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NORTH CENTRAL FOREST EXPERIMENT STATION, FOREST SERVICE—U.S. DEPARTMENT OF AGRICULTURE

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BLACK WALNUT GROWTH BETTER ON DEEP, WELL-DRAINED BOTTOMLAND SOILS

ABSTRACT. — Site requirements of 25-year-old plantation-grown black walnut on floodplains in southern Illinois were studied. Depth to a gravel layer was the only soil factor that significantly influenced height growth. There was a relationship between internal soil drainage and height growth.

OXFORD: 181.32:114.38:114.12:182.8:176.1 *Juglans nigra.* KEY WORDS: site quality, plantations, competition, soil depth, moisture, *Juglans nigra.*

Black walnut will grow on a wide variety of upland and floodplain soils, but more important to the grower is the growth rate on each kind of soil. Information on the potential growth rate on various soils will help the walnut grower select the most suitable planting areas and plan needed cultural practices for older trees.

To supplement current information on black walnut soil requirements, we examined soil properties and tree growth on 45 bottomland plots. From analyses of the data, we found that better growth occurred on soils where gravel layers were deeper than 40 inches, and on soils with good internal drainage.

METHODS

Forty-five plots were studied in black walnut plantations on southern Illinois floodplains. These plantations had not been managed since planting, except for fire protection.

Each study site was carefully examined to assure vegetal, topographic, and soil uniformity. Each plot included at least three to five dominant or codominant black walnut trees that were approximately equal in height, diameter, and spacing. The sites were nearly level with little variation in microrelief. On each plot, three pits 40-inches deep were used to check uniformity of the major physical soil properties such as texture, internal drainage, and depth to gravel layer.

After a site was found to be acceptable, a detailed soil description was made. This included horizon (or layer) thickness, color, texture, consistence, depth to a mottled zone,[1] stone content by volume and size, and topographic features. Bulk soil samples of each horizon (or layer) were collected and the gravel content (more than 2 mm.), textural analysis (less than 2 mm., hydrometer method), and reaction (pH by glass electrode in 1:1 solution) were determined.

On each plot, three to five sample trees were felled and sectioned at 1-foot intervals to 5 feet and then 2-feet intervals to top to obtain height and diameter/age growth information. Because the age of the trees varied from 23 to 28 years, the height and diameter measurements were adjusted to age 25 to facilitate comparisons.

[1]*A mottled zone is a layer that has spots or blotches of different colors or shades of color; it is usually associated with water saturation. These color variations range from gray, red, or yellow spots on a brown background in soils that are periodically saturated to uniform gray or bluish gray in soils that are saturated for prolonged periods.*

Thus, tree height at 25 years is the site index value used in this study.

Examination of soil descriptions indicated that plots could be sorted into two basic groups: (1) *shallow soils* – a gravel layer within 40 inches of the surface (soils of the Elsah series), and (2) *deep soils* – no gravel layer within 40 inches of surface (soils of the well-drained Haymond or Sharon, somewhat poorly drained Belknap and poorly drained Bonnie series). In these southern Illinois floodplain soils, the contact of the overlying silt loam material (essentially gravel-free) and the underlying gravel material is abrupt (less than 1 inch transition zone). The deep soils were further classed as being well-drained, imperfectly drained, or poorly drained. These subgroups were based on the depth to the mottled zone, which indicates restricted internal drainage during a significant part of the year. Restricted internal drainage causes poor aeration, inhibiting root growth and usually resulting in reduced tree height and diameter growth.

Data were then subjected to correlation and multiple regression analyses to develop equations for predicting walnut growth and site index. These analyses related site index (tree height at 25 years) to A horizon thickness, soil texture and pH by layer, depth to mottling or to a compact layer or gravel, degree of mottling, compaction, and numerous biologically sound interactions of these variables.

RESULTS AND DISCUSSION

Height and diameter growth of dominant and codominant trees was significantly less on the shallow than on the deep soil groups (table 1). At 25 years, trees growing on the shallow soils averaged 17 feet shorter and 2.5 inches smaller in diameter than trees on the deep soils. Gravel layers are dry during most of the growing season, and this definitely inhibits root growth. In contrast, extensive root systems can develop in deep soils because of the greater volume of soil from which moisture and nutrients can be extracted.

Although growth in 25 years on the deeper soils was not strongly correlated with drainage class, it was apparent that better walnut growth occurs on the deeper, better-drained soils.

Drainage class, depth to mottling (Inches)	*Plots* (No.)	*Tree height* (Feet)	*Tree d.b.h. (i.b.)* (Inches)
Good (>30)	18	52.2	6.8
Imperfect (6-30)	5	50.2	5.8
Poor (<6)	3	47.1	5.3

Good internal drainage provides favorable conditions for the development of extensive root systems and more complete utilization of moisture and nutrients.

Both the gravel layer and the mottled zone indicate soil conditions that inhibit deeper root growth. Although we did not sample soils with other kinds of restrictive layers, such as fragipan, hardpan, plowpan, claypan, or bedrock near the surface, these soil characteristics would also limit growth by reducing the effective rooting zone.

The multiple regression analyses relating height growth at 25 years to specific soil characteristics yielded predictive equations that accounted for less than 50 percent of the data variation. The lack of definitive relations probably can be attributed to the small sample size, the relatively narrow range in soil characteristics, and the failure to measure certain important stand parameters (e.g., stand density) that may affect height and diameter growth. In a similar study of seven hardwoods growing on the Mississippi floodplain, Broadfoot[2] also was

[2] *W. M. Broadfoot. Problems in relating soil to site index for southern hardwoods. For. Sci. 15(4): 354-364. 1969.*

Table 1. Relation of black walnut height and diameter at 25 years to the depth to a gravel layer

Soil depth	Depth of a gravel layer	Plots	Tree height $\bar{x}$	Tree height σ	Diameter, d.b.h.(i.b.) $\bar{x}$	Diameter, d.b.h.(i.b.) σ
	(In.)	(No.)	(Ft.)	(Ft.)	(In.)	(In.)
Shallow	<40	19	1/ 34.1	9.6	1/ 3.9	1.5
Deep	40+	26	51.4	9.7	6.4	1.9

1/ Height and diameter means are statistically different at the 99 percent probability level.

unable to find definitive relations between site index and these soil characteristics, or several other moisture and chemical soil features. He attributed this to inability to measure the true cause of productivity to the ever-changing soil moisture, nutrient availability, and soil aeration during the growing season.

CONCLUSIONS

An easily recognized soil characteristic – depth to a gravel layer – can be effectively used to rate the suitability of some floodplain soils for black walnut. Grouping soils studied in southern Illinois by depth to gravel – shallow (< 40 inches) and deep (> 40 inches), we found that after 25 years of growth, dominant and codominant walnut trees on deep soils were 51 percent taller and 64 percent larger in diameter than those on shallow soils. Translated into more meaningful terms for the grower, this additional height growth on deep soils could mean a second 16-foot log or a larger crown for nut production. Faster diameter growth would reduce the time required for a tree to attain merchantable size by 40 percent (60 years to a 16-inch log versus 100 years).

Besides checking soils for a gravel layer, the grower also should examine the deep soils for evidence of restricted internal drainage (mottling). This study indicated that walnut growth was better as the internal drainage improved (deeper to mottling).

Knowing the relative productivity of soils in potential planting areas and existing walnut stands will enable the walnut grower to locate new plantations on the best available soils and decide where to apply cultural treatments in older stands. This approach will give the grower a greater assurance of producing the kind of walnut product that he desires in the shortest time.

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