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# Differential Black Walnut Growth on a Recommended Soil Map Unit: Investigation of Related Soil Chemical and Physical Properties

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# Agronomy notes



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# Differential Black Walnut Growth on a Recommended Soil Map Unit: Investigation of Related Soil Chemical and Physical Properties

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Black walnut (*Juglans nigra* L.) is one of the best known and most valuable trees in Kentucky. However, due to its high value, the species has been aggressively harvested from natural stands, creating a limited supply of quality black walnut trees. Many landowners recognize this as an investment opportunity and have placed small tracts of unused land into black walnut production.

Production of high-value black walnut is a long-term investment (50+ years), the success of which is highly dependent upon proper soil site selection. Soils best suited for black walnut production are well drained, more than 40 inches deep, have a pH ranging from 5.0-8.4 and contain less than 35% coarse fragments (% by volume greater than 2 mm). Proper soil-site selection will increase seedling survival and growth, and reduce the length of time between establishment and harvest. Landowners must be aware that planting and cultural practices (i.e. competition control, pruning and thinning) are labor intensive, therefore, rapid growth is of economic importance. Soil site selection should begin by consulting a USDA-NRCS county soil survey report to indentify the soil map unit of an area and describe its suitability for black walnut production. Soil map units that are deliniated on soil maps identify the soil type that dominates the area within each delineated map unit. Although the scale of mapping soils for county soil survey reports is not likely to delineate mapping units smaller than 2-3 acres, it is not uncommon for several kinds of soil to occupy areas smaller than two acres in size in patterns not practical to be shown separately on the soils map. Therefore, small areas should be examined in greater detail in order to more precisley determine soil-site suitability.

A black walnut demonstration planting was established at the Robinson Substation in Quicksand, Kentucky on a soil map unit shown to be suitable for black walnut growth. Over time, however, a distinct differential in growth pattern developed across this uniform appearing site that suggested unsuitable soil conditions were present. The objective of this study was to measure soil chemical and physical characteristics, and relate them to walnut tree growth at this site.

**MATERIALS AND METHODS**

In 1983, black walnut seedlings were planted on a 12' x 12' spacing on a uniform appearing site (230' x 100') delineated on a soil map of the area as being a Nolin-Grigsby (Ng) complex (fine silty, mixed mesic, dystric, fluventic, eutrochrepts and coarse loamy, mixed mesic, dystric, fluventic, eutrochrepts, respectively) (Figure 1). Tree height was used as an index of growth and measured in 1995 using a Criterion 400 measuring laser. Soil was sampled within the planted area at 40 individual sites on a 24' x 24' grid pattern. Soil samples from each sampling point were collected in 12 inch increments to a 4 ft. depth using a truck mounted hydraulic probe. Each soil sample was analyzed for pH, organic carbon (OC), soil test levels of phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), zinc (Zn), and particle size distribution. A more detailed soils map within the planted area was prepared by close examination of soil morphological characterisitics at the individual sampling sites. Soil bulk density was measured at the center 4 inch section of each 12 inch core sample. Linear regression analysis was used to determine the relationship between tree height and individual soil characterisitics.

**RESULTS AND DISCUSSION**

Twelve years after planting, black walnut tree height ranged from 2.5 - 37 ft., resulting in a distinct differential in growth pattern across the study site (Figure 2). Differences in the soil chemical properties measured at the various soil depths did not relate to differences in tree height (Table 1), as indicated by non-significant correlation coefficients.

Intensive sampling of the planted area showed that there were five different soil types contained within what was shown on the soils map to be one map unit. These were: Barbourville loam, eroded; Barbourville loam; Barbourville silty clay loam; Allegheny silt loam; and Shelbiana silt loam. A generalized description of the three soil series is as follows:

**Barbourville Series**:consist of deep well drained soils on footslopes and alluvial fans. They formed in colluvial and alluvial material. Typcially, these soils have a dark brown loam durface layer, 12 inches thick. The subsoil, from 12 to 14 inches, is brown loam and from 18 to 23 inches, is dark yellowish brown gravelly loam. The mottled substratum, from 33 to 50 inches, is yellowish brown gravelly loam. Slopes range from 0 to 20 percent.

