

I. Introduction

Origin and History

Black walnut (*Juglans nigra* L.), also known as eastern black walnut or American walnut, is a fine hardwood species in the family Juglandaceae, section *Rhysocaryon* (Manning 1978). In general, *J. nigra* will not cross with species in the sections *Cardiocaryon* or *Trachycaryon*, but *J. nigra* will cross with *J. ailantifolia* (*Cardiocaryon*) (Williams 1990). *Juglans nigra* will also hybridize to some extent with other *Juglans* species (*Dioscaryon* and *Rhysocaryon*) and one hybrid is recognized: *J. nigra* x *J. regia* = *J. x intermedia* Carr. (USDA-NRCS 2004). Native to the deciduous forests of the eastern United States (US), from Massachusetts to Florida and west to Minnesota and Texas, and occurring naturally in southern Ontario, Canada, black walnut is seldom found in pure stands, but rather in association with five mixed mesophytic forest cover types: sugar maple, yellow poplar, yellow poplar – white oak – northern red oak, beech – sugar maple, and silver maple – American elm (Williams 1990). Black walnut is a large tree and on good sites may attain a height of 30 to 38 m, diameter of 76 to 120 cm, and can exceed 100 years of age (Williams 1990; Dirr 1998; USDA-NRCS 2004). Black walnut is shade intolerant, and control of competing vegetation is especially important in new plantations for the first 3 to 4 years. Black walnut grows best on moist, deep, fertile, well-drained, loamy soils; although it also grows quite well in silty clay loam soils or in good agricultural soils without a fragipan (Williams 1990; Cogliastro et al. 1997). These sites include coves, bottomlands, abandoned agricultural fields, and rich woodlands. Black walnut forms a deep taproot, wide-spreading lateral roots, and has been cultivated since 1686. A toxic chemical ‘juglone’ (5-hydroxy-1, 4-naphthoquinone), naturally occurring in the leaves, buds, bark, nut husks, and roots of black walnut, is a highly selective, cell permeable, irreversible inhibitor of the parvulin family of peptidyl-prolyl *cis/trans* isomerases (PPIases) and functions by covalently modifying sulfhydryl groups in the target enzymes (Henning et al. 1998; Chao et al. 2001). Certain plants, especially tomato, apple, and several conifer species, are adversely affected (allelopathy; foliar yellowing, wilting, and even death) by being grown near the roots of black walnut trees (Goodell 1984; Dana and Lerner 1994). Horses can contract acute laminitis, an inflammation of the foot, when black walnut wood chips or sawdust is used for stall bedding or stables, and paddocks are located too close to walnut trees (Galey et al. 1991). Historically, the bark of black walnut was used by several Native Americans, including the Cherokee, Delaware, Iroquois, and Meskwaki, in tea as a cathartic, emetic, or disease remedy agent, and chewed or applied for toothaches, snake bites, and headaches (Moerman 1998; Moerman 2003). *Caution: the bark should be used cautiously in medicine because it is poisonous.* The Cherokee, Chippewa, and Meskwaki also used the bark to make a dark brown or black dye (Moerman 1998; Moerman 2003). The Comanche pulverized the leaves of black walnut for treatment of ringworm, the Cherokee used leaves to make a green dye, and the Delaware used the leaves as an insecticide to dispel fleas (Moerman 1998; Moerman

2003). The nut meats were also a food source for Native Americans, and the nuts are still consumed today by people and are an important food source for wildlife.

