

Ailanthus altissima (P. Mill.) Swingle

ailanthus

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Synonyms. *Toxicodendron altissimum* Mill., *Ailanthus glandulosa* Desf.

Other common names. Tree-of-heaven ailanthus, tree-of-heaven, copaltree.

Growth habit, occurrence, and use. Native to China, this 12.5- to 25-m-tall deciduous tree is described as "the most adaptable and pollution tolerant tree available" (Dirr 1990). Although it was originally considered a desirable ornamental tree, its desirability and usefulness are now questioned (Dirr 1990; Feret 1985). It is sometimes planted for shelterbelts, for game food and cover, and, rarely, for timber as in New Zealand. *Ailanthus* was introduced into cultivation in England in 1751 (Feret 1985; Illick and Brouse 1926) and brought to America in 1784 (Little 1974). It has become naturalized in many parts of the United States from Massachusetts to southern Ontario, Iowa, and Kansas, and south to Texas and Florida, as well as from the southern Rocky Mountains to the Pacific Coast (Feret and Bryant 1974; Feret and others 1974; Little 1979). In some localities, ailanthus is so well-established that it appears to be a part of the native flora. Wood properties are summarized by Alden (1995) and silvics by Miller (1990). There are a number of other *Ailanthus* species grown in other parts of the world for various purposes (Alam and Anis 1987; Beniwal and Singh 1990; Feret 1985; Rai 1985; Ramikrishnan and others 1990).

The tree of heaven is an aggressive, intolerant pioneer species with rapid juvenile growth of 1 to 1.5 m/year. It invades severely disturbed sites, harsh environments, and poor soils. It suckers from roots and can form dense stands, making it difficult for native species to colonize. Stands may be maintained by root suckering but it does not regenerate from seed under its own canopy (Bordeau and Laverick 1958; Miller 1990). One or more potent inhibitors of seed germination and seedling growth are produced in the bark, leaves, and seeds (Heisey 1990; Lawrence and others 1991). Heisey (1990) concluded that allelochemicals in ailanthus may have potential as naturally produced herbicides.

Flowering and Fruiting. The tree is mainly dioecious with some monoecious individuals (Dirr 1990; Miller 1990). Flowers are usually unisexual, but perfect flowers do occur in some individuals (Feret 1973). Flowering has been observed in seedlings 6 weeks after germination (Feret 1973).

Commercial "seed" consists of the 1-celled, 1-seeded, oblong, thin, spirally twisted samaras. These samaras, with seeds near the middle, are 8 to 12 mm wide and 33 to 48 mm long

(Feret and others 1974) and light reddish brown in color (figure 1). Flowering occurs from mid-April to July (Little 1974). Seeds ripen in large panicles in September to October of the same season and are dispersed from October to the following spring (Illick and Brouse 1926). *Ailanthus* is a prolific seeder: 15- to 20-year-old trees bear considerable quantities. Seeds have no endosperm (figure 2).

Collection of fruits; extraction and storage of seeds. *Ailanthus* seeds have been found in soil seed banks in stands with no individuals present in the overstory. This suggests that seeds may be stored in the soil for some period of time after parent trees have disappeared from the site (Dobberpuhl 1980).

Ailanthus fruits are picked from standing trees by hand or flailed or stripped onto canvas at any time during the late fall and early winter. After collection, the fruits should be spread out to dry (to lose superficial moisture). They may then be run through a macerator and fanned to remove impurities, or they may be flailed or trampled in a burlap bag and run through a fanning mill (Little 1974).

Forty-five kilograms (100 lb) of fruit yields 13.6 to 40.9 kg (30 to 90 lb) of cleaned seeds (Little 1974). Seeds with wings attached weigh from 22,700 to 75,500/kg (10,300 to 34,300/lb), with an average of about 38,700/kg (17,500/lb) (Feret and others 1974; Little 1974). Cleaned seeds (without wings) weigh from 29,000 to 43,000/kg (13,200 to 19,500) with a mean of 37,200/kg (16,900/lb) (Al'benskii and Nikitin 1956). Germination capacity of seedlots is normally in the 75 to 96% range (Al'benskii and Nikitin 1956; Graves 1990; Little 1974).

Seeds should be stored with low moisture contents at temperatures of 1 to 3 °C, and in sealed containers (Heit 1967). However, seed stored in sacks for over a year at temperatures ranging from -6 to 40 °C still had germination of 75% (Little 1974). In Russia, seeds are stored in boxes at 0 to 4 °C, layers about 2.5 cm (about 1 in) thick being separated and topped by layers of dry sand half as thick (Shumilina 1949). Although sensitive to moisture and fluctuating temperatures, seeds can be successfully stored for long periods in sealed containers at low moisture contents in a refrigerator (Heit 1967).

Germination. Stratification appears to improve germination in most cases, although varying amounts of germination occur in unstratified seeds (Bordeau and Laverick 1958; Dirr 1990; Graves 1990; Little 1974; Shumilina 1949). Graves (1990) found that although total germination was not affected by stratification, germination rate was greater in stratified seeds. Thirty to 60 days of stratification at 1 to 5 °C is usually recommended (Dirr 1990; Little 1974; Shumilina 1949), however, Graves reported 70, 77, and 96% germination after stratification at 5 °C for 0, 4, and 12 days, respectively. Seed testing rules recommend temperatures of 20 to 30 °C with no stratification (pericarp removal may increase germination rate); first evaluation at 7 days and a test duration of 21 days (ISTA 1993). *Ailanthus* seed germination was little affected by salt concentrations representative of roadside environments where salt is applied in winter; seeds of native oaks and birch were more sensitive (Bicknell and Smith 1975). Other *Ailanthus* spp. are more difficult to germinate than tree-of-heaven (Ramakrishnan and others 1990).

Nursery practice. Seeds can be sown immediately after collection if conditions permit or stratified and sown in the spring with drills. Broadcast seed should be covered with 1.3 cm (0.5 in) of soil. Fifteen to 25% of the viable seed sown produces usable 1+0 seedlings (Little

1974). Thus, 0.45 kg (1 lb) of seed may yield 3,000 usable plants (Van Dersal 1938). Greenhouse studies indicate that *Ailanthus* could be grown in containers (Feret and Bryant 1974; Feret and others 1974; Heninger and White 1974). Maximum seedling growth occurs at a soil temperature of 19 °C (Heninger and White 1974).

Ailanthus can be produced vegetatively from root cuttings (Dirr and Heuser 1987).

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