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Growing Black Walnut for Nut Production

by William Reid, *Nut Crops Specialist, Kansas State University;* ***Mark Coggeshall,*** *Tree Improvement Specialist, University of Missouri Center for Agroforestry;* ***H.E. "Gene" Garrett,*** *Director, University of Missouri Center for Agroforestry; and* ***Jerry Van Sambeek,*** *Research Plant Physiologist, USDA Forest Service*

Eastern black walnut trees (*Juglans nigra*) produce high-value, hardwood products and distinctively flavored, edible nuts. The potential for producing two valuable products from the same tree has captured the imagination of tree planters for years. Both large and small black walnut plantations have been established with the intent to harvest huge nut crops from trees that will eventually produce veneer-quality logs. However, if experience has taught us anything about black walnut, it is that optimum nut production and optimum wood production are not normally produced by the same tree.

Nut production vs. wood production

Black walnut culture is really the story of two totally different trees all wrapped up into one tree species. The first tree is the walnut timber tree. This tree grows tall and straight in a forest of mixed hardwood trees. Timber-type trees in natural stands or man-made plantations are grown closely together with little or no sunlight reaching the forest floor. Looking upwards, you will note a long, branchless trunk topped by a relatively small canopy of leaves with few, if any, nuts among the leaves. Black walnut timber trees often grow more than 80 years to produce high-quality lumber or veneer.

The second tree is the walnut orchard tree. The orchard tree, by design, has a short trunk, wide spreading branches, and full canopy **(Fig.1).** Trees in the orchard are widely spaced to allow sunlight to reach the lowest limbs. Orchard trees may be grafted to cultivars with proven nut-bearing characteristics. Nuts are produced on terminal shoots and throughout the tree's canopy on short, stout branches or spurs. When grafted to selected cultivars, trees produce thin-shelled black walnuts that yield the high-quality, light-colored kernels that command top price in the marketplace. Grafted orchard trees are precocious, producing nuts within seven years of tree establishment, with the first significant commercial harvest starting at about age 10.

Every black walnut tree grows wood in the form of limbs, trunk and roots. And as the tree matures, every walnut tree will produce at least a small nut crop. The question is not whether a walnut tree can grow both wood and nuts, but rather which crop you wish to maximize. In this bulletin, we describe the cultural practices and cultivar choices necessary to maximize nut production from black walnut trees. Recommendations for black walnut timber production can be found in other bulletins such as the "Managers Handbook for Black Walnut" (Schlesinger and Funk) and the "Walnut Notes" (Burde) ***(see Additional Resources, pg. 15).***

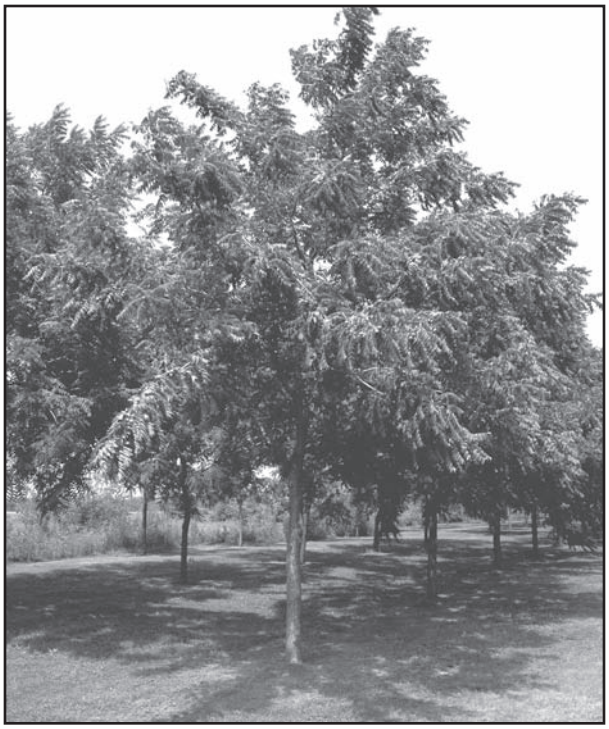


Fig. 1: A black walnut orchard has widely spaced trees that develop a full canopy.

Setting Goals for the Orchard

The ultimate success of a black walnut planting will be defined by the goals you set for the orchard before a single tree is planted.

Black walnut orchards can be established for many reasons, including:

- *To provide the family with high-quality black walnut kernels;*
- *To collect, test or develop black walnut cultivars as a hobby;*
- *To produce a commercially marketable nut crop.*

The methods used to establish the orchard and the intensity of management used to produce a nut crop will differ depending on the goals you set for the planting. The backyard orchardist often grows a few black walnut trees with minimal inputs. Under these conditions, black walnuts will produce an ample supply of nuts in some years allowing the grower to fill his freezer with high-quality walnut kernels that can be utilized during years the trees produce little or no nut crop.

In contrast, the commercial orchardist makes major investments in fertilizers and pesticides to ensure maximum annual nut production. In addition, the commercial orchard must be large enough to allow the efficient utilization of specialized orchard equipment such as orchard sprayers, tree shakers and mechanical nut harvesters.

When drawing up your plans for planting black walnut trees, set realistic goals for both yourself and your trees. It is better to take excellent care of fewer trees than to plant too many trees and become frustrated by not being able to keep up with an exhausting work schedule.

Site Selection

Black walnut trees perform best when grown on deep, well-drained soils. Attempts to establish black walnut trees on shallow soils or excessively wet soils will usually fail. Any soil condition that restricts root penetration to less than 3 feet will slow tree growth and limit nut production. Walnut trees will thrive in soils that range from slightly acidic to slightly basic (pH 6.0 to 7.5) and have a high level of inherit fertility. Problems with pH and low phosphorus need to be corrected during site preparation, along with the removal of tall fescue and other perennial vegetation. (Lime and phosphorus must be incorporated to be effective.)

Commercial orchards should only be established on the very best of black walnut sites. These sites are usually found in broad river bottoms where deep, rich soils create ideal conditions for tree growth. Upland sites with deep, fertile soils and excellent water holding capacity also make acceptable orchard sites. Commercial orchards should not be established on sites that tend to be droughty. Lack of soil moisture during the growing season will severely affect nut quality and accentuate alternate bearing.

Black walnut trees are sensitive to spring frost injury. Freezing temperatures after the onset of budbreak can result in the loss of a tree's entire nut crop. When establishing a black walnut orchard, avoid planting trees in narrow valleys where frost pockets can develop.

The Natural Resource Conservation Service now has a Black Walnut Suitability Index online. Use the Web Soil Survey at http://websoilsurvey.nrcs.usda.gov/app/ and find the black walnut mapping (for Missouri only) under the "Vegetative Productivity" function.

Cultivar Selection

The production of thin-shelled, high-quality nuts is only possible by growing black walnut trees that have been grafted to cultivars known to have these characteristics. In choosing cultivars for your walnut orchard, review all cultivar traits but, keep in mind, there is no "perfect" walnut cultivar that provides all positive characteristics in a single tree. Key cultivar traits include: leafing date, nut weight and percent kernel, disease resistance, and bearing tendency. Recommended cultivars and their key cultivar traits are listed in **Table 1, pg. 3**.

