MagnoliaceaeCMagnolia family

# *Liriodendron tulipifera* L.

## tuliptree

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**Other common names.** yellow-poplar, poplar, tulip-poplar, white poplar, whitewood.

**Growth habit, occurrence, and uses.** TuliptreeC*Liriodendron tulipifera* L.Coccurs naturally throughout the eastern United States from Vermont and southern Michigan south to Louisiana and north-central Florida (Little 1979). It grows under a variety of climatic conditions from sea level to 1,370 m elevation in the Appalachian Mountains and to 300 m in the northern part of its range. This large deciduous tree is among the tallest in the eastern United States and reaches considerable age: tuliptrees planted by George Washington still grow at Mount Vernon Griswold 1999). It can attain heights of 61 m and diameters of 2.4 to 3.7 m at maturity (Beck 1990). The wood is very valuable for lumber and veneer. It is a good honey tree and is planted extensively as an ornamental. Tuliptree has been cultivated since 1663 (Bonner and Russell 1974).

**Flowering and fruiting.** The large, perfect, greenish-yellow flowers of tuliptree open from April to June (Little and Delisle 1962). The fruit is an elongated cone composed of closely overlapped carpels that are dry, woody, and winged (figure 1). Each carpel (samara) contains 1 or 2 seeds (figure 2). The cones turn from green to yellow to light brown as they ripen; they mature from early August in the northern part of the range (Guard 1943) to late October in the South (Bonner and Russell 1974). As the mature cones dry on the trees, they break apart and the samaras are scattered by the wind. Peak dissemination occurs in October and November, but a few samaras fall as late as the following March (Carvell and Korstian 1955; Whipple 1968). In South Carolina, seedfall is usually at least 90% complete by early December (Goebel and McGregor 1973).

Good seed crops occur almost every year; failures, as well as bumper crops, occur infrequently. In North Carolina, 1 large tree produced 29,000 sound seeds, and seedfall of 1.5 million seeds/ha is not uncommon (Beck 1990). In a South Carolina study, 1 of 5 seedcrops was heavy (Goebel and McGregor 1973). Although trees as young as 9 years old have been reported to bear fruit, the normal commercial seed-bearing age of tuliptree is 15 to 20 years (Bonner and Russell 1974).

Tuliptree is pollinated by insects, and the number of filled samaras per cone is very low in natural stands (Boyce and Kaeiser 1961). There is considerable variation among trees, but a general average seems to be about 10% (Bonner and Russell 1974; Carvell and Korstian 1955; Heit 1942; Limstrom 1959; Sluder 1964; Swingle 1939; Whipple 1968). At the extreme northern part of the species= range in southern Ontario, the filled samara proportion was 8 to 10% in isolated trees and 20% in old-growth, high-density stands (Kavanagh and Carleton 1990). Filled samara proportions

in central Mississippi have ranged from 3.5% in isolated trees to 35% in older stands of mixed hardwoods with numerous large tuliptrees. Controlled pollinations in seed orchards have produced filled seed yields as high as 75% (Houston and Joehlin 1989). Some seed orchard managers have placed hives of honeybees in their orchards to increase seed production; results have been varied.

**Collection of fruits.** Mature cones may be picked by hand from standing trees or from logging slash. In the southern United States, cone maturity is first indicated by the color changes in cones from green to yellow, which usually occurs in late October. At this point, cone moisture content is still high (over 60% of fresh weight), and cones must be handled carefully to avoid overheating. Maturity is assured when cones turn dark brown in color, but dry weather can quickly cause cones in this condition to break apart and scatter the samaras (Bonner 1976b). Cones may be collected from logging slash felled as much as 4 weeks before natural maturity, but they must be dried slowly to allow maturation of the seeds. One way to do this is to wait 2 to 3 weeks after felling to pick the cones (Bonner 1976b). Cones and seeds may also be shaken onto canvas or plastic sheets from standing trees in early winter. A mechanical shaker was used successfully to dislodge cones from trees in West Virginia; from 9 to 95% of cones were collected from individual trees without apparent damage (Cech and Keys 1987). Cones from the upper two-thirds of the crown yield more full seeds than cones from the lower one-third (Guard and Wean 1941), probably because of inefficient pollination in the lower branches.

Cones should be spread out to dry immediately after collection. Drying sufficient to separate the samaras usually requires 7 to 20 days, depending on temperature, humidity, and cone moisture content (Bonner and Russell 1974). Cones may be dried more quickly by using the forced air systems of pine cone tray driers, but no heat should be applied.

**Extraction, cleaning, and storage of seeds.** Thoroughly dried cones can be broken apart by hand by shucking, flailing, or treading, or by running them through a hammer mill or macerator (Bonner and Russell 1974; Steavenson 1940). Tuliptree seeds can be de-winged in macerators or in oat debearders. After removal of wing fragments and fruit axes with air-screen cleaners, many of the empty (unfertilized) seeds can be removed with gravity tables or aspirators (Bonner and Switzer 1971). By this process, filled seed percentages of 6 to 10% can be upgraded to 60 or 65%. There are 80 to 100 samaras/cone (Bonner and Russell 1974). Yield data from various locations (table 1) suggest that samaras from southern trees are larger than those from northern trees.

