Verbenaceae—Verbena family

Tectona grandis L. f.

teak

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Growth habit, occurrence, and use. Native to Southeast Asia in India, Burma, Thailand, and Indochina, teak is the only important species of the 3 in the genus *Tectona* (Schubert 1974). It is a large deciduous tree that reaches maximum heights of 30 to 40 m. It grows best in warm, moist tropical climates with 1,250 to 3,000 mm of mean annual precipitation and a marked dry season of 3 to 6 months (Webb and others 1984). Teak has probably been cultivated for centuries in Asia and has been planted for timber production in India and Burma since at least 1840 (Troup 1921). In the Western Hemisphere, teak has been planted since about 1900, beginning in the Caribbean region (Marshall 1929; Moldenke 1935). Because it is a tropical species, in the continental United States, it grows successfully only in southern Florida. Successful adaptability trials have been conducted in Hawaii (Whitesell and Walters 1976). About 130 ha of teak plantations have been established in Puerto Rico and the U.S. Virgin Islands (Weaver 1993). Teak wood is famous the world over for its strength, durability, dimensional stability, working qualities, and the fact that it does not cause corrosion when in contact with metal (Kukachka 1970; Troup 1921). It is currently used for shipbuilding, fine furniture, trim, decorative objects, veneer for decorative plywood, posts, poles, and fuel (Kukachka 1970; Webb and others 1984).

Geographical races of teak have been distinguished by differences in stem form and rate of growth (Champion 1933). These are not recognized botanically even as varieties, but it is most important when establishing plantations to use seeds from a race that will grow well under local conditions (Beard 1943; Champion 1933; Laurie 1938). In Trinidad, trees grown from seeds of Burmese origin have been more satisfactory than those grown from seeds of Indian origin (Beard 1943).

Flowering and fruiting. The small white, perfect flowers of teak are borne on short pedicels, in large erect terminal panicles, about 2 months after the dry season has ended and the large obovate leaves have emerged. The dates vary somewhat depending on the climatic regime, but flowering generally takes place for several months between June and September, and the fruits ripen 2½ to 3 months later (Chable 1969; Mahapol 1954; Troup 1921; White and Cameron nd). The fruits gradually fall to the ground during the following dry season. The fruit consists of a subglobose, 4-lobed, hard bony stone about 1.2 cm in diameter, surrounded by a thick felty, light brown covering (figure 1), the whole enclosed in an inflated bladderlike papery involucre. The stone (often called a nut) contains 1 to 3, rarely 4, seeds (figure 2) and has a central cavity,

giving the appearance of a fifth cell. Schubert (1974) found that the average number of seeds per stone was 1.7. In a survey of the fruits of 23 provenances in India, an average of 51% of the fruits were found to have no seeds, 35% had 1 seed, 12% had 2 seeds, 2% had 3 seeds, and 0.4% had 4 seeds/fruit (Gupta and Kumar 1976).

Collection, extraction, and storage. Teak has borne viable seeds when only 3 years old (Schubert 1974), and good seedcrops are produced by plantations less than 20 years old (Troup 1921). The bladder-like involucre turns from green to brown when the seeds are ripe. The fruits can be swept up from the ground beneath the trees as they fall or else clipped with pruning poles or shaken from the branches. Drying can be completed by spreading the fruits on racks in the sun. For convenience in handling and storage, the involucre can be removed in a mechanical dehusker or by working a cloth bag half-filled with dried fruits against the ground with a foot and then winnowing to separate the fruits from the chaff. Teak fruits in Honduras average 705/kg (320/lb) with the involucres intact and 880/kg (400/lb) with the involucres removed (Chable 1969). In other parts of the world, the number of clean fruits per weight varies from a low of 880 to a high of 3,070/kg (400 to 1,400/lb) (Champion and Brasnett 1958; Parry 1956). The seeds make up about 3% of the weight of the cleaned fruits (Dabral 1976). Teak seeds are true orthodox in storage behavior and keep best at low temperatures and moisture contents. Keiding (1985) reported that seeds stored at 0 to 4 EC and about 12% moisture for 7 years lost no viability. Seeds from fruits stored in sacks in dry warehouses retained their viability for about 2 years (Kushalappa 1977). Longer periods of storage have not been needed in most areas because teak produces good seedcrops almost every year (Mahapol 1954; Troup 1921).