In addition, Center for Agroforestry black walnut researchers have created an online tool to aid potential growers in choosing which cultivars will work for them. The tool can be found at http://extension.missouri.edu/publications/DisplayPub.aspx?P=XM1001

Leafing and flowering dates Black walnut trees are among the latest trees to break dormancy in eastern deciduous forests. Late-leafing is nature's way of ensuring

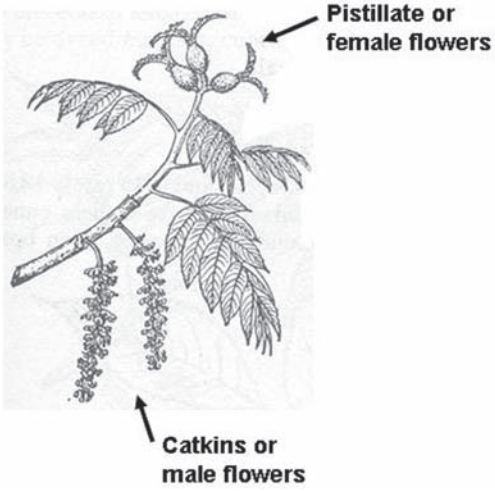


Fig. 2: Catkins are borne on one-year old wood, while pistillate flowers appear on the terminal end of new shoots.

Table 1: Recommended Black Walnut Cultivars							
Cultivar	**Leafing Date[1]**	**Spur Fruiting**	**Anthracnose Susceptibility**	**Nut Weight (g)**	**Percent Kernel**	**Alternate Bearing Tendency**	**Ripening Season[2]**
Sparrow	15	no	low	19	32	medium	early
Sparks 127	12	yes	high	15	33	high	early
Tomboy	7	no	low	22	27	medium	early
Emma K	5	yes	medium	19	34	high	mid
Mintle	4	no	high	16	31	high	mid
McGinnis	4	yes	medium	17	31	high	mid
Drake	17	no	high	19	30	medium	mid
Kwik Krop	15	yes	medium	17	31	high	mid
Sparks 147	21	yes	medium	17	36	medium	mid
Sauber	13	yes	high	15	32	high	mid
Football	6	yes	high	22	29	high	late
Hay	23	yes	low	22	32	medium	late
Rupert	8	yes	low	18	26	low	late
Surprise	13	yes	high	20	33	low	late
Thomas	22	no	low	22	24	medium	late
[1]Leafing date is recorded as days after Davidson, the earliest leafing cultivar under trial in central Missouri. Average leafing date for Davidson in central Missouri = April 12.							
[2]Average ripening dates in central Missouri: **early** = Sept. 1-14; **mid** = Sept. 15-28; **late** = after Sept. 28.							

emerging leaves, along with developing flowering structures, will not be injured by late spring frosts. Temperatures below 26°F will kill emerging buds, destroy catkins and pistillate flowers, and eliminate the potential for nut production. If your planting site has a tendency towards late spring frosts, grafting to late-leafing cultivars is essential.

Black walnut trees have separate male and female flowers, which are located on different parts of the same branch **(Fig. 2, pg. 2)**. Male flowers or catkins start to develop at budbreak along 1-year-old wood. The 2- to 3-inch-long catkins first appear green, and then turn yellow when shedding pollen. After all the pollen is shed, the catkin turns brown and falls from the tree. Female flowers are small, 1/4 inch long, green nutlets tipped with two feathery stigmata that can be red, orange or green in color. Pollination occurs when pollen is transported by wind to the surface of the stigma.

The dates of pollen shed and female receptivity are closely related to leafing date. Preliminary studies indicate that black walnut trees can self-pollinate but cross-pollination increases nut set. In developing plans for your orchard, be certain to establish at least four cultivars with overlapping leafing (flowering) dates to ensure maximum cross pollination.

Nut bearing habit Several black walnut cultivars exhibit a branching habit that can be most accurately described as spur-type growth. Black walnut spurs are short, compact branches that arise along primary limbs **(Fig. 3 and 4, pg. 4)**. These spurs are multi-year-old shoots that grow to a length of 8 to 12 inches and dramatically increase the fruit-bearing capacity of the tree **(Fig. 4, pg. 4)**. The best yielding black walnut cultivars are all spur bearing.

Disease resistance Anthracnose is the most common foliar disease infecting black walnut trees and is a major cause for poor and irregular nut production **(Fig. 5, pg. 4)**. The anthracnose fungus infects leaves shortly after full leaf expansion and can completely defoliate trees by mid-August. Black walnut cultivars vary in their susceptibility to this disease but no cultivar has proven to be fully resistant to infection. Anthracnose can be controlled with fungicide applications as described in the pest control section of this bulletin. **(See pg. 8 for image of anthracnose leaf defoliation).**

Nut production The full nut-bearing potential of black walnut as an orchard crop is not known. Preliminary data indicates that under the very best of conditions and care, a black walnut orchard may be able to produce 2,000 lbs. of husked and air-dried walnuts per acre. However, many cultivars have been selected solely on their ability to produce nuts that shell easily and not on total tree productivity. Choosing cultivars for your planting should be determined by the goals you have set for your trees. For the backyard grower, total nut yield may not be as important as ease of cracking. For the commercial grower, high yield is essential.

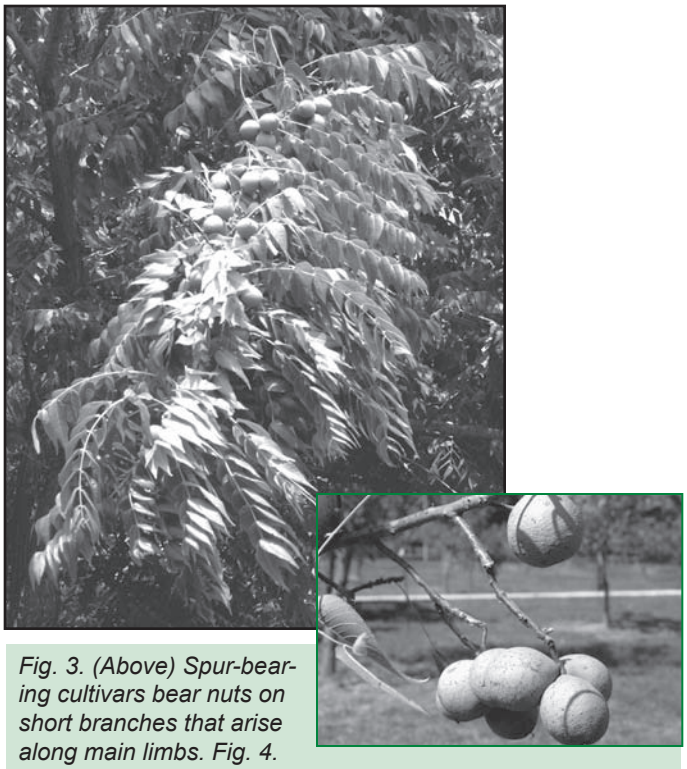


Fig. 3. (Above) Spur-bearing cultivars bear nuts on short branches that arise along main limbs. Fig. 4. (Right) Black walnut spurs are 8-10 inches long and bear nuts on the branch terminal.

Cultivar quality has many dimensions. Percent kernel is the standard measure of a cultivar's ability to produce edible kernel. Generally, the higher the percent kernel, the easier the nut is to crack and shell. Quality of kernel is assessed by both the color of the kernel (light colored is better) and the absence of kernel venation or mottling. Shelling performance (percent kernel) and kernel quality are especially important cultivar attributes for walnut growers who plan on marketing their nuts as a shelled product.

Cultivars vary in their ability to produce nuts annually. Cultivars that are prone to alternate bearing tend to over-produce one year and yield few or no nuts the next. Because the backyard orchardist and hobby grower can not afford the expensive equipment needed to apply crop protection chemicals, these small-scale nut producers will always deal with some level of alternate bearing. In these cases, the selection of alternate bearing cultivars for the orchard may offer enough other advantages (i.e. nut quality, large nut size, etc.) to justify their planting. The commercial black walnut producer should avoid severely alternate bearing cultivars.

