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Studies on the Cultivation and Introduction of Sandalwood (*Santalum album* L) at Karachi, Pakistan 24°59'N 68°56'E

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Efforts were made to germinate the seeds of *Santalum album* L. (Sandalwood) for the first time in the Pakistan. The seeds germinated in about 8-16 days after the treatment of gibberellic acid to break the dormancy of the seeds. 500ppm gibberellic acid solution dose gave the optimum result and untreated seeds gave poor results. The paper encompasses the results related with the effect of irrigation on the germination of seeds and the seedling height plus the subsequent successful growth of this plant during the last 12 years. The optimum conditions for the growth of this plant are discussed.

Key words: *Santalum album*, Dormancy, Seed germination, Economics, Karachi.

Introduction

Sandalwood (*Santalum album* L.) is a small evergreen tree belonging to family Santalaceae. This tree has slender grouping branches, its height can reach upto 18m with a stem girth of 2.4m. Trees are reported to grow at an altitude of 600m and 1050m above sea level, although it may grow at higher heights upto 1350m on lower side they can grow down 360m.

The tree is native to India, parts of Malaysia, Australia, New Zealand and Polynesia. In India it grows wild mainly in the south of Karnataka and Tamil Nadu especially on the Plateau and regions adjacent to Deccan (Brandis 1971; Husain *et al* 1988).

Sandalwood is very much priced for its sweet smelling oil mainly located in its heartwood. The other portions of the plant containing the sandalwood oil (alpha and beta-Santalol) are the roots and the billets which contain 5.57-7% oil respectively. The chief constituents are 90% alpha and beta Santalol (Guenther 1952) which are stimulant on the nervous system (Okugawa *et al* 1955).

Besides the use of its oil in perfumery, the citron coloured wood of this plant is used for making boxes, necklaces, fans and other fancy articles. The plant is known to have the special medicinal significance. It is reported to the anodyne, antiseptic, astringent carminative, diaphoretic, diuretic, expectorant, febrifuge, stimulant and stomachic. It is a folk remedy for acne, boneache, bronchitis, cystitis, gonorrhea, headache, hiccups, nausea and urogenital ailments (List and Horhammer 1969-79; Perry 1980; Duke 1987).

Sandalwood tree is essentially a root parasite and it comes up well in conjunction with the host plants like *Azadirachta indica, Dalbergia sisso, Cassia siamea, Ruta graveolens etc.* (Nagavent and Sirimathi 1980). Before its cultivation, it is, therefore, very necessary to take care of the host parasite ratio, which plays a very important role in the artifical introduction of sandalwood. It is propagated by seeds both under natural and artifical conditions. The Seeds are reported to have a dormancy period of two to three months and the viability period of about eight months, (Nagaveni *et al* 1980). As the tree grows, the essential oil develops in the roots and heartwood, which requires atleast 15-20 years. Full maturity is reached after 60 to 80 years. The sandalwood tree is never felled, but uprooted in the rainy season, when the roots are richer in precious essential oil (Husain 1994).

Being a precious and economically important plant, efforts were made to cultivate and introduce this high altitude loving plant for first time at PCSIR Laboratories, Complex Karachi. Important data regarding its successful cultivation have been included in this paper.

Materials and Methods

Field and laboratory procedure. Source of seeds. Viable seeds of sandalwood were imported from the Forest Research Institute, Banglore, India, back in 1985. Seeds were obtained from plants over 20 years old.

Tetrazolium test. It is a biochemical method for testing the viability of seeds and is determine by the appearance of red colour in the seeds soaked in 2,3,5-triphenyl tetrazolium chloride solution (TTC). For this test the seeds were soaked in 0.2% solution of TTC for 24 hr. The pH of the solution was kept at 6.5. The living tissue changed the TTC to an insoluble red compound while the colour of non-living tissue remained unchanged (Mac Kay 1972; Moore 1973; Lakon 1994).

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Effect of gibberellic acid on the germination. The seeds of sandalwood were washed thoroughly with distilled water before treating them with gibberellic acid. The seeds were soaked for 24 hr in gibberellic acid solution of the following concentration: 400ppm, 500ppm and 600ppm in a water bath maintained at 40°C.

