Black Walnut Nutrition

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Abstract: Information on soil and leaf nutrient concentrations for black walnut are of value only when they are properly sampled, accurately analyzed, and the results correctly interpreted. Guidelines for interpreting soil and leaf analyses and leaf symptoms are presented along with recommendations for correcting nutrient deficiencies or the imbalance of one or more nutrients.

The importance of nutrition in old field plantings of nut bearing trees is well recognized. Black walnut is found naturally on deep, moist, well-drained, and aerated soils that have good structure and are near neutral in pH. However, many walnut plantings are established in residual soils that may be eroded and highly leached. Restoring these soils to the productivity capacity required by black walnut could involve a large investment of time and nutrient management. Excess or deficiency of nutrients can cause an imbalance, which can result in abnormal growth and low nut production. Ideally, the soil's optimum nutrient-balance should be adjusted prior to planting. Broadcast nutrient applications without mixing in existing plantings can be effective; but, depending on the nutrient's mobility, it may require more time for the beneficial effects of some to be realized than for others.

The elements essential for normal growth of walnuts and other green plants have been categorized as major elements, which are required in large amounts, and minor elements, which are required in small amounts. Black walnut requires large amounts of carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg), and smaller amounts of sulfur (S), iron (Fe), manganese (Mn), boron (B), zinc (Zn), copper (Cu), and molybdenum (Mo).These elements are considered essential because their absence can be demonstrated to cause injury, abnormal development, or death to the plant.

DIAGNOSING NUTRIENT NEEDS

One objective for looking at nutrient needs diagnostically may be to determine why a tree or stand exhibits poor growth and/or foliage or other organ abnormalities such as discoloration or unusual development. Another may be to determine the occurrence of nutrient deficiencies that inhibit nut production. Preventing nutrient disorders is easier than correcting them. It may take several years to correct deficiencies or imbalances. During this time losses in growth and yield continue.

Nutrient needs may be estimated (1) by using leaf appearance to identify nutrient deficiency symptoms, (2) by comparative analysis using both soil and leaf analyses, (3) by soil analysis, and (4) by leaf analysis. The appearance of the leaves can sometimes provide the first clue to which nutrient or nutrients are deficient. Nutrient deficiency symptoms for black walnut have been documented (Hacskaylo et al. 1969). They used color photographs to show leaf deficiency symptoms of N, P, K, Ca, Mg, S, Fe, and Mn. A detailed description of each deficiency symptom is provided in Table 1. Although nutrient deficiencies may manifest themselves in quality characteristics of the leaf,

symptoms for a deficiency of one or more elements may be similar to the deficiency symptom of another element. For that reason, leaf symptoms for some nutrient elements such as B, Cu, and Zn have not been included in Table 1. Also, some deficiency symptoms can result from toxicity or nutrient imbalances rather than insufficiency in the soil. The grower should be careful not to mistake injury caused by equipment, insects, pathogenic diseases, herbicides, and pesticides for a deficiency symptom. These agents may produce symptoms that are almost identical to those of malnutrition. Visual deficiency symptoms should be confirmed by leaf mineral analysis.

The comprehensive approach to diagnosing nutrient needs is to analyze leaf samples from trees or a stand that exhibit satisfactory growth and nut yields and corresponding soil samples from the soils in which the trees are growing. The levels of nutrients in the samples are then used as standards to compare other trees or stands of trees and soils. Comparative analyses serve to provide a range of values. The analysis is of the most value when the tree's nutritional differences may be related to some aspect of soil. However the greatest unreliability of comparative values may be expected when values are extrapolated from one growing location to another or from a tree or stand at one stage of development to another of a different age or stage of development.

Leaf Analysis

The leaf is very sensitive to changes in the plant's nutrient supply. The leaf is the food producing organ of the plant and a place of intense metabolic activity. The reliability of the results obtained from leaf analysis depends to a large degree on how and when samples were collected. The concentration of leaf nutrients varies with the time of the year (Table 2), the position of the leaf on the shoot, and with the position of the leaflets on the leaf. Collections should be made between mid-June to mid-July. However, some authors suggest collecting leaf samples as late as early August (Phares and Finn 1971, McHargue and Ray 1932). Concentrations of N and P decrease over the growing season while Ca increases. Calcium concentration decreases from basal to apical leaves on a shoot and from basal to apical leaflets on the leaf. Therefore, the sampling procedure should be standardized. For example, select one or two pair of leaflets from the mid-portion of mature black walnut leaves for the sample rather than from the apical or basal end only. Also, select a date to annually sample the same trees, leaves from the same branches, and position on the branches.