Germination tests. Cut tests of fruits on 56 collections from across the range of teak revealed a potential mean viability of 71% and ranged from 40 to 96% (Danish/FAO Forest Tree Seed Centre 1973). Laboratory germination tests should be carried out in sand at a constant 30 EC for 28 days. Pretreatment to stimulate germination should be 6 repetitions of soaking the fruits in water, followed by 3 days of drying (ISTA 1993). Germination in nursery beds in various parts of the world has varied from 0 to 96% in periods varying from 10 days to 3 months. Seeds extracted from the fruits and treated with fungicide gave a germination of 54% in 12 days (Dabral 1976). Because it is difficult to extract teak seeds from their fruits and untreated teak fruits give protracted, often low and unpredictable germination, some fruit pre-treatment in usually applied. Various pretreatments to hasten or improve germination have been used. Soaking the fruits in water for several days, or alternate wetting and drying as in laboratory testing, have proven effective (Schubert 1959; Troup 1921; White and Cameron nd). In one test, clean fruits were pretreated by 5 cycles of alternate soaking in water for 24 hours and drying in the sun for 48 hours and then sown. Germination began 18 days after sowing and continued to increase for 15 days, after which it gradually decreased. Germination 68 days after sowing was 61% of the total number of fruits sown (Schubert 1974). Weathering of the epicarp and mesocarp aids germination. Seeds inoculated with *Scytalidium* sp., a cellulolytic fungus isolated from teak litter, and kept moist for 21 days had 96% germination compared to 20% for uninoculated control (Dadwal and Jamaluddin 1988). Increases in germination of 5 to 12% over controls (21% germination) were obtained with treatments of IAA and GA alone and in combination at various concentrations (Uanikrishnan and Rajeeve 1990). A novel method reported from Thailand is to expose the fruits to ants for 1 to 2 weeks: they attack and remove the felty covering and thus speed up germination without loss of viability (Bryndum 1966). Soaking of fruits from 11 Indian

provenances in a nutrient solution resulted in a higher seedling yield (34%) than control (18%), water soak (30%) or scarification (28%). It is felt that nutrient deficiencies in some of the sources resulted in lower germination or early seedling failure (Gupta and Pattanath 1975). A temperature of 30 EC appears to be optimal for germinating teak seeds (Dabral 1976). Some seeds that were stored for several months germinated better than fresh seeds (Champion and Brasnett 1958; Mahapol 1954; Troup 1921), probably because seeds need a period of after-ripening (Coster 1933). Because they tend to have a greater number of seeds per fruit, larger fruits yield a significantly higher number of seedlings per fruit. It is recommended that fruits smaller than 14 mm in diameter be culled (Banik 1977). Seeds from dry regions frequently are more difficult to germinate (Troup 1921). Germination is epigeal (Troup 1921).

Nursery practice. Teak fruits are usually broadcast in nursery beds and covered with 1.2 to 2.5 cm (½ to x1 in) of sand, soil, or sawdust (Schubert 1956; White and Cameron nd). A seedling yield of about 25% can be expected from good seedlots (White and Cameron nd). The beds should be watered just enough to keep them moist. Once the seedlings have become established, watering should gradually be reduced. Field planting is generally done with "stump" plants (seedlings with the tops removed) or potted plants grown in plastic nursery bags. The stump plants are grown in the nursery until they reach 1.2 to 2.5 cm (½ to 1 in) in diameter at the root collar which have had the top cut back to about 2.5 cm (1 in) and the taproot cut back to 18 or 20 cm (7.0 to 7.9 in) in length (Schubert 1956; White and Cameron nd). Ideally, plants of suitable size can be grown in 6 to 9 months. In Thailand (Kushalappa 1977) and India (Gupta and Pattanath 1975) at least some nurseries undercut the beds and remove seedlings large enough for stump plants after 1 year and allow the rest to grow another year when the whole bed is harvested. Sowing of the nursery beds should be timed so that the proper size is reached in time for planting at the start of the rainy season. Another approach is to harvest in the dry season and store the dormant stumps in beds of dry sand for 3 months before planting at the start of the wet season (Kushalappa 1977). Direct seeding is also practiced. It requires prepared seed spots. Early growth is slow and often high mortality results (Weaver 1993). Teak can also be reproduced by coppicing, because cut stumps produce very vigorous sprouts.

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