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Moraceae—Mulberry family

Morus L.

mulberry

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Growth habit, occurrence, and use. The mulberry genus—*Morus*—comprises about 12 species of deciduous trees and shrubs native to temperate and subtropical regions of Asia, Europe, and North America (Rehder 1956). Seeds of 2 native species and 2 naturalized species are described here (table 1). White (sometimes called "Russian") mulberry was introduced to the United States by Mennonites from Russia in 1875. The United States Prairie States Forestry Project planted an average of over 1 million trees of this species annually from 1937 through 1942 for windbreaks in the Great Plains from Nebraska to northern Texas (Read and Barnes 1974). The high drought resistance of white mulberry makes it well suited for shelterbelt planting (Read and Barnes 1974).

There are 2 mulberries indigenous to North America. Littleleaf mulberry occurs in Arizona, New Mexico, Oklahoma, Texas, and Mexico and has not been cultivated (table 1). Red mulberry has a wide range that covers most of the eastern United States, Great Lakes region, and the southern Great Plains. Though once common, red mulberry is decreasing over its range, possibly because of an unidentified bacterial disease (Moore and Thomas 1977). Its place is being taken by the introduced and naturalized white mulberry (Core 1974).

White mulberry is highly prized in Asia for its leaves, which are eaten by the silkworm—*Bombyx mori* L. The 7 or more forms and varieties of white mulberry differ in their relative drought resistance and in chromosome number and may be climatic races. Both white and red mulberry are diploids (2n=2x=28), but black mulberry has a high polyploidy level (2n=22x=308) (Ottman 1987).

Mulberries are valuable as food for birds and animals. Up to 18 bird species have been recorded eating the fruit in northeastern Kansas, with catbirds (*Dumetella carolinensis*) and robins (*Turdus migratorius*) consuming the most fruit (Stapanian 1982). Opossums (*Didelphis virginiana*), raccoons (*Procyon lotor*), fox squirrels (*Sciurus niger*), and eastern gray squirrels (*S. carolinensis*) eat the fruit in appreciable amounts, and cottontail rabbits (*Sylvilagus floridanus*) feed on the bark in winter (Core 1974).

All the mulberry species have white sap that contains latex (Hora 1981). The heartwood is durable, making it

Table 1—*Morus*, mulberry: nomenclature and occurrence

Scientific name & synonyms	Common name(s)	Occurrence
***M. alba* L.** *M. alba* var. *tatarica* (L.) Ser.	**white mulberry,** Russian mulberry, silkworm mulberry	China; naturalized in Europe & North America
***M. microphylla* Buckl.**	**littleleaf mulberry,** Texas mulberry, mountain mulberry	Arizona, New Mexico, Oklahoma, Texas, & Mexico
***M. nigra* L.**	**black mulberry,** Persian mulberry	Iran; widely cultivated in Europe
***M. rubra* L.**	**red mulberry**	Vermont & Massachusetts to New York, extreme S Ontario, Michigan, & Wisconsin, SE Minnesota, SE Nebraska, central Kansas, W Oklahoma, central Texas, E to S Florida

Sources: Core (1974), Read and Barnes (1974), Wasson (2001).

usable for fenceposts. Other specialty products include farm implements, cooperage, furniture, interior finish, and caskets (Burns and Honkala 1990).

Flowering and fruiting. Mulberry plants are normally dioecious, but they can also be monoecious on different branches of the same plant. The pendulous pistillate (female) and staminate (male) catkins are arranged on spikes and appear in April and May (Rehder 1956). The pistillate catkins in white mulberry are 0.5 to 2 cm long and staminate catkins are 2.5 to 4 cm long (FNAEC 1997; Radford and others 1968). The pistillate catkins in red mulberry are 1 to 3 cm long and the staminate catkins are 3 to 5 cm long (Radford and others 1968).