Leaflets should be placed in paper bag. If plastic bags are used, precautions should be taken to prevent leaves from molding. Select leaves from branches around the upper half of the crown. Leaves that are dirty or have been injured by insects, disease or other factors should be discarded. Collections should be delayed several days after heavy rains because some of the nutrients may be dissolved in the rainwater. A sample of 10 to 20 leaves from each tree should be adequate for most analyses. After leaves have air-dried for several days, they may be sent to a plant test laboratory for analysis. When equipment is available, leaves can be oven-dried and ground before sending them to the laboratory for analysis.

Interpreting Leaf Analysis

The literature on black walnut fertilizations trials was recently summarized (Ponder 1997). He concluded that the lack of long-term fertilization studies affect efforts to satisfactory diagnose and prescribe adequate fertilizer recommendations. Also, many of the published results that showed a response to fertilization did not include data on soil and leaf analyses (Geyer et al. 1979, Stringer and Wittwer 1985, Jones et al. 1993). Thus, while there may have been an increase in the supply of a limiting nutrient that resulted in the growth and/or nut yield response, the impact of the nutrient

application on soil and leaf nutrient concentrations for trees in the studies are not known. Leaf analyses are usually able to detect these kinds of dilution effects.

The key factor in the successful use of leaf analysis to detect nutrient deficiencies is having reliable information on leaf composition values that are associated with deficiency and optimum growth and yield. Such information is very scarce. However, limited, some information is available on black walnut leaf composition (McHargue and Ray 1932, Phares and Finn 1971, Ponder 1976, Maeglin et al. 1977).

Phares and Finn (1971) were the first authors to compile a list of tentative critical black walnut leaf composition values based on their research and other published reports (Table 3). Phares and Finn (1971) used good growth as the primary criterion for selecting the critical nutrient levels, but subsequent research has shown that these critical levels are applicable for increasing nut yields (Ponder et al. In press).

Fertilization application rates to correct deficiencies based on leaf symptoms and leaf analyses are not presented. Deficiencies should be corrected using recommendations based on soil analyses.

Soil Analysis

Attempts to relate tree growth and nut production to soil-nutrient analyses has had limited value. Tree performance is neither consistently nor highly correlated with soil analyses. Similarly, soil analysis is not highly correlated with leaf analyses. There are two major reasons for this. One is the difficulty in determining meaningful values for availability of a particular nutrient to the tree; thus any method of extracting an element from the soil is arbitrary in comparison to what actually happens in the root environment during nutrient uptake. Most chemical extractions will give different values, depending on the soil properties.

The second reason is the variability in the root distribution of a given tree. It can vary considerably with soil type. However, regardless of the limitations of soil analyses, they are necessary to fully understand the nutrient status of the tree. Tentative soil nutrient standards are presented in Table 4. Knowledge of soil nutrient levels can be essential in correcting imbalances and heading off future problems. The upper foot of soil should be sampled in a grid or other systematic pattern so that the origin of the sample can be identified. By keeping the 0 to 6 inch depth separated from the 7 to 12 inch depth for the analysis, the manager can look at the vertical distribution or movement of nutrients, especially applied P and lime. If trees are on the site, both soil and leaf samples should be from the same area. Also, consistently collect samples from the same trees and from the same local spot on the ground. This will reduce sample variation and increase the reliability of the data from the analysis. Based on test results, recommended nutrient applications can then be made in the tested area.

pH

Maintaining the proper pH is important in any fertilization program. The effects of soil pH on plant growth are indirect, very complex, and may vary with soil types. Alteration of plant growth occurs because others factors are changed in the soil as pH changes (Thomson and McComb 1962). For example, ammonium nitrate applications can decrease soil pH resulting in a decrease in Mg, Ca, K, and P concentrations in the soil. The decrease occurs during leaching as those of hydrogen and aluminum replace ions of these nutrients on the soil particles. Soil pH has a direct

effect on the soil's microbial activity and this activity is important in the breakdown of organic matter and the subsequent release of N and P.