Ripening season Black walnut cultivars can be grouped into three ripening periods; early, mid-season and late. In areas with a 195-day frost-free growing season such as central Missouri, early-ripening cultivars mature Sept. 1-14. (Frost-free growing season for black walnut orchards can be defined as the number of days of the year with temperatures above 28°F.) Mid-season cultivars ripen Sept. 15-28 and late-ripening cultivars

Fig. 5: Anthracnose appears as irregular brown spots on the foliage. Infected leaflets yellow before dropping off the tree during the growing season.

become harvestable after Sept. 28. However, the length of growing season at your location will determine when a walnut cultivar will ripen and should influence your cultivar choices. A map of frost-free days is available from the National Climatic Data Center **(see pg. 15)**.

In growing areas with a long growing season (210 days or greater), the husks of early-ripening cultivars will begin to soften during the heat of late August. High temperatures accelerate husk decomposition leading to kernel color darkening and a marked decrease in nut marketability. To avoid heat-related kernel quality problems, growers in long-season climates should avoid early-ripening black walnut cultivars.

In contrast, growers establishing orchards in cooler climates (less than 180-day growing season) should avoid planting late-ripening cultivars that may not complete nut development before the first fall freeze. Nuts that freeze before ripening will produce dark, water-soaked kernels that are unmarketable.

Orchard Design

The design of your black walnut orchard should allow trees plenty of room to develop the large canopy needed for optimum nut production. Minimum tree spacing should be 25 to 30 feet depending on soil type. Trees established on the best flood plain soils will grow quickly and should be established at the wider distance – 30 x 30 feet. Trees established on less-than-optimum soils will exhibit slower growth rates and can be planted closer together (25 x 25 ft.).

Establishing black walnut trees too close together (less than 25 ft. apart) will result in tree crowding and lower limb loss before onset of significant nut production. In contrast, wide planting distances (40 to 60 feet) have been used in walnut agroforestry systems to allow the intercropping of agronomic crops between tree rows. Although intercropping improves cash flow during the years of tree establishment (years 1-7), wide tree spacing will significantly reduce profits from nut production

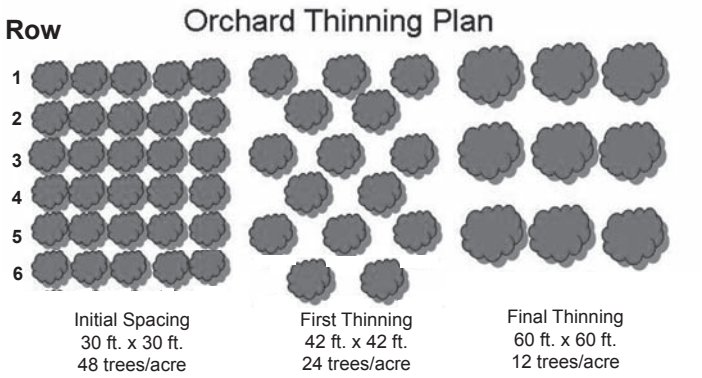


Fig. 6: An orchard thinning process, planned around cultivar selection, should be a part of every walnut orchard. Establish two adjacent rows of each cultivar on a 30 x 30 ft. spacing.

during the early years of orchard development (during years 7 through 25).

Commercial walnut orchardists should establish trees with a sequential tree thinning plan in mind **(Fig. 6).** Depending on tree growth rate, trees established at a 30 x 30 foot spacing will begin to crowd each other in 20-25 years. As limbs of adjacent trees start to touch, lower limbs become shaded and nut production will begin to decrease. In an orchard where all trees are performing equally, a thinning at age 20-25 could consist of the following: the orchardist removes every other row of trees on the diagonal, allowing the remaining trees additional room for canopy development (remaining trees have 42 x 42 ft. spacing). As walnut trees continue to grow, one additional thinning will become necessary at tree age 40 to 50. Again, every other tree row is removed, leaving remaining trees at a final spacing of 60 x 60 feet **(Fig. 6)**.

Obviously, in many orchards, trees do not grow uniformly. Under such circumstances, the orchardist must carefully select the trees to be removed to reach the desired final spacing of approximately 60 x 60 feet. The design of the orchard should also include a wise arrangement of walnut cultivars. Black walnut trees are partially self-fruitful, but nut production is increased if orchards include several cultivars to ensure cross pollination. To ensure cross pollination, arrange cultivar rows by date of average leafing. Since flowering dates are closely related to leafing dates, arranging cultivars by leafing date should ensure that flowering dates for adjacently planted cultivars will overlap and increase cross pollination.

To assist with mechanical nut harvest and sale by cultivar, keep all trees within a row of the same cultivar. Up to four adjacent rows of the same cultivar can be established without a fear of diminished cross pollination (assuming one starts on a 30 x 30 ft. spacing).

Methods for Establishing Black Walnut Trees

Establish black walnut trees by using one of three methods – planting grafted trees; planting seedling trees then grafting 2-3 years later; or by direct-seeding nuts then grafting the resulting seedlings 3-4 years later. Each method offers advantages and disadvantages. Prospective walnut growers should choose the method suited to their skills and economic situation.

Grafted trees Transplanting grafted trees of desired cultivars is the simplest way to establish a black walnut orchard. Trees should start to bear nuts within four to six years after transplanting. Unfortunately, many recommended cultivars are not widely available from commercial nurseries making it difficult to obtain grafted trees.

Seedlings Seedling black walnut trees are widely available and can be purchased from commercial nurseries or from State Forest Nurseries. If possible, use seedlings grown from nuts produced by the Kwik-Krop or Sparrow cultivars to provide the rootstock for your orchard. All seedling trees must be grafted to desired cultivars two to three years after establishment regardless of the seed source. Nut production should begin three to five years after grafting. Starting a walnut orchard with seedlings offers the advantages of low initial costs and the opportunity to establish cultivars not available from commercial nurseries. Disadvantages include a delay in the onset of nut production and the expense of grafting your trees. Instructions for grafting walnuts can be found in "Propagating Pecan and Walnut in Missouri" **(see Additional Resources, pg. 15)**.

Nuts Walnut trees are easily grown from properly stratified nuts. To start your own trees, collect nuts in the fall that are well filled (i.e., nuts that do not float when washed). Choose nuts from the Kwik-Krop or Sparrow cultivars if possible. Hull the seed nuts but do not allow to air dry. Stratify freshly hulled nuts in moist sand by placing them in layers about 3 inches deep and holding them in a cool room or refrigerator (35° to 40°F) for 90 to 120 days. Be sure the nuts are kept moist throughout the stratification process to ensure uniform germination after planting.

Plant stratified seeds in the spring after the danger of frost passes. Seedlings can be grown in a nursery row and transplanted the following year or planted directly in the orchard. Homegrown seedlings require two to three years to grow large enough for grafting. Starting an orchard from seed has the same advantages and disadvantages as starting with seedlings, but with one added disadvantage: freshly planted walnut seed is susceptible to predation by squirrels.

Transplanting Walnut Trees

Bareroot stock Transplant both grafted trees and seedling trees in early spring as soon as the soil can be easily dug. After receiving your trees, plant bareroot trees as soon as possible to prevent roots from drying. Prune each tree before planting by trimming off about 1/3 of the top growth. Prune off broken or rotten roots and cut the taproot back to 24 inches. Taproot pruning of 1-year-old seedlings is usually unnecessary.

Dig your planting hole large enough to fit the entire root system. Hold the tree in position and fill soil in around the roots making sure the fibrous roots are spread out in their natural positions. The tree should be planted at the same depth as it was in the nursery. Water the tree in after transplanting. Do not place soil amendments or fertilizers in the planting hole.

