

PRELIMINARY FINDINGS AND METHODS OF MEASURING DIFFERENCES IN WOOD COLORATION AS A RESULT OF GIRDLING EASTERN BLACK WALNUT

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ABSTRACT.—Eastern black walnut (*Juglans nigra* L.) is often planted at spacings that require pre-commercial thinning. These thinnings are deemed pre-commercial due to the small diameter of the trees and the low ratio of dark wood to light wood (i.e. heartwood to sapwood). As a consequence of size and wood quality, these thinnings are often an expense rather than a source of revenue. In an effort to increase the value of these thinnings it would be beneficial to increase the ratio of dark wood to light wood. One way to increase the amount of dark wood is through costly processing using steam. However, several non-scientific studies have reported that dark wood can be increased by girdling small trees and allowing them to remain on the stump for a limited period of time. This study was designed to explore this idea. In a black walnut plantation scheduled for thinning, ten trees were randomly selected and double-girdled. At that time, increment cores were taken 30.5 cm above the top girdle. These trees were allowed to remain on the stump for 22 months before they were harvested. Following their harvest the trees were sawn in half to reveal both the dark and light wood over the length of the log. This study found that in seven of the nine logs sampled there was a slight increase in the proportion of dark wood to total wood. However, a t-test failed to identify any differences from samples taken prior to girdling. Further, it was visually evident that none of the seven logs with increases showed a consistent change throughout the length of the log, and therefore it is not likely that girdling will improve the marketability of the log or the market value of the tree. The conclusions of this study suggest that consistency in methods of sampling are required to make valid comparisons related to any movement of wood coloration within a log.

For many Missouri landowners, the idea of planting eastern black walnut (*Juglans nigra* L.) trees for the sawlog or veneer market may seem like a poor investment, since it may take 60 to 80 years before a return is realized. From a financial perspective, the uncertainty and risk involved with a 60 to 80 year investment makes it seem somewhat tenuous. However, even though harvesting black walnut nuts can generate an intermediate cash flow, the prospect of selling marketable sawlogs or veneer is often the deciding factor for choosing black walnut for planting.

In Missouri, markets for small diameter hardwood timber are being explored. By marketing smaller diameter trees, the investment period can be shortened considerably. Small diameter markets may work for native oaks (*Quercus* spp.); however, black walnut's appeal in the market is due to its dark colored heartwood. Small diameter black walnut logs have a large amount of light colored sapwood in relation to the darker colored heartwood (Panshin and DeZeeuw 1980). Because of this ratio of light wood to dark wood, black walnut may be an unlikely candidate for the small diameter market.

Although there are commercial methods, such as steaming (Chen and Workman 1980), that increase the amount of coloration in black walnut, these methods are often too expensive for small sawmills. The search is on for a low cost method of increasing the proportion, or amount, of dark colored wood in small diameter black walnut. The purpose of this study was to determine if girdling and leaving trees standing for a period of time would provide a cheap, effective way to increase the colored wood content in small diameter eastern black walnut trees. When the girdled tree is harvested, the light colored sapwood will theoretically have been darkened to match the color of the heartwood, thus

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Table 1. Location, reference/log number, DBH, and measurements of wood characteristics used in computing the percent change of light to dark wood for the ten girdled trees.

Location	Ref./Log Number	DBH (cm)	Increment Borer Readings			Log Readings ¹			
			C-H	C-B	% H-T	C-H	C-B	% H-T	Avg. %
Row 4 - #22	I	24.6	7.8	10.9	71.6%	8.8 9.6	10.2 11.1	86.3% 86.4%	86.4%
Row 4 - #18	II	24.9	7.1	10.0	71.4%	6.8 7.5	10.2 11.0	66.7% 67.5%	67.1%
Row 4 - #14	III	28.7	6.7	13.7	49.1%	6.6 5.8	13.8 11.3	47.9% 51.1%	49.5%
Row 2 - #16	IV	23.4	7.4	9.5	77.9%	6.7 7.2	8.7 9.3	77.5% 77.4%	77.5%
Row 2 - #18	V	27.2	8.1	11.2	72.3%	10.3 9.9	11.7 13.5	87.6% 73.7%	80.7%
Row 2 - #20	VI	25.9	7.0	12.5	56.0%	10.2 7.9	10.5 12.2	96.9% 64.7%	80.8%
Row 2 - #22	VII	27.4	No reading			10.4 8.9	13.9 12.6	74.7% 70.4%	72.5%
Row 2 - #25	VIII	22.6	7.3	10.2	71.6%	7.0 7.8	9.0 10.5	78.2% 74.7%	76.5%
Row 3 - #19	IX	26.4	6.3	10.0	62.5%	7.9 6.6	10.7 10.3	74.0% 64.2%	69.1%
Row 3 - #24	X	26.9	5.3	10.5	50.5%	7.3 7.1	10.8 11.1	67.1% 64.5%	65.8%

¹ Log measurements are taken for both radii of the colored wood on the open face of the cut log.