The pH should be maintained between 6.0 and 7.2. The pH should be corrected during site preparation and tested periodically to detect any change in pH. Lime is usually added to raise the pH of most soils to the desired level. The amended pH can be expected to last from 3 to 5 years.

Continued applications of acid forming fertilizers such as ammonium nitrate can result in nutrient imbalances. However, maintaining high soil pH (above 7.2) can reduce the availability of zinc. Nitrogen applied with P often increases the concentration of P in the plant, but the increase varies with the type of N as well as with soil conditions. Although the imbalance of nutrients in the soil is somewhat understood, the impact of nutrient imbalance on the growth and nut production of black walnut is not.

Maximum P availability to plants is realized between a pH of 6.2 to 6.7. The movement of P in the soil is relatively slow compared to other nutrient elements. Consequently, both growth and nut yield responses may require several years. For example, improvements in the amount of growth was noticeable in young trees during the first summer following treatment, but mature trees were much slower in showing a response (Seer 1960). Some of the difference in response time could also be attributed to physiological differences associated with the age of the trees. Seer (1960) reported that English walnut nut yield and kernel percentages were significantly improved by an application of superphosphate. The response from a single application of P can last several years. Also, depending on the soil P levels, infection levels of the beneficial mycorrhizal forming fungi may be affected. It appears that high soil nutrient levels, especially P, suppress mycorrhizal formation. These beneficial fungi have the ability to inhabit roots and improve P nutrition of the plant. Unless soil P levels are excessive, normal mycorrhizal development should compliment root uptake of P (Ponder 1984).

Cation Exchange Capacity (CEC)

The balance of cations [H, K, Ca, Mg, and sodium (Na)] can be important for adequate nutrition. For soil with a CEC of 5 to 10 meq/100 g soil, the following percentage base saturations are suggested: 65 to 75 for Ca, 10 to 15 for Mg, 2.5 to 7 for K, and 0 to 5 for H and Na. Despite the interrelationships between K, Ca, and Mg ratios, less than optimum for these elements probably will not seriously affect yields unless the ratio of one of these elements to another is very wide (Mills and Jones 1996). For example, Ca deficiency is not likely unless the ratio of Ca:Mg is less than 2:1 and Mg deficiency is not likely until the ratio is greater than 20:1.

Lime when applied as dolomitic lime also supplies Mg. Calcite lime does not supply Mg. Although the effects of K, Ca, and Mg on other elements are less than the effects on each other, the concentration of these elements in the soil and leaf are affected by and have an effect on other elements.

Recommendations given by the testing laboratory will explain the fertilizer rate to use to raise the soil nutrient level to the acceptable range. The laboratory may also explain which fertilizer to use.

TIMING NUTRIENT APPLICATIONS

Fertilizer applications to correct deficiencies should be made when black walnut can make the most efficient use of the nutrients. The most inefficient time to apply N is in the winter when roots are

less active and least able to absorb it. Losses from leaching and dinitrification can also occur at this time. Phosphorus is very immobile. It requires several years to move short distances in the soil profile, and can be applied at the manager's convenience. When convenient, shallow disking the soil following P fertilization can decrease the time it takes for P to become available for plant uptake. Lime can also be applied at any time. Although not tested as a recommended practice, black walnut should benefit from split applications of fertilizer. Important nutritive sensitive events are occurring in black walnut throughout the growing season. Flower initiations occurs in late summer; diameter growth, fruiting, and fruit maturation begins in the spring and continues over much of the summer. Jones et al. (1993) reported that late summer fertilization increased nut production by 32% over spring fertilized trees and by 34% over unfertilized trees. Split applications of N are recommended on sandy soil to reduce leaching losses.

Black walnut nut yields in response to early spring fertilizations should not be expected to be evident until the second year after fertilization; however, leaf N concentrations will show a response in the current year's foliage (Ponder et al. In press). Careful annual testing of soil and leaves will be the best guide to determining how often to apply fertilizers.

