rooting of cutting due to auxin treatment might be due to stimulation of nutritional reserves and their mobilization to the region of root formation. The process of root formation depends upon promoter/ inhibitor ratio [24]. Thus, easy-to-root species have higher concentration of promoters while difficult-to-root have more inhibitors. Further, it appears that growth regulators hasten the formation of root primordial, thereby helping in rooting of cuttings [28].

3.4 Air-layering

Generally, air layering is used in the propagation of those plants which do not show easier propagation through seeds or cuttings and are hard-to-root or do not root at all. Air layering of woody plants first initiate callus development and then, followed by root formation at the base of incision. The air layering has an added advantage over other methods since the food reserve of the parent branch induces formation of a well-developed root system. Success of air layers in woody tree species is generally determined by various external and internal factors which are common to the adventitious rooting of stem cuttings. In external factors, season, temperature, relative humidity and application of growth regulators and their concentration are important. The internal factors being tissue characteristics, age of the plant, nutritional status, endogenous root promoters and inhibitors, etc. [29] elaborated the role of different factors affecting the success of air-layering in *Acacia catechu*. Significantly increased rooting percentage can be achieved in all these tree species with growth regulators application to the air layers. July-September season is the best growth phase for obtaining more and earlier rooting, maximum number of roots/air layering and longest roots per air-layering. PGR’s improves the success of air layers with regard to percent rooting, days required for rooting, number of roots per air layer and length of root. IBA 500 ppm results maximum success of air layers in *Aegle marmelos, Michelia champaca* and *Terminalia chebula.* Strong and deep rooted plant system is essential to establish air layers in sound condition which can supply enough nutrient and moisture. Weak root system with fewer roots or non-formation of proper roots in air layers results in higher post–separation mortality reducing the final survival percentage in difficult-to-root species.

The relative performance of a particular genotype changes at different locations as a result of genotype and environment interaction. The temperature and humidity levels have a significant role in the propagation of tree species. In general, the application of auxins in lower concentration promotes root induction, but its optimal level varies with the plant species as well as the nature of auxins. Also, a proper balance between auxins and the nutrients is necessary for the optimal rooting response of cuttings.

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