**Allegheny Series**:consist of deep well drained soils on terraces, footslopes and alluvial fans. They formed in old alluvial material. These soils have a dark yellowish brown loam surface layer 9 inches thick. The subsoil from 9 to 28 inches is strong brown clay loam and from 28 to 42 inches is yellowish brown loam. The substratum from 42 to 65 inches is yellowish brown loam. Slopes range from 0 to 25 percent.

**Shelbiana Series**: consist of very deep, well drained soils on terraces. They formed in mixed alluvium from sandstone, siltstone and shale. The surface layer is very dark grayish brown loam 10 inches thick. The subsurface from 10 to 18 inches is dark brown loam. The subsoil from 18 to 65 inches is dark yellowish brown loam. The substratum from 65 to 80 inches is dark yellowish brown loam with common grayish brown mottles. Slopes range from 0 to 20 percent.

Differences in tree height appeared to be related to the occurrence of the five soil types indentified, despite all soil types being recommended as suitable for black walnut production. Greatest average tree height (Av.=29.4') was measured on the eroded Barbourville loam while the least amount of growth was measured on the Shelbiana silt loam (Av.= 10.9'). Table 2 shows the textural class for each sampling depth of the five soil types identified. These data show that the Barbourville soil types are loamier in texture to a depth of 4 ft than Allegheny and Shelbiana, suggesting that a difference in soil porosity or drainage might be responsible for the differential tree growth. However, no visable signs of restricted drainage (gray color and/or mottling) were observed.

Prior to soil sampling, several of the smaller black walnut trees were hand excavated to observe root growth. The root systems of these trees were poorly developed and exhibted predominately shallow lateral growth suggesting a soil compaction problem. Table 3 shows the average soil bulk density for each sampling depth. As expected, soil bulk density increased with increasing soil depth (range 1.35 - 1.79 g/cm$^3$). However, these data indicate that tree growth on the study site was greatest in areas where soil bulk density was the highest. While these results are difficult to explain based on our general understanding of root growth and soil compaction, work reported by Daddow and Warrington (1993), suggest that soil texture is a major factor to be considered when determining "growth-limiting" bulk density (GLBD). For example: soil with a large amount of fine particles (silt and clay) will have smaller pore diameters and a higher penetration resistance at a lower bulk density than a soil with a large amount of coarse particles. Daddow and Warrington concluded that coarse-textured soils will usually have higher GLBD than fine-textured soils.

## CONCLUSION

Black walnut production is a long-term investment that requires proper soil/site selection for maximum tree growth. The results from this study clearly demonstrate the soil heterogeneity that can occur on small, yet uniform appearing tracks of land, and the effect this variability can have on growth of black walnut. Due to the scale of mapping used in published soil surveys, intensive soil sampling should be done on areas to be used, in order to identify small scale differences in soils which may be present.

The Nolin-Grigsby complex soil map unit shown on the NRCS soils map actually contained five different soil-types in the 0.5 acre study area. Black walnut tree height was greatest on the loamy textured Barbourville soils as compared to the slightly heavier textured Allegheny and Shelbiana soils, suggesting that differences in soil texture across the study site had a greater influence on tree height than differences in soil pH, OC, P, K, Mg, Ca, and Zn levels measured to a depth of 4 ft.

## REFERENCES

Daddow, R.L. and G.E. Warrington. 1993. Growth-limiting soil bulk densities as influenced by soil texture. WSDG-TN-00005, USDA Forest Service, Fort Collins, CO.