Container-grown stock Transplant container-grown walnut trees in early October or in March. Dig your planting hole twice as wide as the container but no deeper than the depth of the container. After removing the tree from the container, check for an encircling taproot. Use a pair of pruning shears to cut off the taproot at the point the root starts to circle. Next, use a hay hook to gently pull out the smaller roots that are circling around the outside of the root ball. Place the tree in the planting hole and spread out the fine roots. Fill in the planting hole with topsoil. The tree should be planted at the same depth as it was in the container. However, be sure to cover the root ball and associated potting soil with about one inch of soil to help keep the root ball from drying out.

Weed control Weeds must be controlled in a 6- to 7-foot wide area around the newly transplanted tree regardless of orchard size. For large plantings, the entire orchard should be kept free of competing vegetation during the establishment year. Complete vegetation control can be achieved by shallow cultivation or the application of herbicides. Small plantings can use a wood chip mulch over a permeable weed barrier fabric to suppress weed growth and preserve soil moisture. After tree establishment, plant a sod-forming, shallow-rooted, cool-season grass to prevent encroachment of tall fescue into the orchard.

If the transplanted tree makes 8 to 10 inches of new growth by early June, spread a half-cup of ammonium nitrate fertilizer around the tree over the entire weed-free area. Nitrogen applications to trees slow to establish themselves (less than 8 inches of new growth) can cause a leaf burn and should be avoided. To ensure survival, keep the tree well watered throughout the growing season and especially during droughty periods.

Care of Non-bearing Trees

Water and nutrients A productive black walnut orchard is enhanced by developing trees with strong trunks and healthy root systems. Adequate soil moisture throughout the growing season and proper fertilization are keys to strong, vigorous tree growth. Water newly established walnut trees when conditions become dry by soaking the entire rooting zone deeply once a week. Once trees re-establish a vigorous root system (two to three years after planting), natural rainfall is often adequate to keep the tree growing rapidly especially if orchards are established on deep alluvial soils.

Apply nitrogen fertilizer twice a year, in March and in May, at the rate of one-cup ammonium nitrate per inch of trunk diameter. Spread the fertilizer over the area within the dripline. Keep the area around the tree weed-free to ensure maximum benefit from water and fertilizer applications.

Pruning Tip pruning helps shape the young walnut tree and promotes the formation of a strong trunk. Tip prune in February or March by clipping off 3 to 4 inches from all terminal growth. When the tree starts its growth in early spring, these cuts force buds along the entire branch to break. This gives the tree a more dense appearance and greater leaf area. Tip prune again in July, but this time, do not prune the central leader. Cutting all lateral branches back stops their growth and channels their photosynthetic energy into strengthening the trunk.

Resist the temptation to "prune the tree up" while the tree is still small. Lower lateral branches should be left on the tree until they are 1 inch in diameter. Once lateral limbs have grown to 1 inch in diameter, remove the lowest one or two limbs each year in March until you have achieved 8 to 10 feet of clear trunk.

Every time you prune walnut trees (dormant or summer pruning), look to correct tree structural problems. If a branch has formed a narrow crotch at the point of connection with the trunk, remove the entire branch to eliminate future problems with limb breakage. If the tree has formed multiple central leaders, prune to a single leader. The goal is to have two or three well-spaced lateral branches every 2 feet along the central stem. Make sure lateral branches are spaced evenly around the trunk and staggered with respect to those below them to create a well balanced crown.

Staking Install tree stakes adjacent to young trees to provide a convenient aid for tree training. Stakes also help prevent wind damage and can aid in preventing deer damage. Wooden stakes, steel conduit pipe and steel T-posts have been used successfully to stake black walnut trees. Tie the tree to the stake using 1-inch-wide plastic ribbon or engineer's flagging tape to help form a straight central leader. Training trees to a stake is espe-

cially important for field-grafted trees to prevent wind damage and possible graft loss.

Walnut trees are a preferred target for deer damage. Male deer will strip the bark off young trees by rubbing their antlers against the lower portion of the tree. Bucks seem to prefer walnut trees 1 ½ to 3 inches in diameter and will begin rubbing in late summer and continue into the fall. In areas of high deer populations, place a steel T-post (knobby sides pointing outward) on opposite sides of a tree to help prevent buck rub **(Fig. 7).** Drive posts in the soil 4-6 inches away from the tree. Steel fence posts have the disadvantage of having a sharp, angular top that can injure young trees as the wind rubs the tree against the post. To prevent this type of injury, cut the neck out of a 16 oz. plastic soft drink or water bottle and slide bottom part of the bottle over the fence post. The plastic bottle provides a smooth surface that does not injure the tree.

Pest control Throughout the growing season, scout for insects that can cause complete defoliation of small trees. These insects include the walnut caterpillar, fall webworm and yellow-necked caterpillar. These three species of defoliating insects all feed on walnut foliage in large colonies attacking trees sporadically within the orchard. Spot treat only infested trees with an insecticide **(see Table 3, pg. 8).**

Fig. 7: Install a steel T-post next to young trees to aid in tree training and to deter buck rub.

Care of Bearing Trees

Water and nutrients Trees perform best when provided a sufficient supply of water throughout the growing season. Selecting the best possible site for black walnut tree growth is the best way to ensure adequate water supplies. In addition, take steps to preserve soil moisture by developing a weed-free area around each tree. To conserve moisture between tree rows, plant a cool-season, perennial, low-growing grass that can tolerate frequent mowing. The weed-free zone can be maintained with herbicides, the application of wood chip mulch and/or a permeable weed-barrier fabric. Do not use hay or grass clippings to mulch your trees. These kinds of "soft" mulches provide an excellent home for tree-gnawing rodents.

On marginal sites, the ability to irrigate your trees will increase yield, nut size and annual production. However, the question becomes, will the increases in nut yield and quality pay for the costs of installing, operating and maintaining an irrigation system? From a strictly economic viewpoint, the answer to that question is most often no. But once again, go back to the goals for your planting. Make your decision to install an irrigation system based on those goals.

Nitrogen fertilization is essential for stimulating nut production in black walnut. Added nitrogen will stimulate leaf growth and increase female flower production. Once trees begin bearing, apply nitrogen fertilizers two times during the year – 60 lbs. actual nitrogen/acre during the first part of March and 40 lbs. actual nitrogen/acre during early October. Apply ammonium nitrate (33 percent nitrogen) or urea (46 percent nitrogen) with conventional equipment across the entire orchard floor. Use leaf analysis of leaflets collected in late June to early August to determine your trees' needs for phosphorus, potassium and micronutrients. Optimum nutrient concentrations are listed below in **Table 2**.

Table 2: Optimum or normal concentrations of mineral nutrients in walnut foliage in late June through July

Element	Dry weight conc.	Normal range
Nitrogen (N)	Percent	2.2 to 3.5
Phosphorus (P)	Percent	0.2 to 0.33
Potassium (K)	Percent	0.9 to 2.0
Calcium (Ca)	Percent	1.2 to 2.5
Magnesium (Mg)	Percent	0.3 to 0.6
Iron (Fe)	ppm	50 to 200
Manganese (Mn)	ppm	25 to 220
Zinc (Zn)	ppm	20 to 80
Boron (B)	ppm	30 to 80
Copper (Cu)	ppm	5 to 20

Pest control Several key pests limit the production of nuts from black walnut trees. Strategies for controlling these pests will depend on the goals you have set for the orchard. All major pests can be controlled through the judicious use of pesticides; however, not all growers can afford the equipment needed for spraying large trees. The backyard orchardist and black walnut hobbyist can meet their goals for producing walnuts without pest control measures. In contrast, growers with the intent to produce walnuts for profit must learn how to iden-

tify key pests and when to apply pest control measures. Although applicable for all black walnut producers, this section on pest control provides recommendations primarily for the commercial orchardist. Pesticide recommendations are given in **Tables 3 and 4**.