Botany

Juglans nigra (section *Rhysocaryon*) is the largest and the most valuable timber tree of the *Juglans* species, and is hardy to USDA hardiness zone range of four to nine (Dirr 1998). Black walnut is monoecious with male and female flowers maturing at different times (McDaniel 1956). Staminate catkins (5 to 10 cm) develop from axillary buds on the previous year's wood and appear as small, scaly, cone-like buds, and the female flowers occur in two- to eight-flowered spikes borne on the current year's shoots (Brinkman 1974; Williams 1990; Flora of North America Editorial Committee 1993+; Dirr 1998). The female flowers more commonly appear first (protogyny) and flowering occurs with or shortly after the leaves. Because flowering is dichogamous self-pollination is unlikely, thereby promoting outcrossing. The fruit is a drupe-like, furrowed nut enclosed in a thick, indehiscent yellowish-green husk that develops from a floral involucre (Brinkman 1974). Fruits are subglobose to globose, rarely ellipsoid, 3.5 to 8 cm, warty, with scales and capitate-glandular hairs (Flora of North America Editorial Committee 1993+). The fruit occur singly or in clusters of two to three, and are edible, sweet, oily, and high in protein (Reid 1990). The nut is subglobose to globose, rarely ellipsoid, 3 to 4 cm, very deeply longitudinally grooved, and the surface between the grooves is coarsely warty (Flora of North America Editorial Committee 1993+). Leaves are alternate, pinnately compound, 30 to 60 cm long, with nine to 23 leaflets, nearly glabrous and somewhat lustrous dark green, pubescent and glandular beneath, with petioles 6.5 to 14 cm long covered with glandular hairs (Flora of North America Editorial Committee 1993+; Dirr 1998). Black walnut stems are stout, densely grey-downy, smooth and reddish buff; have a chambered light brown pith (paler than that of butternut, *J. cinerea*), and a distinctly notched leaf scar. Terminal buds are ovoid or subglobose, 8 to 10 mm long, and weakly flattened (Flora of North America Editorial Committee 1993+). Lateral buds are smaller, often superposed, and greyish in color. *Juglans nigra* has a dark grey or brownish bark, deeply split into narrow furrows and thin ridges, the ridges are chocolate in color when cut, forming a roughly diamond-shaped pattern. The sapwood of black walnut is nearly white and the heartwood varies from light to dark brown. The wood is heavy, hard, strong, stiff, normally straight grained, and has good resistance to shock (Forests Products Laboratory 1999). The chromosome number of black walnut is $2n = 32$ (Woodworth 1930). Black walnut trees produce seed at about 12 years of age, with good seed crops occurring every 2 to 3 years (Brinkman 1974). Seeds of black walnut, like most *Juglans* spp., have a dormant embryo, but dormancy can be broken by fall sowing or by moist prechilling of seeds at 1 to 5 °C for 3 to 4 months (Brinkman 1974).

Economic Importance

Black walnut is one of the largest hardwood trees found in the US, and is valued economically and ecologically for its wood and edible nuts. Quality black walnut wood demands high market prices for many uses including furniture, veneer, cabinets, interior architectural woodwork, flooring, and gunstocks. Black walnut wood with figured grain demands even higher market prices. Curly and wavy figure can produce interesting characteristics in veneers, and these can arise from walnut butts, crotches, and burls. The nut is an important food source for wildlife and is also consumed by humans. The majority of black walnut trees occur in natural stands, with walnut plantations (approximately 13, 800 ac) accounting for one percent of all the black walnut volume (ft³) in the US (Shifley 2004). There are 11 states that currently have the greatest volume of black walnut growing stock on timberland, and these include Missouri, Ohio, Iowa, Indiana, Illinois, Tennessee, West Virginia, Kansas, Pennsylvania, Virginia, and Michigan (Shifley 2004). Since the last (1997) comprehensive inventory and summary of the black walnut resource in the eastern US, the number and volume of black walnut trees has increased, except in Michigan, Virginia, and Pennsylvania where walnut volume is level or decreasing (Shifley 2004). In addition to the multi-million dollar US market consumption of walnut wood, for the period 1999-2003, the US exported walnut lumber to 67 countries (58,434.2 m³; \$40,964,481.; averages per year) and walnut logs to 49 countries (62,897 m³; \$37,238,327.; averages per year) (USDA-FAS 2004). Black walnut yields edible nuts that are used in baking (cookies, cakes, etc.) and ice cream products. The Hammons Products Company (Stockton, MO; <http://www.black-walnuts.com>) is the world's premier processor and supplier of American black walnuts for both food and industrial uses. Selection of black walnut trees for nut quality and production has developed slowly over the years, but over 700 cultivars have been named and the percent of edible kernel has improved to over 34% (Reid 1990; Reid et al. 2004). Black walnuts are low in saturated fats (3.4 g per 100 g edible nut), have zero cholesterol, and are high in polyunsaturated (35.1 g per 100 g edible nut) and monounsaturated fats (15 g per 100 g edible nut) (USDA-ARS 2004). Black walnuts are also a good source of protein (24.1 g per 100 g edible nut) and fiber (6.8 g per 100 g edible nut) containing low levels of sugar (1.1 g per 100 g edible nut) (USDA-ARS 2004). Ground black walnut shell (see Hammons Products Company, <http://www.black-walnuts.com>) is a hard, durable, non-toxic, biodegradable abrasive product used for blast cleaning and polishing. It is also used for industrial tumbling and deburring, as well as for uses in oil well drilling, water filtration, and as explosive fillers.