After the treatment, the seeds were washed with distilled water to ensure that the seed coat was free of gibberellic acid as its excess can cause the elongation of stem at the time of germination. The seed germination was recorded at 30°C. The cumulative data on the germination of seeds in different concentrations GA3 is presented in Fig 1.

*Culture experiments.*The treated seeds were sown in nursery beds measuring 3.5m x 2.5m beds, covered with fine layers of sand and adequately watered. No sweet sand and manure were added at the nursery stage. When the seedling attained the age of 45 days and were needle shaped, in general appearance, they were pricked in polyethylene bags having leaf compost and sweet-sand at a ratio of 1:1.

As there is a special requirement for the primary host for the cultivation of this plant, the seeds of *Cassia siamea* were simultaneously sown alongwith them. Plants were kept in light shade for 3 months. To control the nematode attack, Furadon was added in each container.

When seedling attained the height of 40 cm they were planted in the soil beds. Pits of 30 cm^3 were digged for planting the saplings in the month of September to October. The maximum distance between the pits was around 4 m. Manual weeding was done during the first 2 years. There is no particulars need of balanced use of fertilizer, and plant protection measures. The mean of temperature and humidity % for the last 12 years (1986-1997) has been given in Fig 2.

Irrigation. The record of irrigation was maintained daily, twice a week, weekly and fortnightly.

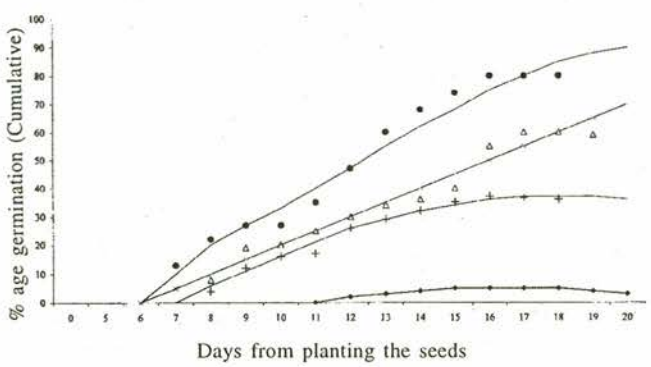

Fig 1. Effect of gibberelic acid on the germination of *Santalum album* seed at 30°C. O Control D 400 ppm · 500 ppm +600ppm.

Physico-chemical properties of soil. A composite sample of the soil was taken to determine its physico-chemical properties. Clay, silt and sand contents were determined by Bouyoucos hydrometer (Foth and Turk 1972). The pH and electrical conductivity were determined in a suspension of soil and water at a ratio of 1:2 on pH meter using glass electrode and the conductivity meter, respectively. Carbonates were determined by potentiometer method (Willham 1948). Concentration of micronutrients was determined on atomic absorption spectrophotmeter (Hitachi Z-8000 coupled with Zeeman's correction) employing DTPA extortion method (Chaudry *et al* 1978), organic matter was determined by dichromate method (Welcher 1973).

The analysis regarding the composition of the soil is as follows: sand 77.4%, clay 11.3%, silt 11.3%, texture of soil (loamy sand), pH 7.5, E.C. 1.5 mm-hos, organic matter 2.9%, $CaCO_3$ 15%, moisture content 6.03%, DTPA extract of soil contained Zn 8.2 ppm, Fe 60.8 ppm, Cu 0.16 ppm, Mn 43.4 ppm and Mg 660 ppm.

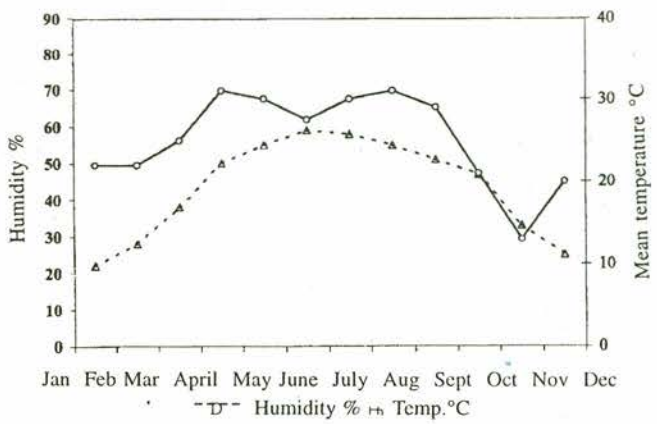

Fig 2. Mean of temperature and humidity % of 12 years (1986-1997).