Table 3: Recommendations for Black Walnut Insect Control

Insect Pest	Timing	Pesticide	Rate/Acre
Acrobasis Moths	Leaf burst	Asana XL®	4.8 - 14.5 oz.
		Confirm 2F	8 - 16 oz.
		Lorsban 4E® or Nufos 4E®	1.5 - 4.0 pts.
		Warrior®	2.56 - 5.12 oz.
Walnut Curculio	After pollination	Asana XL®	4.8 - 14.5 oz.
		Imidan 70WSB	1.0 - 3.13 lbs.
		Sevin 80W	2.5 - 6.25 lbs.
		Warrior®	2.56 - 5.12 oz.
Fall Webworm, Walnut Caterpillar and Yellow-Necked Caterpillar	When colonies appear	Asana XL®	4.8 - 14.5 oz.
		Confirm 2F	8 - 16 oz.
		Dipel ES	1 - 4 pt.
		Imidan 70WSB	1.0 - 3.13 lbs.
		Javelin WG	0.25 - 4 lbs.
		Lorsban 4E® or Nufos 4E®	1.5 - 4.0 pts.
		Warrior®	2.56 - 5.12 oz.
Aphids and Walnut Lace Bug	If 25 or more adults are found per compound leaf	Asana XL®	4.8 - 14.5 oz.
		Guthion 2L®	6 - 8 pts.
		Lorsban 4E® or Nufos 4E®	2.0 - 4.0 pts.
		Sniper 2E®	1.5 - 2.25 pts.
		Warrior®	2.56 - 5.12 oz.
Walnut Husk Fly	Shortly before harvest. Include a feeding attractant with the insecticide	Asana XL®	4.8 - 14.5 oz.
		Lorsban 4E® or Nufos 4E®	1.5 - 4.0 pts.
		Imidan 70WSB	1.0 - 3.13 lbs.
		Warrior®	2.56 - 5.12 oz.

® = Restricted use pesticide

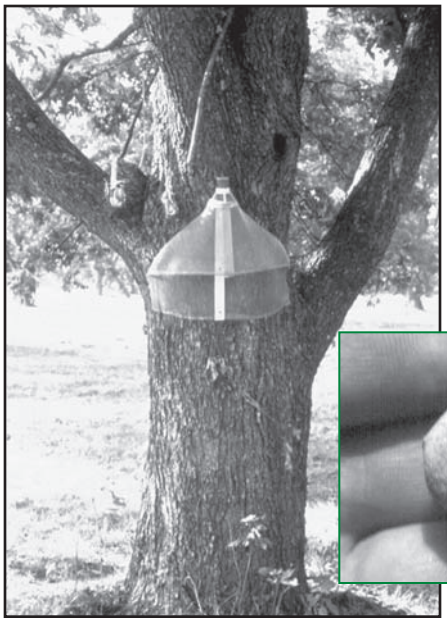
Anthracnose causes yellowing of the leaves and early leaf drop. Early leaf drop also can be caused by cultivar genetics, low nitrogen in the tissue of the tree, or other leaf diseases.

Disease control The control of anthracnose is essential for promoting annual nut production. Maintaining healthy leaves until fall is the only way a tree can create enough carbohydrates to fill the current season's nut crop and have enough stored carbohydrates to stimulate next season's pistillate flower production. The anthracnose fungus over-winters on decaying leaves and infects new leaves as they become fully expanded in the spring **(See Figure 5, pg. 4)**. Often a single well-timed application of fungicide can provide season-long control of this disease. A fungicide should be applied as soon as pistillate flowers are pollinated (when stigmas turn black). Timing of this application is critical so cultivar differences in flowering date must be taken into account. The earliest flowering trees may require a second fungicide application 10 to 14 days after the first spray. During unusually wet seasons, additional fungicide applications may be necessary.

Insect control The commercial orchardist must control three major insect pests and carefully monitor two leaf feeding caterpillars. The walnut shoot moth overwinters as an immature larva in a protective structure called a hibernaculum attached to a scale of a dormant bud. As buds start to swell in early spring, larvae emerge and bore into the bud, feeding off the shoot and killing the terminal. Since female walnut flowers are borne on the

Table 4: Recommendations for Black Walnut Disease Control

Disease	Timing	Pesticide	Rate/Acre
Walnut Anthracnose	Post pollination	Abound	9.2 - 12.3 oz.
		Flint	2 - 4 oz.
		Pristine	10.5 - 14.5 oz.
		Syllit	4 lbs.
	Additional applications at 2-week intervals based on weather conditions	Abound	9.2 - 12.3 oz.
		Flint	2 - 4 oz.
		Pristine	10.5 - 14.5 oz.
		Syllit	4 lbs.



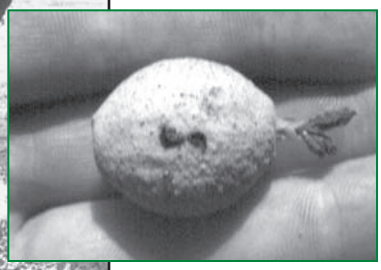


Fig 8. (Below) Walnut curculios carve crescent-shaped oviposition sites in walnut fruit soon after pollination. Fig. 9. (Left) A trunk-mounted cone cage used to monitor walnut curculio activity.

ends of the current season's new growth, the destruction of an entire terminal is devastating to nut production. To control this pest, an insecticide must be applied at bud swell.

After nuts are pollinated, walnut curculios crawl or fly up into the tree canopy searching for black walnut fruit to lay their eggs. Adult curculios are small, brownish-gray, snouted beetles that feature a beak nearly one-half as long as their body. The female curculio carves a crescent-shaped gouge into the fruit then lays her eggs inside **(Fig. 8)**.

As curculio larvae hatch and begin to feed on the nuts, they are aborted from the tree. Curculios have the potential to remove a large portion of the nut crop very early in the season. The timing for control measures is similar to the timing used for controlling walnut anthracnose. Commercial growers should combine an insecticide with their fungicide treatment and apply together during this critical post pollination spray window. Following the post pollination spray, growers should use trunk-mounted cone traps to monitor for any additional curculio activity in their orchards **(Fig. 9**). A second insecticide treatment may be necessary if traps indicate significant curculio populations.

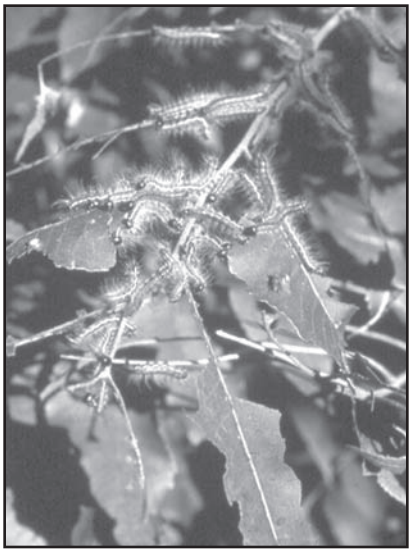


Fig 10: Walnut caterpillars feed together as a colony, completely defoliating large portions of a tree's canopy.