SOIL and PLANT ANALYSIS LABORATORY

Most leading state universities that have agriculture programs maintain and operate soil and plant testing laboratories. However, many of them probably do not make fertilizer recommendations for black walnut, but they do make recommendations for growing non-irrigated corn. The recommendation for non-irrigated corn should be adequate for supplying the nutrient needs for black walnut. The Soil and Plant Analysis Laboratory in Madison (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 and their organic matter and nutrient content (Parker et al.1992). Request that the testing laboratory provide both test results and recommendations in units that you understand (ie., lbs/ac not ppm). The form containing the results and recommendations will usually have an explanation for the tests and conversion factors that can be used to make appropriate unit changes as part of the interpretation. Visit with personnel at your Natural Resources Conservation Service office, County Extension office, District Forester office or local University Extension Forester's office for help in locating a testing laboratory or any other help and suggestions for your trees.

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Table 1. General description of deficiency symptoms for various nutrients in black walnut leaves.[1]

Nutrient	Most apparent deficiency symptoms
N	Leaflets and rachis small. Leaflets yellow to yellowish-green, veins yellow. Leaflets have a rough, crinkly appearance. Number of leaflets reduced.
P	Leaflets and rachis small. Yellowish rachis. Chlorotic areas on the leaflets between veins. Lateral leaflets exhibit bronzing. Number of leaflets reduced.
K	Leaflets light yellowish green with marginal yellowing, especially at tips. Rachis yellow-green to yellow. Leaves small. Number of leaflets reduced.
Ca	Leaves very small. Leaflets have chlorotic areas and patches of light green to yellow. Terminal leaflet has tip burn. In extreme case, leaf loses most green coloring and appears bleached. Number of leaflets reduced.
Mg	Leaf size about normal. Some small chlorotic areas. Leaflets yellow-green to light green. Veins remain green. Number of leaflets normal.
S	Leaves are small. Leaflets pale green to almost bleached white. Veins near base of leaflet darker green than other leaflet tissue. Rachis is green to purple. Number of leaflets normal.
Fe	Similar to sulfur except less reduction in leaflet size and veins remain green especially adjacent to the mid-vein. Leaflet surface smooth. Number of leaflets normal.
Mn	Leaf size about normal. Rachis is brownish, basal leaflets show bleaching along margins, and overall leaf color is yellow-green. Number of leaflets normal.

[1]Hacskaylo et al. 1969.

Table 2. Mean concentrations of N, P, K, Ca, and Mg in leaves from young (first sampled at age eight) black walnut trees at different times of the growing season for two years.[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

[1]Ponder et al. 1979.

Table 3. Tentative leaf composition standards and reported leaf composition levels for black walnut.

Nutrient	Phares & Finn[1]	McHargue and Roy[2]	Mills and Jones[3]
	---------- Percent ----------		
Nitrogen	2.00 - 2.60	2.18	2.47 - 2.98
Phosphorus	0.10 - 0.25	0.32	0.16 - 0.24
Potassium	0.75 - 1.30	2.45	1.32 - 1.47
Calcium	0.50 - 1.10	2.68	1.90 - 2.01
Magnesium	0.15 - 0.45	0.47	0.51 - 0.64
Sulfur	0.05 - 0.25	0.05	0.15 - 0.16
	----------Parts per million ----------		
Manganese	30 - 80	110	207 - 274
Iron	40 - 100	78	69 - 129
Zinc	15 - 50	26	33 - 55
Boron	20 - 50	--	66 - 81
Copper	5 - 10	11	10 - 12
Molybdenum	0.05 - 0.10	--	0.10 - 0.30

[1]Phares and Finn 1971, sampled in mid-August.
[2]McHargue and Ray 1937, sampled in August.
[3]Mills and Jones 1996, sampled in summer.

Table 4. Tentative soil range for pH, organic matter, N, P, K, Ca, and Mg levels for suitable black walnut sites.[1]

	Analysis						
pH	Organic matter	N	P	K	Ca		Mg
	(%)	(%)	---------- lbs/a ----------				
6.5-7.2	2.0-3.5	0.25-0.3	60-80	225-275	2000-3000[2]	3000-4000[3]	250-500[2] 375-600[3]

[1]Parker et al. 1992.
[2]Sandy soil
[3]Silty soil