The green, female flowers have 4 sepals, 1 pistil that is 2-parted at the top, and a 2-locular ovary positioned above the floral organs. The ovary is about 2 mm long (Radford 1968). The style in white mulberry is red-brown and 0.5 to 1 mm long; the styles in red and littleleaf mulberries are whitish and about 1.5 mm long (FNAEC 1997). All mulberries have hairy stigmas. On the average, 44% of the pistillate inflorescences are parthenocarpic, with seedless fruits being somewhat smaller than seeded fruits (Griggs and Iwakiri 1973). Some varieties—such as Illinois everbearing mulberry, a cross between red and white mulberries—do not produce seeds (Reich 1992).

The male flowers are green tinged with red and have 4 sepals and 4 stamens; the filiform filaments vary from 2.7 mm in white mulberry to 3 to 3.5 mm in red mulberry (FNAEC 1997). The anthers open longitudinally (Fernald 1970). The sepals are pubescent and vary from 1.5 mm long in white mulberry to 2 to 2.5 mm in red mulberry (FNAEC 1997).

According to Griggs and Iwakiri (1973), the mulberry ovary is similar to that of other fleshy drupaceous fruits both morphologically and in growth pattern; therefore, the seed should be classified as a drupelet rather than an achene or nutlet. In the development of the mulberry fruit, the calyx adheres to the ovary and becomes an accessory part of the drupelet.

The multiple fruit is composed of many small, closely appressed drupelets (figure 1). Cultivated fruits are about 2 cm long, but fruits from native-grown trees are usually less than 1 cm long and have a cylindrical shape (Hora 1981). White mulberry fruits measure 1.5 to 2.5 x 1 cm, littleleaf mulberry fruits, 1 to 1.5 cm long, and red mulberry fruits, 1.5 to 6 x 1 cm (FNAEC 1997).

Red mulberry bears on the average 50 multiple fruits per branch and yields about 8.6 fruits/g or 8,600 fruits/kg (3,900 fruits/lb) (Burns and Honkala 1990; Griggs and Iwakiri 1973; Halls 1973). Mature trees can produce about 3.7 hl (10 bu) of fruit (Reich 1992). Open-grown trees produce up to about 7 times the amount of fruits per plant than do trees growing in the understory (Halls 1973).

Figure 1—*Morus*, mulberry: fruit and leaves of *M. alba*, white mulberry (**left**) and *M. rubra*, red mulberry (**right**).

Each fruit contains a dozen or more small drupelets (figures 2 and 3) that have thin, membranous coats and endocarps (stones) (Griggs and Iwakiri 1973). White mulberry yields about 10.7 to 32.0 drupelets per fruit, whereas red mulberry yields 10.7 to 30.0 drupelets per fruit (Stapanian 1982). Red mulberry seeds ("stones") are 2.8 mm long and 1.8 mm wide, white mulberry seeds are 2 to 3 mm long, and littleleaf mulberry seeds are about 2 mm long (FNAEC 1997). Red and littleleaf mulberry seeds are yellowish, whereas white mulberry seeds are light brown. Seed yield is up to 22 g/tree for open-grown plants and up to 3 g/tree for understory plants (Halls 1973). Seed embryos are curved, with cotyledon tips nearly touching the radicle (figure 3).

Fruits ripen and drop from the trees during the months of June to August (table 2), though they are often dispersed by birds and animals. Fruiting season can be extended by applying plenty of water during the summer months (Reich 1992). Varieties differ in size and color of ripe fruit (figure 1 and table 3) and vary in taste from insipid to sweet. The fruits stain everything they touch, so that planting mulberries along patios, sidewalks, driveways, and parking lots is NOT recommended (Reich 1992). Large fruit crops appear nearly every year on white mulberry in the Great Plains (Read and Barnes 1974) (table 3). Seed bearing begins at about 5 years of age for white mulberry, 2 years for open-grown red mulberry, and 4 years for red mulberry in the understory (table 3) (Halls 1973). In forest stands, optimum

Figure 2—*Morus alba*, white mulberry: longitudinal section through a seed.