The final major insect attacks as the nuts begin to ripen. Walnut husk flies lay a large number of eggs inside softening walnut husks. Legless larvae (maggots) hatch and feed throughout the husk causing the husk to turn black and staining the nut meat. For growers concerned with delivering the highest possible quality nut, husk flies must be controlled. There are two strategies for managing husk flies. If a grower can harvest, hull and wash nuts before larvae can cause significant husk decay, he can avoid making insecticide applications. But this strategy relies on the grower's ability to harvest each cultivar quickly and as soon as they start ripening. For large plantings, the harvest operation is time consuming and harvesting faster than the growing maggots can eat becomes a losing battle. Chemical control of husk flies is aimed at killing adult flies. Growers should scout their orchard for fly activity and spray an insecticide shortly before nuts begin to ripen. To increase the effectiveness of the insecticide treatment, a fly-feeding-attractant such as a protein bait or molasses should be added to the spray mix.

Fall webworm and walnut caterpillar are two foliage-feeding insects that, in some years, can completely defoliate infested trees. Both of these gregarious caterpillars are problems only during outbreak years so growers should monitor their orchards carefully for signs of colony development. Fall webworm larvae feed in large colonies protected by dirty white webbing. In contrast, the walnut caterpillar also feeds in large colonies **(Fig. 10)** but does not build a protective web. Both insects have two generations per year. An insecticide treatment is warranted when an average of 10 colonies can be sighted per acre of trees.

Walnut aphids and walnut lace bugs feed on the underside of black walnut foliage, sucking plant sap from the leaves. When populations of aphids and lace bugs build to outbreak proportions, the combined feeding of thousands of insects destroys leaf photosynthetic capacity, ultimately reducing tree vigor. Fortunately, these insects are rarely a problem during most years but growers should scout their orchards carefully throughout the summer for signs of an aphid or lace bug outbreak (> 25 insects per compound leaf). Outbreaks of these insect usually occur during hot, dry summers.

Harvest *(See Figs. 11-18, pg. 11)*

Walnut harvest is the most time consuming and costly part of black walnut orcharding. Prompt harvest is key for maintaining peak kernel color. The longer a fully ripened husk remains on the nut, the darker the kernels will become **(Fig. 11**). Nuts are ripe and ready to harvest

when you can press your thumb into the husk and leave an indentation **(Fig. 12)**. Commercial orchardists can use a tree shaker to remove the crop from the tree when 50 percent of the nuts are ripe **(Fig. 13)**. Small scale producers can allow nuts to fall naturally, but nuts should be picked up regularly for prompt hulling to preserve kernel color and decrease husk fly problems.

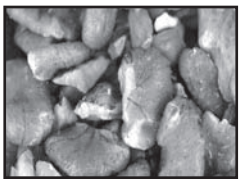
Large growers have successfully modified commercially available pecan harvesters for picking nuts up from the ground. For the small scale producer, the hand-operated Nut Wizard has saved many a sore back **(Figs. 14 & 15).** Once the nuts are gathered, they should be hulled promptly. Small walnut growers can use homemade tire and cage hullers to remove nut husks **(Fig. 16)**. Commercially manufactured nut hullers used in the Persian walnut industry can also be adapted for use by black walnut producers.

Following hulling, the nuts should be washed in a 1,000 ppm chlorine solution bath (1 teaspoon regular bleach/ gallon water) to remove any remaining hull and to disinfect the nuts. Most washing systems are homemade, but all involve an agitation system to stir up the nuts during the cleaning process **(Fig. 17)**. Freshly hulled nuts that float to the top of the water bath are poorly filled and should be discarded. Washed nuts should be placed on screen racks and allowed to air dry **(Fig. 18)**. Large drying bins with a forced air system can be used to dry walnuts but heated air should never be used.

Marketing Nuts

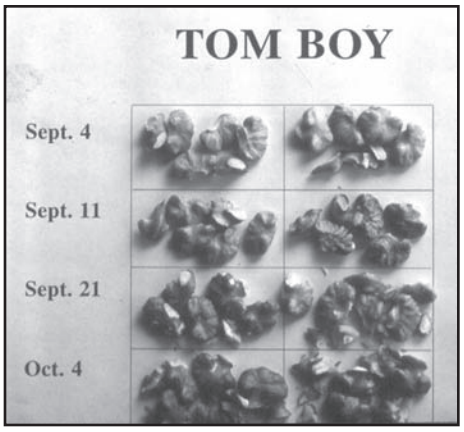
For many black walnut enthusiasts, harvesting enough nuts for personal use and to give as gifts to family and friends is the extent of their marketing plan. However, commercial growers must develop a ready market for the tons of nuts they produce. Currently, there is only one commercial black walnut processor in the U.S., Hammons Products Company of Stockton, Mo. They operate more than 250 stations at locations typically in the Midwest to buy walnuts harvested from native trees. In addition, they will purchase clean and dry walnuts from orchards of improved cultivars at a premium price based on percent kernel, kernel quality and moisture content.

Some walnut producers have discovered that they can add value to their crop by marketing either cracked nuts or black walnut kernels directly to the consumer. The commercial processing of black walnuts requires specialized equipment that is either custom manufactured (crackers) or modified from other nut processing industries (sorters, inspection tables, baggers). The processing of black walnuts is a technologically complicated activity that is outside the scope of this publication.



Currently, black walnut orcharding is a highly speculative business. Like any business, successful black walnut growers have been innovators both in producing a walnut crop and marketing that crop to consumers. They are adept in adapting machinery from other nut industries for use in the black walnut orchard and they are innovative in developing markets for their crop.

For ideas on marketing and guidelines for budgeting a black walnut orchard, contact the University of Missouri Center for Agroforestry. The Center offers additional information on marketing specialty crops and has designed an Agroforestry Black Walnut Financial Model to assist with decisions including tree spacing, nut harvest and whether to use improved (grafted) or unimproved trees. This convenient spreadsheet tool will help make estimates about future nut production and tree diameters. Visit www.centerforagroforestry.org and select the "Profit in Agroforestry" link to access the model.



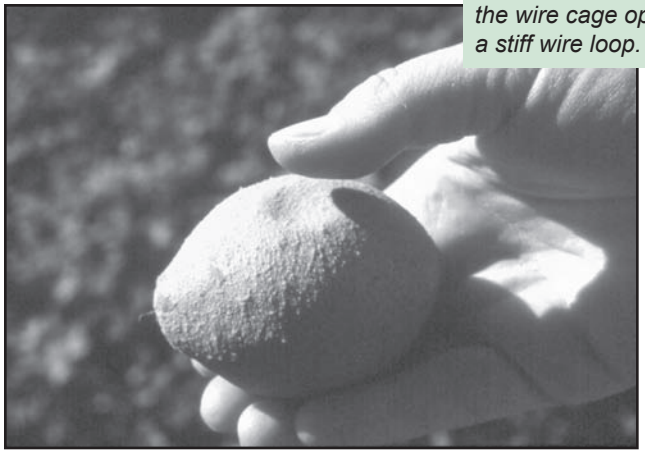
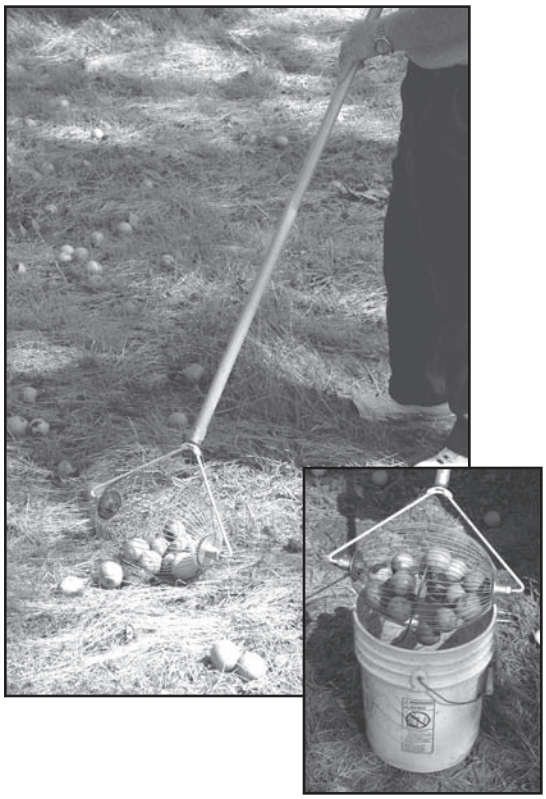
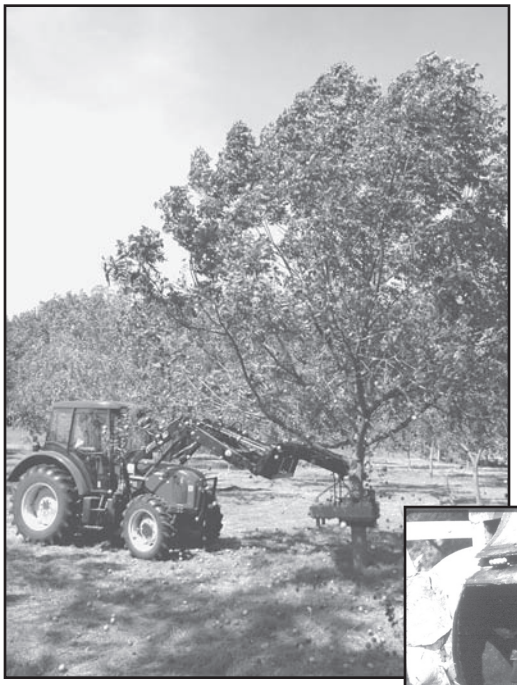