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Extension Soils Specialist

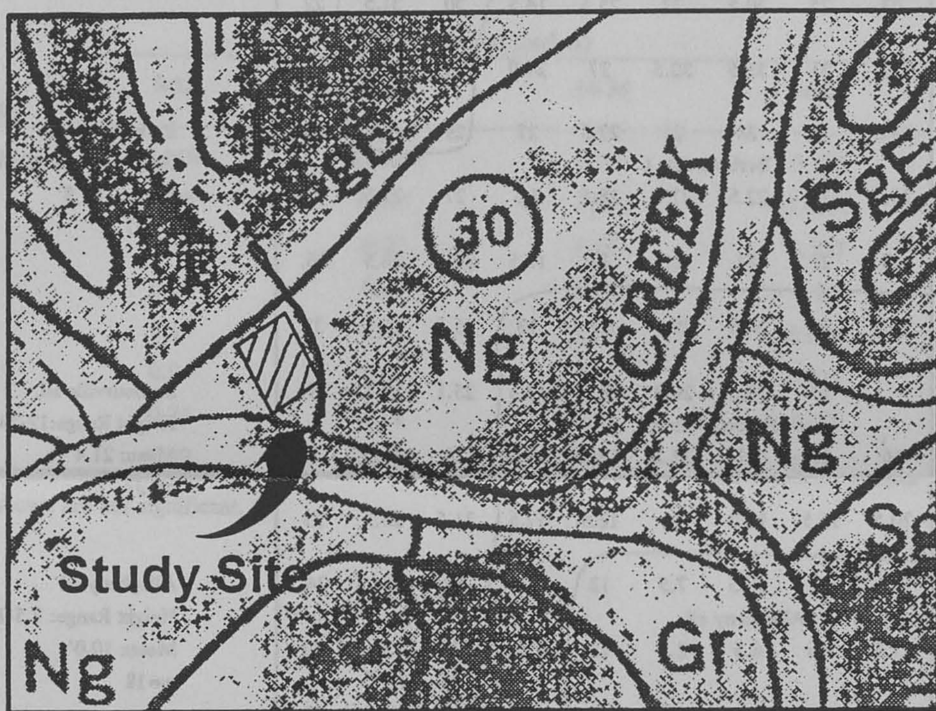


Figure 1. Soil survey map of black walnut study site are showing its location within the Nolin-Grigsby comples (Ng) soil map unit.