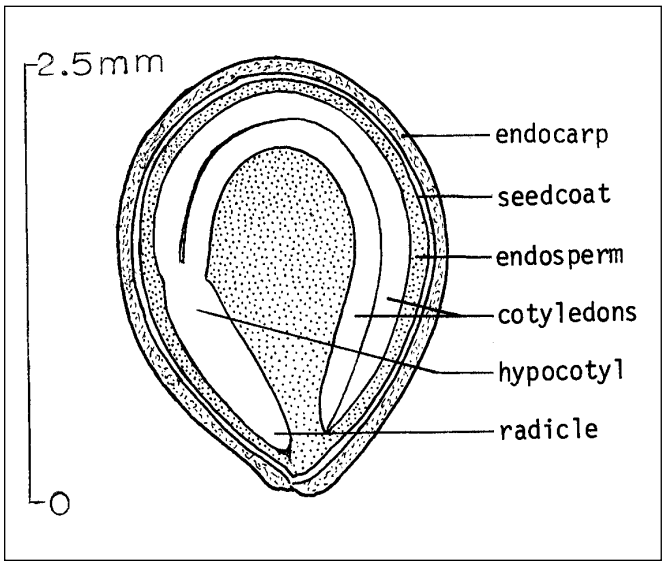

Figure 3—*Morus rubra*, red mulberry: cleaned seeds.

seed-bearing age is 30 to 85 years; the maximum being 125 years (Lamson 1990).

Collection of fruits. Before the fruits are collected, fruits from every tree should be sampled and checked, because mulberry fruits can develop without seeds. Ripe mulberry fruits may be collected by stripping, shaking, flailing, or waiting for them to fall from the tree onto a ground cloth. Fruits should be collected as soon as most are ripe to avoid loss to birds and animals. Seedlots of red mulberry fruits collected 4 to 5 days after falling yielded 89% germination, whereas seeds from fruits collected 1 to 2 weeks after falling reduced germination to 73% (Huffman 1996). Soaking red mulberry seeds in water for 48 and 72 hours reduced germination to 56 and 33%, respectively, making it advisable to not soak seeds for more than 24 hours (Huffman 1996). Seedlots from white mulberry fruits collected in early July that were cleaned and sown immediately showed 75% germination (Dirr and Heuser 1987). Fresh fruits, placed in tubs, can be stored in a cooler at 3 to 5 °C for up to 2 weeks without harming the seeds. Forty-five kilograms (100 lb) of fresh fruit of either species yields from 0.9 to 1.4 kg (2 to 3 lb) of clean seeds (Read and Barnes 1974) (table 4).

Extraction and storage of seeds. Fresh fruits are usually soaked in water and run through a macerator, where pulp and empty seeds are skimmed or floated off. If the fruits are not sufficiently ripe, soaking them in water for 24 hours will aid in the maceration. Fermentation at moderate indoor temperatures for 1 to 2 days before maceration facilitates extraction and improves viability of white mulberry seeds (Taylor 1941). A more efficient method is to spread the fruits on a clean floor, allow them to soften at room temperature for 4 to 5 days and then run them through a seed macerator with the water adjusted so that only the pulp goes through (the plate should be adjusted to 4 mm) (Engstrom

Table 2—*Morus*, mulberrry: phenology of flowering and fruiting

Species	Location	Flowering	Fruit ripening
M. alba	E US	May	July–Aug
	Nebraska	May	June–Aug
	Oklahoma	Apr	Late May–June
M. microphylla	SW US	Apr–May	June–Aug
M. rubra	E US	Apr–May	June–Aug

Sources: Engstrom (1969), FNAEC (1997), Little and Delisle (1962), Read and Barnes (1974), Rehder (1956).