Fig. 11. (Left) The influence of harvest date on kernel color. Fig. 12. (Below) Nuts are ready to be harvested when they can be dented with your thumb. Fig. 14. (Right) Roll a 'Nut Wizard' harvester over fallen walnuts and they become trapped inside the wire cage. Fig. 15. (Inset, right) Nuts are released by spreading the wire cage open with a stiff wire loop.





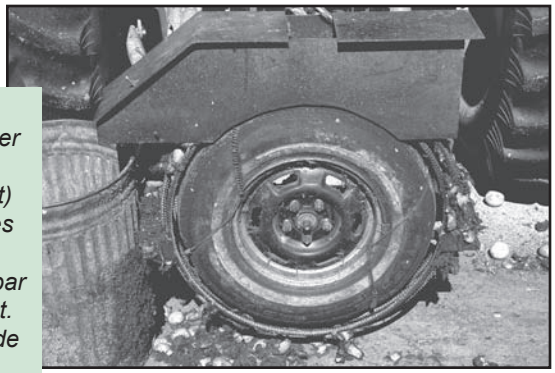
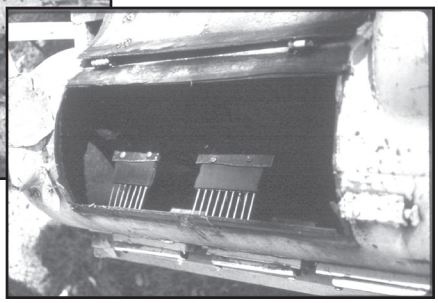


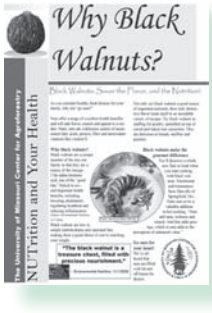
Fig. 13. (Left) A tree shaker mounted to a front-end loader is used to remove walnuts from the tree. Fig. 16. (Right) The tire and cage huller uses the force of a rotating tire to smash the hull against a rebar cage, removing hull from nut. Fig. 17. (Below) A homemade nut washer features rubberized stirring paddles. Fig. 18. (Below right) Nuts are spread on drying racks and allowed to air dry.



About the Center for Agroforestry Nut Tree Research Program

The University of Missouri Center for Agroforestry (UMCA), established in 1998, is one of the world's leading centers contributing to the science underlying agroforestry. The Center seeks to develop the scientific basis for designing and prescribing agroforestry practices within a "systems context," which allows technology to be used most effectively. To achieve this goal, our research efforts have been organized into research clusters to enhance creativity and productivity among a range of investigators from many disciplines.

The Nut Tree Research Cluster features research on pecan, black walnut and chestnut, including field studies, market research and outreach. UMCA supports the nation's most comprehensive research programs for developing the eastern black walnut and Chinese chestnut as nut crops for agroforestry practices. Primary research is conducted at the 660-acre Horticulture and Agroforestry Research Center, New Franklin, Mo., and includes experimental black walnut orchards grown on a trellis system and demonstrations of black walnut trees intercropped with pine for an alley cropping and silvopasture practice study area.



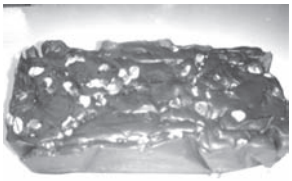
Black Walnuts ... A heart-healthy nut

Black walnuts are low in saturated fats, have no cholesterol, and are high in polyunsaturated and monounsaturated fats (the good fats) which can lower "bad" cholesterol levels (LDL) without damaging good cholesterol (HDL).

They also contain iron, minerals and fiber, and provide the nutritional benefits of tree nuts that are enjoyed in today's popular diets.

For a *"Why Black Walnuts"* nutrition guide and recipes, visit http://www.centerforagroforestry.org/nutrition/index.asp

Black Walnut Value-Added Products: Unique Niche Market Opportunities

Product	*Description*
	**Packaged Nutmeats:** Packaged nutmeats, ideal for snacking and cooking, store well on retail shelves and can bring high prices, especially "recipe-ready." Hammons Products Company, for example, sells a one-pound bag of recipe-ready nutmeats for $15. Hammons' products are distributed nationwide via online sales and direct orders. Go to the following Web site and click on "Hammons Nut Emporium": http://www.hammonsproducts.com/
	**In-Shell Black Walnuts:** For buyers who want to crack their own nuts and extract the nutmeats. Hammons Products Company sells a five-pound bag for $15. Farmers' Markets are a good place to sell in-shell nuts.
	**Candies and Sweet Treats:** Black walnuts pair nicely with chocolate, fudge, cakes and a variety of sweets. Options include selling black walnuts to wholesale candy manufacturers or processing your own candies for sale online, at festivals or farmers' markets.
	**Abrasives for Industry and Cosmetic Products:** Black walnut shell fragments are used in cosmetic products for their exfoliant properties. Black walnut shell abrasive is also used to blast clean and polish soft metals, fiberglass, wood, plastics and stone. The oil drilling industry uses black walnut shell as a key ingredient in making and maintaining seals. Ground black walnut shell serves as an environmentally safe and effective filtration media when separating crude oil from water.

University of Missouri Center for Agroforestry: The Applied Black Walnut Breeding Program

Black walnuts are typically harvested in Missouri from the wild — usually by hand by a landowner – often collected as they fall from trees in forested areas. This type of harvesting allows for significant inconsistencies in quality, size, flavor and level of ripeness, complicating production of this nut for consumer purchase. Due to these inconsistencies, wild-harvested nuts also command a lower market price than similar nuts produced with consistent qualities, such as the familiar size, color and flavor of the English walnuts grown in California.