Tuliptree seeds are orthodox in storage behavior; they may be stored at low seed moisture contents (6 to 10%) and low temperatures (2 to 5 °C). No long-term storage data are available, but storage for several years under these conditions without loss of viability is common (Bonner and Russell 1974). Excellent results have also been reported for 3 to 4 years of moist storage in outdoor soil pits (Paton 1945; Williams and Mony 1962) or in drums of moist sand held in cold storage at 2 °C (Bonner and Russell 1974).

**Pregermination treatments.** Seeds to be sown in the spring and seeds taken from dry storage need pretreatment to overcome dormancy. The traditional method of moist storage in well-drained pits or mounds of mixed soil, sand, and peat, can successfully overwinter for as long as 3 years (Bonner and Russell 1974; Williams and Mony 1962). Cold, moist stratification in plastic bags, both with or without peat moss or other media, in refrigerators for 60 to 90 days is widely used (Bonner and Russell 1974). Recommended temperatures for cold stratification are a constant 2 to 5 °C (Adams 1968; Bonner and Russell 1974), but alternating weekly temperatures of 0 and 10 °C

(Chadwick 1936) or 2 and 12 °C (Boyce and Hosner 1963) have also been successful. Percentage and rate of germination of some sources of tuliptree have been significantly increased by soaking seeds in solutions of the potassium salt of gibberellic acid ($GA_3$) (100 and 1,000 mg/l), but no practical application of this method has been reported (Bonner 1976a).

**Germination tests.** Germination tests should be carried out at the common alternating temperature regime of 20 °C in the dark for 16 hours and 30 °C in light for 8 hours. Seeds should be given cold, moist stratification for 60 to 90 days before testing on the top of moist blotters for a period of 28 days (AOSA 1993). If empty seeds have not been removed from test samples, germination percentages will be quite low because of the naturally low proportion of filled seeds common in this species. Germination of the filled seeds should be good, however; percentages of 80 to 90% are common (Bonner and Russell 1974). Seeds ungerminated at the end of a test should be cut to determine if any embryos are present. Viability can also be estimated by tetrazolium staining (ISTA 1993) and by radiography (Belcher and Vozzo 1979; Kaeiser and Boyce 1962; Taft 1962). Germination is epigeal (figure 3).

**Nursery practice.** Untreated seeds may be sown in the fall, but stratified seeds must be used for spring sowing. Seeds may be broadcast at rates of 25 to 75 kg/$m^2$ (1 to 3 lb/$ft^2$) of bed space or sown in rows 20 to 30 cm (8 to 12 in) apart at a rate of 80 to 100 seeds/m (24 to 30/ft) (Bonner and Russell 1974). Bed densities of 110 seedlings/$m^2$ (10/$ft^2$) are recommended (Williams and Hanks 1976). To assure proper bed density, the proportion of filled seeds must be known before sowing. The seeds should be covered with 6 mm (3 in) of soil or 12 to 25 mm (2 to 1 in) of sawdust and beds should be shaded for 1 to 2 months from the start of germination (Bonner and Russell 1974). Fumigation with MC-33 (67% methyl bromide plus 33% chloropicrin) at 300 pounds/acre has been recommended for control of cylindrocladium root rotCC*Cylindrocladium scoparium* Morg. (Affeltranger 1969), but the probable ban of methyl bromide in coming years will prevent the use of this method.

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**Figure 1**—*Liriodendron tulipifera,* tuliptree: cone and single samara, × 2.

**Figure 2**—*Liriodendron tulipifera,* tuliptree: longitudinal section through an embryo of a samara, × 4.

**Figure 3**—*Liriodendron tulipifera,* tuliptree: seedling development at 1, 18, and 48 days after germination.

**Table 1C***Liriodendron tulipifera,* tuliptree: seed yield data

| Place collected | Cone wt/ cone vol kg/hl | Cone wt/ cone vol lb/bu | Seed wt/ cone vol kg/hl | Seed wt/ cone vol lb/bu | Cleaned seeds Range /kg | Cleaned seeds Range /lb | Cleaned seeds Average /kg | Cleaned seeds Average /lb | Samples |
|---|---|---|---|---|---|---|---|---|---|
| Warren Co., MS | 39 | 30 | 8 | 6 | 9,455-17,200 | 4,288B7,804 | 12,680 | 5,750 | 3 |
| Oktibbeha Co., MS | 32 | 25 | C | C | C | C | C | C | C |
| North Carolina* | C | C | C | C | 32,430-75,080 | 14,710B34,050 | 41,200 | 18,700 | 9 |
| Eastern Tennessee | C | C | 9 | 7 | C | C | C | C | C |
| New York | C | C | C | C | 15,170-30,980 | 6,880B14,050 | 23,440 | 10,630 | 9 |
| | C | C | 9-24 | 7B19 | 22,050-52,920 | 10,000B24,000 | 30,870 | 14,000 | C |

**Sources:** Bonner and Russell (1974), Heit (1942).

* Seed moisture content was 10% when the counts were made.