Table 3—*Morus,* mulberry: height, seed-bearing age, seedcrop frequency, and fruit ripeness criteria

	Height at maturity (m)	Year first cultivated	Minimum seed-bearing age (yr)	Years between large crops	Fruit ripeness criteria	
					Preripe color	Ripe color
M. alba	3–14	1700s	5	—	White	White, pinkish, or purplish
M. microphylla	7.5	—	—	—	Dark green	Red, purple, or black
M. nigra	10	1548	—	Yearly	Greenish red	Purple to black
M. rubra	12	1629	10	2–3	—	Dark red, dark purple to black

Sources: Little and Delisle (1962), Read and Barnes (1974), Rehder (1956), Sargent (1940), Small (1933).

1969). The now-clean seeds remain. Small samples may be cleaned by rubbing the fruits gently through a 2.4-mm (#6) round-hole screen and floating off the pulp (Read and Barnes 1974). A 1% lye solution can be used to remove any sticky pulp left on the seeds after maceration.

Cleaned seeds should be spread to air-dry in the shade, then cleaned by fanning before storage or use. Lightweight trash and seeds can be removed with a gravity table (Myatt and others 1991). Subfreezing temperatures of –23 to –18 °C are recommended for storage of dry mulberry seeds (Engstrom 1969). Numbers of seeds per weight are listed in table 4.

Pregermination treatments. Germination of untreated seeds in the laboratory may vary greatly because part of each collection may consist of seeds with dormant embryos and impermeable seedcoats (Read and Barnes 1974). Engstrom (1969) found that some seeds that had no pretreatment—but were extracted from fruits that were fermented before the seeds were extracted—did germinate completely under light at low night and high day temperatures. Fresh seeds sown in the fall are usually not pretreated (Lamson 1990). For spring-sowing, stratification in moist sand at 0.6 to 5 °C for 30 to 120 days has improved germination (Afanasiev 1942; Core 1974; Lamson 1990; Read and Barnes 1974; Taylor 1941).

Germination tests. The International Seed Testing Association (ISTA 1999) recommends testing mulberry seeds on top of moist blotters for 28 days at diurnally alternating temperatures of 30 °C (day) for 8 hours and 20 °C (night) for 16 hours. No pretreatment is stipulated in the rules. Germination is epigeal. Red mulberry requires light to germinate under laboratory conditions (Dirr and Heuser 1987). Germination values of red mulberry seedlots obtained from official laboratory tests vary greatly. The germination after 30 days of cold moist stratification was 88% with 95% full seeds; germination after 60 days of cold moist stratification was 1 to 66% and after 90 days it was 3 to 68% (USDA FS 2002).

Tests on pretreated seeds run on wet absorbent paper, wet sand, and mixtures of sand and peat at the same temperature regime for 15 to 45 days with a daily light period of 8 to 16 hours resulted in germination ranging from 20 to 92% (Heit 1968; Read and Barnes 1974; Taylor 1941). In a laboratory study of seeds planted in sand, red mulberry seeds exhibited very high seedling emergence at 25 °C under moderate moisture conditions (4 to 20%) but did not germinate at 5 or 10 °C (Burton and Bazzaz 1991). Seedling emergence was calculated as 75% of the final emerging seedlings divided by the number of days required to achieve 75% emergence (Burton and Bazzaz 1991).

Nursery practice. In fall or spring, properly pretreated mulberry seeds mixed with sand may be broadcast or sown in drills. Rows can be drilled 20 to 30 cm (8 to 12 in) apart, with 164 seeds/m (50/ft) of row, and barely covered with soil. In Oklahoma, white mulberry is sown with 65 to 82 viable seeds/m (20 to 25/ft) in a 7.5- to 10-cm (3- to 4-in) band to produce 33 usable seedlings/m (10/ft) (Engstrom 1969). One Nebraska nursery uses a seedling density of 197 to 262/m of drill (60 to 80/ft) (Korves 1969). Freshly harvested and processed white mulberry seeds have been successfully hand-sown in July at 312 seeds/m^2 (29 seeds/ft^2), lightly raked, rolled, and then covered with straw mulch: germination occurred 2 weeks later (Peaslee 2002).

