SOILS AND NUTRITION MANAGEMENT FOR BLACK WALNUT

Felix Ponder, Jr.[1]

ABSTRACT—Although walnut may survive when planted in unsuitable soils, most likely growth will be slow and the trees will be of poor quality. Sufficient time should be spent locating quality sites for this valuable and high-site demanding species. Undoubtedly, only ideal soil conditions will allow for adequate root expansion and for soil levels of nutrients and water to be sufficient for consistent growth and nut production. Nitrogen (N) is often the limiting nutrient to tree growth. Fertilization of young walnuts for growth is usually offset by an increase in vegetation competition from weeds. Benefits from fertilization are more likely before crown closure, after thinning, and for active growing large-diameter trees a few years before harvesting. Greater payoffs from fertilization can likely be expected from nut production, especially for trees of nut varieties with larger and more consistent nut crops.

Black walnut (*Juglans nigra* L.) is perhaps the most valuable hardwood tree species in North America. It is prized for manufacturing high quality furniture and for carvings because of its hard wood, dark luminous color, and ease of processing. Its nutmeat is used for human consumption and is important for wildlife. In addition, the shells are ground for use in many products. Black walnut occurs as a minor component in mixed deciduous forests in eastern United States and in the deciduous forest region of southern Ontario (Burns and Honkala 1990). Quality black walnut logs for veneer and lumber are declining faster than they can be grown as harvesting continues and fewer quality sites are being regenerated to the species. In some plantings, the management objective is production of wood and nuts or just nuts. Many of the acres regenerated to black walnut and other high value species lack sufficient cultural treatments required for sustained good growth and high quality logs. In most cases, except for correcting soil pH, early fertilization is not required or recommended. Several years of weed control is needed. If nut production is the management goal, even on good sites, bearing trees will require fertilization.

The poor performance of black walnut on marginal sites can often be explained by reduced potential for rooting and consequent water stress impacts on photosynthesis and leaf abscission (Pallardy and Parker 1989). Walnut seedlings had poor root growth in soils that had high clay content and poor internal drainage (Dey and others 1987). In this paper I will briefly summarize the available literature on soil and nutrient relations for the species. Readers wanting more specific information on experimental results with fertilization should see Ponder (1997) and Pallardy and Parker (1989).

SOILS ON THE PLANTING SITE

Most of the minerals used by plants are derived from the soil; therefore, because black walnut is a high site-demanding tree, considerable attention should be placed on soil selection for the species, and on management practices that increase the opportunity for its roots to be in a healthy environment. Particular attention should be given to soil drainage (both surface and internal) and soil depth. Walnut grows best on land of good quality. Throughout its range, walnut generally reaches its greatest size and value along streams and on the lower portion of north or east facing slopes (Table 1). It needs a fertile soil. Black walnut needs a soil that provides an adequate supply of moisture throughout the growing season while at the same time provides adequate aeration for roots. Soils with medium to fine textures such as loam, sandy clay loam, silt loam or clay loam with good internal drainage are ideal for the species. The combined

[1]Research Soil Scientist (FPJr), USDA Forest Service, North Central Research Station, 208 Foster Hall, Lincoln University, Jefferson City, MO 65102. To contact, call 573-681-5575 or 573-875-5341, ext. 234 or e-mail at fponder@fs.fed.us.

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Table 1.—Significant soil /site characteristics for black walnut growth.

Soil/site Characteristics	Suitable	Questionable	Unsuitable
Slope exposure	North or east		South or west
Position on slope	Middle, or lower with good drainage		Upper, or lower with poor drainage
Slope	0 to 15 %	15 to 30 %	>30 %
Depth to bedrock, gravel or clay layer	> 3 feet	2 to 3 feet	< 3 feet
Drainage class	Well to moderately well drained	Somewhat poorly drained	Excessively, poorly, or very poorly drained
Duration of flooding	Standing water up to 4 days in early spring		Standing water more than 4 days
Soil texture	Loam, silt loam, silty clay loam, silt, clay loam, sandy loam, sandy clay, fine sandy loam	Silty clay	Clay, sand, loamy sand, loamy fine sand

effect of soil texture and depth determines, to a large degree, available soil moisture, which can become critically low during some parts of the growing season.

The effective soil rooting depth should be 3 to 5 feet or more and not restricted by a sand or gravel layer, compacted till, massive clay layer or bedrock. Soils that are poorly drained, droughty, and sandy should be avoided. Suitable soils may be found on bottomlands that are not prone to excessive flooding (floods lasting more than 3 days) and low uplands including terraces.