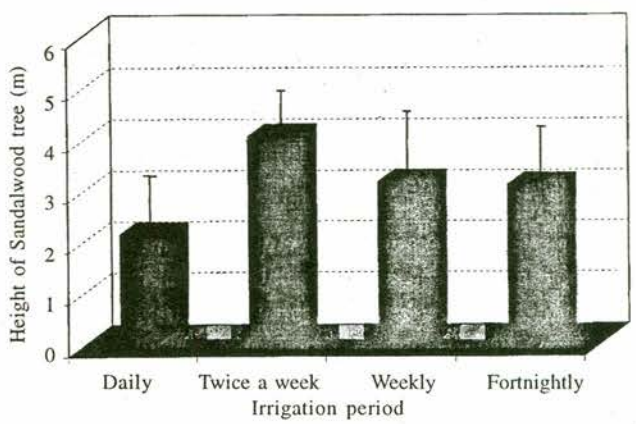

Fig 3. Effect of irrigation on the growth of Sandalwood tree from Jan.-Dec. (Mean of 12 years.1986-97) vertical bars show + SEM. P<0.0.05.

Results and Discussion

The first difficulty encountered with the cultivation of sandalwood was the dormancy of its seeds. To overcome this difficulty various concentrations of gibberellic acid (400, 500 and 600 ppm) were tried. The seeds showed maximum germination about 80% at 500ppm dose (Fig 1). They germinated in about 8-16 days at this dose. Nontreated seeds showed lesser degree of germination over an extended period of time. The optimum germination at 500 ppm dose indicates that dormancy breaking by gibberellic acid is concentration dependent (Audus 1963; Raychaudri and Verma 1980).

The selection of the host plant is another important factor for its cultivation. In our studies *Cassia siamea* was selected as host because of its resistance to spike disease, which commonly infect sandalwood tree (Raychaudhri and Verma 1980).

Effect of irrigation of any plantation largely depends on the climatic conditions i.e. temperature, humidity, wind speed and the soil moisture at a particular place. Considering the overall Karachi climate, the optimum irrigation schedule was found to be twice a week (Fig 3). During the course of study, it was observed that water logging was very critical for this plant. There is no need of watering this plant each day. Wilting and retardation of growth of those plants was observed by watering it daily, especially during the initial stages of plantation.

The rate of growth of sandalwood is known to depend on various factors like soil, climate, wind direction etc. The successful cultivation of sandalwood trees indicates that the above-mentioned factors are available for this plant in Karachi.

The average stem girth of 35 cm and the average height of 4.0 m (Table 1, Fig.4 A and 4 B) are clear proofs of it. The studies of ealier authors also indicate that the growth of this plant is satisfactory under our local conditions (Anonymous 1972). The trees grown are 12 years old now, which are flowering and fruiting each year. During all this time, attack of insects and fungi were observed. Keeping these observations in view, it can be concluded that sandalwood trees can be cultivated in Karachi quite successfully.

Table 1

The growth rate of sandalwood trees during the last 12 year period (1986-1997)

Age (Year)	Mean stem girth (cm)	Average height (cm/m)
1	2.5 ± 2	45 ± 2 cm
2	3.0 ± 1	50 ± 1 cm
3	5.3 ± 3	55 ± 2 cm
4	6.4 ± 2	65 ± 1 cm
5	8.4 ± 3	78 ± 2 cm
6	9.3 ± 1	1.0 ± 3 m
7	11.6 ± 3	1.5 ± 4 m
8	13.6 ± 4	2.0 ± 3 m
9	15.5 ± 2	2.5 ± 2 m
10	20.5 ± 2	3.0 ± 1 m
11	28.6 ± 3	3.5 ± 2 m
12	35.0 ± 4	4.0 ± 3 m

Values reported are mean ± SEM.

Fig 4A. Sandalwood tree growing in PCSIR Laboratories Complex, Karachi.

Fig 4B. Seed of Sandalwood and twig of healthy tree.

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