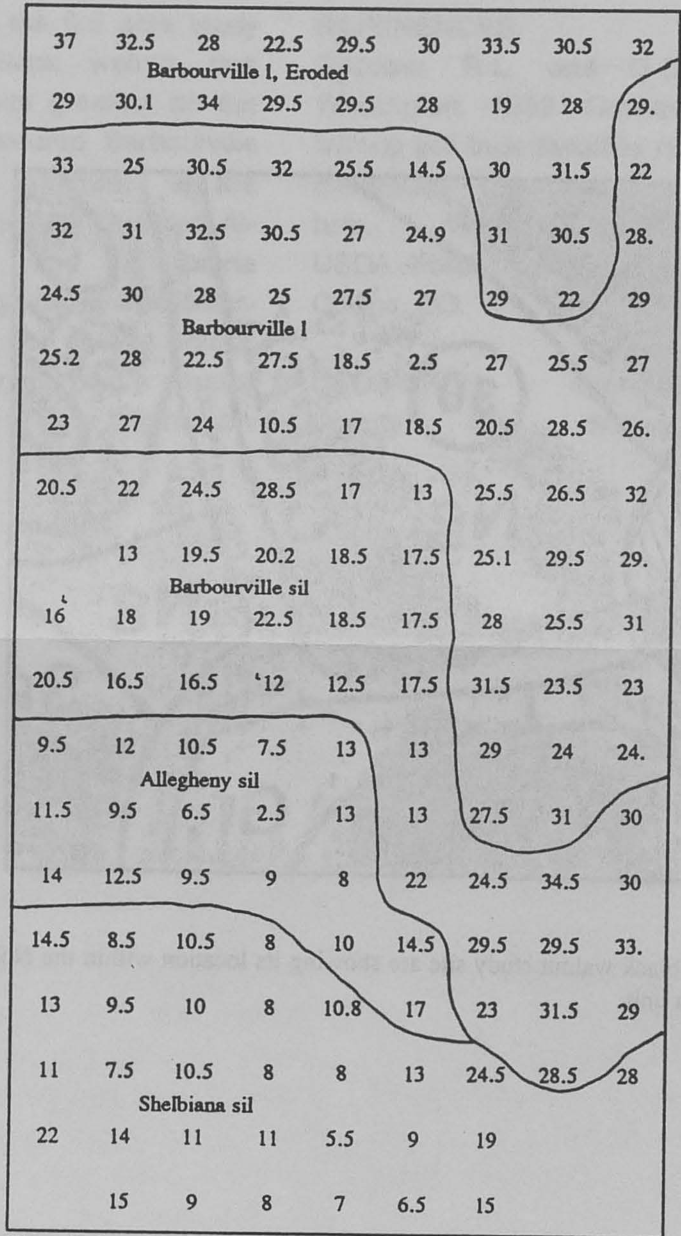

Figure 2. Location of identified soil map units and individual tree height (ft.) of twelve year old black walnut planting.

**Barbourville l, eroded**
**Height Range: 19-37'**
**Mean: 29.4'**
**n=23**

**Barbourville l**
**Height Range: 10.5-33'**
**Mean: 25.8'**
**n=57**

**Barbourville sil**
**Height Range:12-34.5'**
**Mean: 21.4'**
**n=37**

**Allegheny sil**
**Height Range: 2.5-17'**
**Mean: 10.0'**
**n=18**

**Shelbiana sil**
**Height Range: 5.5-28'**
**Mean: 10.9'**
**n=30**

Table 1. The relationship between black walnut tree height and various soil chemical characterisitics as indicated by regression coefficient of determination.

| | $R^2$ | | | |
|---|---|---|---|---|
| | Soil Depth (inches) | | | |
| Chemical Characterisitic | 0-12 | 12-24 | 24-36 | 36-48 |
| Organic Carbon | 0.008 | 0.00009 | 0.02 | 0.166 |
| Phosphorus | 0.08 | 0.017 | 0.02 | 0.0005 |
| Potassium | 0.15 | 0.02 | 0.06 | 0.227 |
| Calcium | 0.10 | 0.07 | 0.11 | 0.20 |
| Magnesium | 0.14 | 0.08 | 0.005 | 0.024 |
| Zinc | 0.04 | 0.01 | 0.04 | 0.021 |
| water pH | 0.24 | 0.18 | 0.21 | 0.30 |
| buffer pH | 0.29 | 0.19 | 0.09 | 0.11 |

All $R^2$ values shown are not significant.

Table 2. Textural class of samples taken by depth for the five soil types identified.

| | Map Unit | | | | |
|---|---|---|---|---|---|
| Soil Depth | Barbourville | | | | |
| | l,eroded | l | sil | Allegheny sil | Shelbiana sil |
| inches | ..............................Texture Class‡.............................. | | | | |
| 0-12 | sl | l | l | sicl | sicl |
| 12-24 | sl | l | l | cl | sicl |
| 24-36 | sl | l | l | sl | cl |
| 36-48 | l | sl | sl | sl | l |

‡ sl=sandy loam; l=loam; sicl=silty clay loam; cl=clay loam.

Table 3. Soil type, bulk density at various depths and coresponding tree height.

| Soil Type | Soil Depth 0-12" | 12-24" | 24-36" | 36-48" | Tree Height |
|---|---|---|---|---|---|
| | ....................bulk density (g/cm$^3$) | | | .................... | ft |
| Barbourville l, eroded | 1.59 a+ | 1.74 a | 1.78 a | 1.79 a | 19-37 |
| Barbourville l | 1.51 ab | 1.57 bc | 1.66 ab | 1.69 ab | 10.5-32.5 |
| Barbourville sil | 1.52 ab | 1.67 b | 1.67 ab | 1.69 ab | 12-34.5 |
| Allegheny sil | 1.48 b | 1.66 b | 1.61 b | 1.71 ab | 2.5-17 |
| Shelbiana sil | 1.35 c | 1.54 c | 1.63 ab | 1.61 b | 5.5-28 |

+ Values within a column for each sampling depth followed by the same letter are not significantly different at the 95% level of probability.

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