With an increase in the development of plantations of grafted, high-producing nut cultivars, comes the increased need for supplemental fertilization. Research is being done to improve the benefits of nutrient fertilization by studying nutrient application rates for mineral and organic fertilizer amendments based on soil test results. Fertilization recommendations for black walnut do exist (Parker and others 1992). Soil fertility levels should be in the range of pH 6.5 to 7.2, 2.0 to 3.5% organic matter, 0.25 to 0.3% nitrogen (N), 60 to 80 lbs/ac phosphorus (P), 225 to 275 lbs/ac potassium (K), 2,000 to 3,000 lbs/ac calcium (Ca), and 250 to 300 lbs/ac magnesium (Mg). However, in most cases, the correlation between soil nutrient supply and tree growth and nut production is poor.

It is recommended that a soil test for nutrient levels be done as part of the site selection process and as part of the maintenance program to maintain growth and nut production. Care must be used in the interpretation of the results and laboratory recommendations because most soil tests have been calibrated to agronomic crop needs rather than for trees or horticultural crops. However, pH is a good indication of lime needs and the availability of some nutrients. For example, in soils with pH of 7.0 or higher, zinc (Zn) is held very tightly by the soil and may be unavailable for plant uptake.

Leaf analysis is a much better indicator of N, P, K and Zn deficiencies than soil test. Leaf nutrient concentrations give a much clearer indication of the tree's actual nutrient status. Black walnut leaf samples should be collected from several trees between the last 2 weeks of June and first 2 weeks of July from current year's growth. Leaves that are dirty or that have been damaged by insects or disease should be discarded. Sampling should be delayed for several days after heavy rains. Leaflets from the mid portion of the leaf omitting the first two to three leaflets at the bottom and at the top of the leaf should be collected with sufficient leaflets (75 to 100) to yield a 5- to 10-gram sample after leaflets are processed (dried and ground).

The nutrient-testing laboratory selected should be suitable for your needs. Most leading state universities that have agriculture programs maintain and operate soil and plant testing laboratories. If the laboratory does not make fertilizer recommendations for black walnut, you may need someone to interpret the results. The Soil and Plant Analysis Laboratory in Madison, WI (University of Wisconsin, Soil and Plant Testing Laboratory, 5711 Mineral Point Road, Madison, WI 53705, phone 606/262-4364) can analyze soil and plant samples and make recommendations for walnut based on the soil's pH, organic matter, and nutrient content (Parker and others 1992). Visit with personnel at your local Natural Resource Conservation office, County Extension office, or District Forester office for help in locating plant tissue testing laboratories and for other helpful suggestions.

Once a leaf analysis program has been established, leaves should be collected from the same trees and branches during the period as in previous years. Although, the grower will decide how often trees will be tested, it is best to test trees annually, especially if trees are being fertilized for nut production. The benefits of fertilization are limited by the tree's ability to convert nutrients into wood and nuts. The grower must remember that factors other than nutrition, such as inadequate moisture during the growing season and other weather related problems as well as inherent soil/site problems could limit good annual growth and nut production.

While the leaf analysis is a representation of the tree's actual nutrient condition, the combination of soil test and leaf analysis gives better information on what may be limiting the tree's productivity. The two tests provide additional information for making management decisions. Table 2 contains leaf nutrient values from walnut trees growing on a good soil for wood and nut production. Also, the change in nutrient levels during the growing season demonstrates the importance of collecting samples the same time as in previous years for comparing nutrient changes.

FERTILIZATION

Nitrogen can be supplied either in an organic form from legumes growing on the site (plantation) or by applying inorganic nitrogenous fertilizers. Legumes can supply in excess of 150 pounds of N per acre in one growing season. Nitrogen fixed by legumes is released to the soil and is free to be taken up by the trees or other vegetation. Because N is released from the legume over the growing season, it may be more beneficial than annual fertilizer applications for tree growth (Ponder 1994). However, an application of commercial N fertilizer can be done without the complications that may be associated with establishing and growing legumes. Diameter growth of 11-year-old walnut trees treated with slow-release fertilizer increased by 33 to 87% the first year and had more diameter growth 5 years later than tree fertilized with ammonium nitrate.

Phosphorus and K can be applied in combination with N or applied individually when inadequate levels are indicated by leaf analysis. Diammonium phosphate contains both N and P in concentrations of 18 and 46%, respectively. Nutrient sources such as triple superphosphate and muriate of potash can be used to supply P and K when applied separate or in combination with each other.