The Center for Agroforestry has been working since 1996 to develop black walnut into an orchard crop, striving for identification of the best-suited cultivars for Missouri climate and soils. Since the start of the applied breeding program, approximately 60 different black walnut nut cultivars have been acquired and placed in a series of grafted orchard collections at the University of Missouri Horticulture and Agroforestry Research Center (HARC) in New Franklin, Mo. Through orchard production, a consistent, top-quality nut can be harvested to meet consumer demand for a milder flavor and lighter color while retaining the black walnut's revered heart-healthy source of fat.

In addition to evaluating both parent trees and their seedling offspring in the breeding program, a unique aspect of the Center's research is the growth of black walnut trees on a trellis system. This process stimulates the production of flowers on accessible branches and is helping researchers develop a better understanding of how to cultivate this species in an orchard setting. For example, pruning schedules, fertilization and pest control measures, etc., can have a major impact on orchard productivity and profitability, and the Center's research is beginning to address these important questions. Since black walnut cultivars must be propagated via grafting, the selection of specific rootstocks for use in establishing new orchards is also important. Early results from one young rootstock study indicate the rootstock source can have an influence on early survival and seed production, at least through age 5. The Center will continue to evaluate whether these early results can predict future orchard productivity.

Mark Coggeshall, UMCA Tree Improvement Specialist, leads a tour of the HARC black walnut research site. The trees are grown on a trellis system to stimulate the production of flowers on easily accessible branches. These flowers can then be hand pollinated to produce nuts. The nuts are sown in containers, and the resulting seedlings will be evaluated for a series of years to determine if they out-perform their parents in terms of nut quality and productivity.

Black Walnut Genetic "Fingerprints" In attempting to shift black walnut from a "backyard hobby nut tree" to a serious orchard tree crop, it is essential that the exact genetic makeup of each cultivar is known. Dozens of named cultivars exist, with many of these names created by tree hobbyists and shared among one another. However, nut tree specialists must know how these cultivars differ genetically to pursue hybridization techniques for producing improved black walnut cultivars for an orchard setting. The genetic make-up, or "fingerprint," of each cultivar must be known as the first step in an accurate breeding program.

To identify the genetic makeup of the Center's black walnut collection, nut tree researchers submitted leaf samples from all trees in the black walnut repositories at HARC in 2004 to the Hardwood Tree Improvement and Regeneration Center at Purdue University. These samples provided DNA material for use in creating genetic fingerprints for each tree using a series of microsatellite markers. These markers can now be used to identify male and female parents of a seedling if the parents are in the database.

Through these efforts, and additional work at outlying farms and research sites, the Center continues to reveal the great potential of black walnut trees in orchard plantings — and to make major strides in developing new cultivated varieties of black walnut for Missouri in the future.

Black Walnut Grower's Calendar

Attention to your markets is a year-round activity. Watch for opportunities to promote your crop through festivals, retail sales, farmers' markets or on-farm events, such as the Stockton Black Walnut Festival or the Missouri Chestnut Roast. Build a relationship with local grocers and local chefs by offering product samples or cooking demonstrations.

Month	Non-bearing Trees	Bearing Trees	Pest Management
Jan.	Plan grafting efforts	Maintain equipment	Maintain equipment
Feb.	Collect scionwood Tip prune trees	Prune orchard	
March	Fertilize trees Plant bare-root stock Tip prune	Prune orchard Fertilize trees	Scout for walnut shoot moth
April	Apply weed control	Apply weed control	Spray for walnut shoot moth as needed at budburst
May	Field-graft trees to recommended cultivars	Keep groundcover mowed	Scout for curculio; spray for anthracnose & walnut curculio, as needed, after pollination
June	Water newly planted trees Stake new grafts	Keep groundcover mowed Thin nut crop if needed	Scout for walnut aphids and lacebugs
July	Prune off new shoots below new grafts Tip prune	Keep groundcover mowed Irrigate as needed	Scout for caterpillar & fall webworms
Aug.	Make sure newly planted trees have adequate water	Keep groundcover mowed Irrigate as needed	Scout for walnut husk fly
Sept.	Establish cool season cover crops	Harvest promptly Clean and market nuts Irrigate as needed	
Oct.	Plant container-grown stock	Finish nut harvest Fertilize trees	
Nov. & Dec.		Market crop!	

Events to Consider for Marketing Black Walnuts

Farmers' Markets: Check with the Missouri Department of Agriculture or your local Chamber of Commerce for information about markets in your area.

Annual Missouri Chestnut Roast: This event showcases chestnuts, walnuts and pecans, and brings approximately 4,000 guests to the University of Missouri Horticulture and Agroforestry Research Center each October. Visit www.centerforagroforestry.org for more information.

Stockton Black Walnut Festival: Held annually the last weekend in September, the Stockton Black Walnut Festival is the largest celebration of black walnuts in the nation. Information online at www.stocktonmochamber.com

Best of Missouri Market: This annual event brings together producers of Missouri value-added agricultural products and craftsmen at the Missouri Botanical Gardens. Visit www.mobot.org to learn more.

Missouri EXCHANGE

Missouri Exchange is a free service connecting buyers and sellers of Missouri-grown agricultural products, including nuts, fruit crops, timber and native plants. Register your black walnut crop on the site to allow potential buyers to contact you. Missouri Exchange is online at: **www.missouriexchange.com**

Additional Black Walnut Resources

In Print

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Freeze/Frost Maps. National Climatic Data Center. www.ncdc.noaa.gov/oa/climate/freezefrost/frostfreemaps.html

Hammons Products Company: World's largest processor and distributor of eastern black walnuts. Hammons establishes hulling stations across the central U.S. during harvest season, and offers prices for both wild harvested nuts and nuts from improved cultivars. www.black-walnuts.com.

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Insects attacking black walnut in the Midwestern United States. USDA Forest Service. Author: Steven Katovich. Available online at: http://nrs.fs.fed.us/pubs/4719

Missouri Nut Growers Association: Contact Dwight or Barb Ittner by email at dwighti@netins.net for more information.

Northern Nut Growers Association: The Northern Nut Growers Association, Inc. (NNGA) brings together experts in nut tree cultivation, farmers, amateur and commercial nut growers, teachers and scientists, nurserypeople, foresters and beginning nut culturists. www.nutgrowing.org or www.northernnutgrowers.org

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The Walnut Council: Founded in 1970, the Walnut Council is an international association representing nearly 1,000 woodland owners, foresters, forest scientists, and wood-producing industry representatives in 45 states and seven foreign countries. www.walnutcouncil.org/general.htm

Acknowledgements

Authors:
William Reid, Ph.D., is the Research and Extension Horticulturalist specializing in nut tree crops and the Director of the Pecan Experiment Field at Kansas State University. Dr. Reid holds adjunct faculty status with the University of Missouri Center for Agroforestry.

Mark Coggeshall, Ph.D., is a Tree Improvement Specialist, University of Missouri Center for Agroforestry, specializing in walnut tree improvement.

H.E. "Gene" Garrett, Ph.D., is the Director of the University of Missouri Center for Agroforestry and a faculty member of the University of Missouri Department of Forestry, specializing in silviculture and agroforestry.

Jerry Van Sambeek, Ph.D., is a Research Plant Physiologist for the USDA Forest Service and a research collaborator with the University of Missouri Center for Agroforestry.

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Produced by the
University of Missouri Center for Agroforestry
Gene Garrett, Ph.D., Director
203 ABNR Columbia, MO 65211

Technology Transfer and Outreach Unit
Michael Gold, Ph.D., Associate Director
Larry D. Godsey, Economist
Dusty Walter, Technical Training Specialist
Julie Rhoads, Events Coordinator
Michelle Hall, Sr. Information Specialist

For more information, visit www.centerforagroforestry.org
(573) 884-2874; umca@missouri.edu

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