Beds should be mulched with straw, leaves, or burlap and kept moist until germination begins. Beds should be half-shaded for a few weeks after germination, which usually begins 1 to 2 weeks after spring-sowing (Dirr and Heuser 1987). Twelve to 50% of the seeds of white mulberry should produce usable seedlings. One-year-old seedling stock is used for field planting; seedlings should be dug about 25 cm (10 in) deep with a very sharp blade—main roots are rather stout and tough (Engstrom 1969).

Bacterial canker can be serious threat to white mulberry seedlings in the southern Great Plains; however, treatment of soil with formaldehyde solution before seeding has provided

Table 4—*Morus*, mulberry: seed yield data

Species	Seeds (x1,000)/weight				Samples
	Range		Average		
	/kg	/lb	/kg	/lb	
M. alba	286–770	130–350	517	235	18+
M. rubra	440–1,100	200–500	792	360	4

Sources: Engstrom and Stoeckler (1941), Read and Barnes (1974), Swingle (1939).

adequate control. Mulberry seedbeds should not be located near older mulberry trees (Davis and others 1942). Damping-off may occasionally be a problem, but losses are usually minimal, probably due to nursery cultural methods presently used (Wright 1944). Fungal leaf-spot caused by *Cercospora* spp. and *Mycosphaerella mori* (Fuckel.) E.A. Wolf, as well as bacterial leaf-spot caused by *Pseudomonas mori* (Boy. & Lamb.) Stev. may cause damage.

Mulberries are easy to root from summer softwoods; June and July are optimum months (Dirr and Heuser 1987). When mid-July cuttings were treated with 8,000 ppm IBA in talc and stuck into sand, 100% rooted in 3 weeks (Dirr and Heuser 1987).

References

Afanasiev M. 1942. Propagation of trees and shrubs by seed. Circ.C106. Oklahoma Agricultural Experiment Station. 43 p.

Burton PJ, Bazzaz FA. 1991. Tree seedling emergence on interactive temperature and moisture gradients and in patches of old-field vegetation. American Journal of Botany 78(1): 131–149.

Core EL. 1974. Red mulberry, *Morus rubra* L. In: Gill JD, Healy WM, comp. Shrubs and vines for northeastern wildlife. Gen. Tech. Rep. NE-9. Upper Darby, PA: USDA Forest Service, Northeastern Forest Experiment Station: 106–107.

Davis WC, Wright E, Hartley C. 1942. Diseases of forest-tree nursery stock. For. Pub. 9. Washington, DC: USDA Civilian Conservation Corps. 79 p.

Dirr MA, Heuser CW Jr. 1987. The reference manual of woody plant propagation: from seed to tissue culture. Athens, GA: Varsity Press. 239 p.

Dirr MA. 1998. Manual of woody landscape plants: their identification, ornamental characteristics, culture, propagation and uses. 5th ed. Champaign, IL: Stipes Publishing. 1187 p.

Engstrom A. 1969. Personal communication. Oklahoma City: Oklahoma Department of Agriculture, Forestry Division.

Engstrom HE, Stoeckler JH. 1941. Nursery practice for trees and shrubs suitable for planting on the Prairie-Plains. Misc. Pub. 434. Washington, DC: USDA. 159 p.

Fernald ML. 1970. Gray's manual of botany. 8th ed. New York: Van Nostrand Co. 1632 p.

FNAEC [Flora of North America Editorial Committee]. 1997. Flora of North America North to Mexico. Volume 3, Magnoliophyta: Magnoliidae and Hamamelidae. New York: Oxford University Press: 390–392.

Griggs WH, Iwakiri BT. 1973. Development of seeded and parthenocarpic fruits in mulberry (*Morus rubra* L.). Journal of Horticultural Science 48: 83–97.

Halls LK. 1973. Flowering and fruiting of southern browse species. Res. Pap. SO-90. New Orleans: USDA Forest Service, Southern Forest Experiment Station. 10 p.