Table 2.—Mean concentrations of N, P, K, Ca, and Mg in leaves from 8-year-old black walnut trees at different times of the growing season for 2 years and suggested sufficiency range.[1]

Date Sampled	Nutrient Element				
	N	P	K	Ca	Mg
	Percent				
First year					
June 11	3.11	0.32	1.07	1.96	0.51
July 6	2.91	0.25	0.97	1.97	0.42
August 11	2.84	0.24	1.02	2.36	0.44
Second year					
June 11	3.52	0.25	0.98	1.28	0.37
July 6	3.02	0.20	0.80	1.61	0.36
August 11	2.73	0.21	0.83	2.15	0.41
Suggested sufficiency range[2]	2.47 – 2.98	0.16 – 0.24	1.32 – 1.47	1.90 – 2.01	0.51 –0.64

[1]*Ponder and others 1979.*

[2]*Mills and Jones 1996, sampled in summer.*

Fertilization of newly established walnut plantings has not proven very beneficial, especially if ideal soils were on the site. In most cases fertilizers depress the growth of seedlings and young trees by stimulating the growth of competing weeds. Controlling competing weed can increase walnut growth. In natural stands, Clark (1967) and Phares (1973) determined that only minor improvements in diameter growth could be obtained by reducing competition (release) and fertilization of walnut trees larger than poles. Ponder (1998) and Ponder and Schlesinger (1986) reported that while there was some benefit from fertilization, release increased diameter growth more. The diameter growth of 18-year-old plantation walnut trees was better when P and K were combined with N than when N was applied alone or P and K together.

Nutrient sufficiency ranges for various nutrients have been developed for black walnut to help determine nutrient needs based on leaf analyses (Mills and Jones 1996). As a guide, nutrients are added as leaf tissue levels approach the lower end of the range or below and nutrients are removed from the fertilizer program as the leaf tissue level of a given nutrient approaches the upper end of the range or higher. The nutrient sufficiency range for N, P, K, Ca, and Mg are presented in Table 2. The sufficiency range for some other nutrients in parts per million are: manganese (Mn), 207 to 274; iron (Fe), 69 to 129; Zn, 33 to 55; boron (B), 66 to 81; copper (Cu), 10 to 12; molybdenum (Mb), 0.10 to 0.30; and sulfur (S), 1500 to 1600. In general, to satisfy N needs for nut production, an application of 90 to 100 lbs of actual N per acre should be applied in March to early April and again in early August depending on leaf analysis. Both P and K should be applied at a rate of 60 to 100 pounds of actual ingredient in the spring. In cases of severe deficiency larger quantities can be applied.

Jones and others (1993) provided evidence that nut production was increased with an application of 6.4 oz of N, P, and K (13-13-13)/cm of tree diameter late in the summer compared with spring a spring application (Table 3). In another study, nut production was significantly increased following annual applications of N, P, and K fertilizers combined (Ponder 1998).

When legumes are used in the management of trees, soil test should be used to indicate the need for P and K rather than leaf analysis. Excessive P and K applied for legume nutrition will not adversely affect trees. By effectively taking care of P and K requirements for legumes, the trees need for these nutrients are also met.

While many black walnut growers are interested in producing wood and nuts, some are mostly interested in producing nuts. Nut producing cultivars are being grafted onto rootstocks of plantation trees that lack many of the nut producing characteristics of the cultivars (Hanson 1999). Several walnut plantations in Missouri are being managed primarily for nut production. Grafted trees of improved varieties are producing good nut crops annually. One reason for these growers success is likely due to the attention they give their trees and not to the soils the trees are planted on which are typically not suited or would not be recommended for growing black walnut for wood production.

Table 3.—Mean 5-year nut production of black walnut trees fertilized at different times of the year[1].

Treatment		
Time	Fertilizer Applied	Nut Production
		#/year/tree
Spring	Yes	127.5
Spring	No	125.7
Late summer	Yes	187.0
Late summer	No	122.1

[1]*Jones and others 1993.*

For example, the Knaust planting, which is approximately one-half acre in size with 35 trees, is being managed for nut production (Table 4). The deep silt loam soil has a fragipan at 18 to 27 inches of the soil surface, which severely limits available water during some parts of the growing season. The grower spreads 21 to 28 pickup loads of cow manure around trees annually in early spring. In mid April, the grower applies 450 pounds of 13-13-13 fertilizer. The orchard floor is covered with “cheat”, a grass that dies by late June to form a mulch mat that conserves moisture and stops the invasion of other plants. Although restricted by water pressure and only with a garden hose available for use, some trees are watered. For this site, the difference in nut production in dry years may mean few or no nuts if trees were not watered. Nutritionally, under good management, the soil quality of the orchard exceeds that of a soil on a good site (Table 4). The grower summed up nut production, as “I am kept busy from fall into the winter cracking nuts, which I sell for by mail-order at $8.50 a pound.”