References

Brinkman KA (1974) *Juglans* L. Walnut. In: Schopmeyer CS (tech coord) Seeds of woody plants in the United States, USDA For Serv Agric Handb 450, Washington, pp 454-459

- Chao SH, Greenleaf AL, Price DH (2001) Juglone, an inhibitor of the peptidyl-prolyl isomerase Pin1, also directly blocks transcription. *Nucl Acids Res* 29 (3):767-773
- Cogliastro A, Gagnon D, Bouchard A (1997) Experimental determination of soil characteristics optimal for the growth of ten hardwoods planted on abandoned farmland. *For Ecol Manage* 96 (1-2):49-63
- Dana MN, Lerner BR (1994) Black walnut toxicity. HO-193, Purdue Univ Coop Exten Serv, West Lafayette, pp 1-2
- Dirr MA (1998) Manual of woody landscape plants: their identification, ornamental characteristics, culture, propagation and uses, 5th edn. Stipes Publishing, Champaign, pp 500-502
- Flora of North America Editorial Committee (1993+) Flora of North America North of Mexico, 7+ vols. New York and Oxford, <http://www.eFloras.org>
- Forest Products Laboratory (1999) Wood Handbook—Wood as an Engineering Material. Gen Tech Rep FPL-GTR-113. USDA For Serv, For Products Lab, Madison, p 9
- Galey FD, Whiteley HE, Goetz TE, Kuenstler AR, Davis CA, Beasley VR (1991) Black walnut (*Juglans nigra*) toxicosis: a model for equine laminitis. *J Comp Pathol* 104:313-326
- Goodell E (1984) Walnuts for the northeast. *Arnoldia* 44 (1): 3-19
- Henning L, Christner C, Kipping M, Schelbert B, Rucknagel KP, Grabley S, Kullertz G, Fischer G (1998) Selective inactivation of parvulin-like peptidyl-prolyl *cis/trans* isomerases by juglone. *Biochem* 37:5953-5960
- Manning WE (1978) The classification within the Juglandaceae. *Ann Mo Bot Gard* 65:1058-1087
- McDaniel JC (1956) The pollination of Juglandaceae varieties - Illinois observations and review of earlier studies. *Annu Rep North Nut Grow Assoc* 47:118-132 (published in 1957)
- Moerman DE (1998) Native American ethnobotany. Timber Press, Portland, pp 927
- Moerman DE (2003) Native American ethnobotany: a database of foods, drugs, dyes and fibers of Native American peoples, derived from plants. University of Michigan – Dearborn, (<http://herb.umd.umich.edu>)
- Reid W (1990) Eastern black walnut: potential for commercial nut producing cultivars. In: Janick J, Simon JE (eds) *Advances in new crops*, Timber Press, Portland, pp 327-331
- Reid W, Coggeshall MV, Hunt KL (2004) Cultivar evaluation and development for black walnut orchards. In: Michler CH, Pijut PM, Van Sambeek J, Coggeshall M, Seifert J, Woeste K, Overton R (eds) *Black walnut in a new century*, Proc 6th Walnut Council Res Symp, Gen tech Rep NC-243, US Dept Agric, For Serv, North Central Res Stn, pp 18-24
- Shifley SR (2004) The black walnut resource in the United States. In: Michler CH, Pijut PM, Van Sambeek J, Coggeshall M, Seifert J, Woeste K, Overton R (eds) *Black walnut in a new century*, Proc

6th Walnut Council Res Symp, Gen tech Rep NC-243, US Dept Agric, For Serv, North Central Res Stn, pp 188

USDA-ARS (2004) U.S. Department of Agriculture, Agricultural Research Service, USDA nutrient data lab, USDA national nutrient database for standard reference, release 17 (<http://www.nal.usda.gov/fnic/foodcomp>)

USDA-FAS (2005) Foreign Agricultural Service Export Commodity Aggregations, Dept of Commerce, US Census Bureau, Foreign Trade Statistics (<http://www.fas.usda.gov/ustrade>)

USDA-NRCS 2004 The PLANTS Database, Version 3.5 (<http://plants.usda.gov>). National Plant Data Center, Baton Rouge.

Williams RD (1990) *Juglans nigra* L., Black walnut. In: Burns RM, Honkala BH (tech coords) Silvics of North America, Vol 2. Hardwoods. USDA For Serv Agric Handb 654, Washington, pp 386-390

Woodworth RH (1930) Meiosis of microsporogenesis in the Juglandaceae. *Am J Bot* 17(9): 863-869