Heit CE. 1968. Thirty-five years' testing of tree and shrub seed. Journal of Forestry 66: 632–634.

Hora B, ed. 1981. The Oxford encyclopedia of trees of the world. Oxford, UK: Oxford University Press. 288 p.

Huffman GR. 1996. Seed handling and propagation of hardwood trees and shrubs at Oklahoma Forestry Services' Forest Regeneration Center. In: Landis TD, South DB, tech coords. National Proceedings, Forest and Conservation Nursery Associations. Gen. Tech. Rep. PNW-389. Portland, OR: USDA Forest Service, Pacific Northwest Research Station: 43–48.

ISTA [International Seed Testing Association]. 1999. International rules for testing seeds: rules 1999. Seed Science and Technology 27 (Suppl.) 333 p.

Korves T. 1969. Correspondence. Fremont, NE: Plumfield Nursery.

Lamson NI. 1990. *Morus rubra* L., red mulberry. In: Burns RM, Honkala BH. tech. coords. Silvics of North America. Volume 2, Hardwoods. Agric. Handbk 654. Washington, DC: USDA Forest Service: 470–473.

Little EL Jr, Delisle AL. 1962. Time periods in development: forest trees, North American. In: Altman PL, Dittmer DS, eds. Growth including reproduction and morphological development. Washington, DC: Federation of American Societies for Experimental Biology: 382–386.

Myatt A, Huffman G, Odell J. 1991. Seed processing manual. Washington, OK: Oklahoma Department of Agriculture, Forestry Division, Forest Regeneration Center.

Moore DM, Thomas WP. 1977. Red mulberry, *Morus rubra* L. In: Halls LK, ed. Southern fruit-producing woody plants used by wildlife. Gen. Tech. Rep. SO-16. New Orleans: USDA Forest Service, Southern Forest Experiment Station: 55–56.

Ottman Y. 1987. Rediscovering the realm of fruiting mulberry varieties. Fruit Varieties Journal 41(1): 4–7.

Peaslee A. 2002. Personal communication. Jackson, NJ: New Jersey Forest Tree Nursery.

Radford AE, Ahles HE, Bell CR. 1968. Manual of the vascular flora of the Carolinas. Chapel Hill: University of North Carolina Press. 1183 p.

Read RA, Barnes RL. 1974. *Morus* L., mulberry. In: Schopmeyer CS, tech. coord. Seeds of woody plants in the United States. Agric. Handbk 450. Washington, DC: USDA Forest Service: 544–547.

Rehder A. 1956. Manual of cultivated trees and shrubs hardy in North America. 2nd ed. New York: Macmillan. 996 p.

Reich L. 1992. Native American fruits. Organic gardening 39(2): 52, 54–57.

Sargent CS. 1940. Manual of the trees of North America (exclusive of Mexico). 2nd ed., corrected and reprinted. New York: Dover. 934 p.

Small JK. 1933. Manual of the southeastern flora. New York: J.K. Small. 1554 p.

Stapanian MA. 1982. A model for fruiting display: seed dispersal by birds for mulberry trees. Ecology 63(5): 1432–1443.

Swingle CF, comp. 1939. Seed propagation of trees, shrubs, and forbs for conservation planting. SCS-TP-27. Washington, DC: USDA Soil Conservation Service. 198 p.

Taylor CA. 1941. Germination behavior of tree seeds. Washington, DC: USDA Forest Service, Prairie States Forestry Project. 64 p.

USDA FS [USDA Forest Service]. 2002. Unpublished data. Dry Branch, GA: National Tree Seed Laboratory.

Wasson E. 2001. Trees and shrubs: illustrated A–Z of over 8500 plants. Willoughby, NSW, Australia: Global Book Publishing: 483–484.

Wright E. 1944. Damping-off in broadleaf nurseries of the Great Plains region. Journal of Agricultural Research 69: 77–94.