The Gardner planting is another profitable nut operation (Table 4). Trees were, also, planted on soils typically not recommended for walnut wood production because the silt loam soil is poorly drained. The trees were later severed and stumps were grafted with several nut-producing cultivars. However, the grower maintains cheat grass for weed suppression and soil fertility, including the addition of minor nutrients, for good nut production (Table 4). The grower said that in some years he has all the nuts he can process without completely harvesting the nut crop.

While these two success stories are practical and not scientifically replicated, they do indicate that taking care of the nutritional needs of black walnut can increase nut production. These examples also suggest that providing good nutrition on marginal soils can make a difference for nut production.

In summary, planting black walnut on a good site is the first step to having a successful plantation. Soils that are 3 to 5 feet deep, well-drained, and have good moisture availability are important site criteria for the species. Sites with good soil moisture are candidates for fertilization. However, some sites with limiting site factors such as less than ideal soil depth, can respond to fertilization. The largest fertilization response will occur where nothing other than nutrient deficiencies limit the site's productivity. Annual testing of soil and leaves will serve as the best guide for determining the frequency of fertilizer application.

Table 4.—Soil chemistry for the upper six inches of soil at Marcules, Knaust, and Gardner black walnut sites[1].

	Depth (in)			**Depth (in)**			**Depth (in)**		
Sites	**0-2**	**2-4**	**4-6**	**0-2**	**2-4**	**4-6**	**0-2**	**2-4**	**4-6**
		pH			*EC (mmhos cm^{-1})*[2]			*% Carbon (OM)*[3]	
Marcules	7.2	6.7	6.6	127	23	14	2.1	1.0	0.9
Knaust	7.5	7.5	7.4	259	173	109	5.2	2.6	1.1
Gardner	7.5	7.5	7.4	152	144	97	3.5	3.0	2.0
		P (lbs/A)			*K (lbs/A)*			*NO_3-N (lbs/A)*	
Marcules	195	118	119	648	339	242	12.7	6.3	4.2
Knaust	427	259	114	1339	907	755	25.8	14.7	9.7
Gardner	186	154	148	644	523	426	9.3	8.8	4.7
		Ca (lbs/A)			*Mg (lbs/A)*			*Na (lbs/A)*	
Marcules	3627	2565	2571	271	108	89	17.8	13.8	17.3
Knaust	7691	5105	2949	639	373	220	33.3	23.3	23.6
Gardner	4889	4392	3893	536	432	386	18.3	17.5	16.0
		S (lbs/A)			*Fe (lbs/A)*			*Mn (lbs/A)*[4]	
Marcules	19.5	12.6	10.7	124	129	126	183	165	123
Knaust	67.7	23.7	14.0	99	88	69	163	170	185[5]
Gardner	22.0	20.8	16.3	73	69	59	233	216	198
		Zn (lbs/A)[4]			*Cu (lbs/A)*			*B (lbs/A)*	
Marcules	62.3	46.0	39.7	7.2	6.2	7.2	1.4	0.6	0.5
Knaust	42.3	25.7	13.3	4.8	4.6	5.7	2.7	1.4	0.6
Gardner	93.8	90.5	118	6.4	5.7	5.5	2.0	1.6	1.1

[1]Mean of four random samples. The Marcules plantation is on a bottomland site with deep, nearly level, well drained Huntington silt loam soil. The Knaust plantation is on a bottomland site with deep, moderately well drained silt loam soil with a firm and brittle 15 inch thick fragipan less than 28 inches from the soil's surface. The Gardner plantation is on a bottomland site with deep, somewhat poorly drained silt loam soil.

[2]Electrical conductivity used as an index of the total concentration of dissolved salts.

[3]OM=organic matter, P=phosphorus, K=potassium, NO_3-N=nitrate nitrogen, Ca=calcium, Mg=magnesium, Na=sodium, S=sulfur, Fe=iron, Mn=manganese, Zn=zinc, Cu=copper, B=boron.

[4] High Mn and Zn levels are due to their application to the soil.

[5] Samples are in the correct order.

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