C-H : heartwood width in cm for both increment borer and log measurements

C-B : total width in cm for both increment borer and log measurements

% H-T: Percentage heartwood width to total width in cm for both increment borer and log measurements

increasing the quantity of useable wood (Chen, Stokke, and Van Sambeek 1997, 235). If successful, this may facilitate the marketing of trees grown in agroforestry configurations that require thinning prior to the trees reaching a commercial size.

This study was a preliminary test of methods and procedures to answer two main questions. First, does girdling a black walnut tree and allowing it to dry on the stump increase the amount of colored wood? Second, what effect does this method have on the market value of the small diameter eastern black walnut log?

Methods

This study was conducted at the Sho-Neff Plantation near Stockton, Missouri. Sho-neff consists of about 194.2 ha with 123.8 ha of eastern black walnut trees of various ages planted at various spacings. The plantation is divided into 25 areas for research and management.

In 2001, Hammon's Products Company, owner of the Sho-Neff, conducted a thinning to remove approximately one-third of all trees in the plantation. Ten trees (table 1) marked for thinning were chosen at random for this study from Area 16A of Sho-Neff. These trees were native black walnut seedlings, planted in 1976 at a spacing of 6 m x 12 m. Annual crops of soybeans, wheat, and milo had been grown between the rows of trees from 1977- 1988. A traveling gun system irrigated the area for several years while crops were being grown.

On April 4, 2001, these ten trees were double girdled with a chainsaw. Girdling started at about 25.4 cm from the ground. Approximately a 7.6 cm space was left between each girdle. An increment core representing one radii was taken at approximately 30.5 cm above the top girdle at the time of girdling. The trees were left standing until January 2003. On January 24, 2003, the trees were felled, cut to 2.4 m- 3 m lengths, hauled to the Horticulture and Agroforestry Research Center at New Franklin, Missouri and placed inside a storage shed.

On July 8, 2003, a Woodmizer sawmill was used to cut the logs lengthwise. When possible, the increment bore entry points were identified and efforts were made to orient the log such that parallel cuts would approximate the angle of increment sampling. However, due to imperfections in log straightness and loss of some bore entry points, there were times when this was not possible. Slabs of about 2.5 cm thickness were removed from the logs until the approximate center of the log was exposed. By cutting the logs lengthwise, any color change could be examined in terms of consistency along the length of the log. Photographs of the slabs were taken for reference purposes. The slabs were numbered the same as the logs.

To analyze the logs, measurements were taken from the center of the log to the edge of the dark colored wood (C-H) and then from the center of the log to the beginning of the bark (C-B). These measurements were taken using a digital caliper, and were taken at about 30.5 cm above the top girdle (the height of increment bore samples) on the half-log that was left after the slabs were cut off. Each log was measured twice, from the center out to the left and from the center out to the right. After measuring C-D and C-B on both sides of the log, an average estimate of the relationship between dark colored wood to total wood was calculated.

The increment cores were also measured using a caliper and measured from the center to the edge of the dark wood (C-H), and from the center out to the beginning of the bark (C-B). Dark colored wood was calculated as a percent of total wood. A comparison of the C-H/C-B ratio from the increment cores was compared to the average C-H/C-B ratio from the logs to determine if any color change had occurred.

A t-test of pre- and post-girdling mean measurements of colored wood was conducted using SAS (1999) to test whether the differences were significantly different from zero. Pre-girdling measurements used the dark wood measured from the increment borer. Post-girdling used a measure of colored wood that was calculated as an average of the colored wood measured across both radii inside a log. For example, the colored wood for log I measured 7.8 cm (Increment bore), while the inside log measurement used was 9.2 cm (the average of two radiuses across the width of colored wood from the logs interior).

Results

To analyze color movement, differences in the percentage of dark colored wood to total wood were compared from the increment borer samples and the logs. At the time of the girdling, dark colored wood and heartwood were synonymous. However, after waiting the 22 months from the time of girdling, dark colored wood could be a combination of heartwood and wood that may be dark in color due to stain or various other reasons (e.g., movement of the dark heartwood color into the lighter colored sapwood)(Bamber and Fukazawa 1985).

Table 1 shows the ratio of dark wood (C-H) to total wood (C-B) from the increment core readings taken at the time of girdling. Log VII had no reading because a portion of the increment borer sample was missing. This made it impossible to determine where the center of the log would have been. It is interesting to note the variance in the percentage of heartwood in trees that are of the same age. One of the trees had as much as 78% heartwood, while another had as little as 49%. Increment core measurements indicate that most of the trees had about 72% heartwood; however, the mean ratio was approximately 65% heartwood to total wood. The proportion of heartwood to total wood was inversely related to the DBH of the tree, which supports other studies on this topic (Nelson 1976). For example, the tree with 49% heartwood had the largest DBH.

Caliper measurements taken from the cut logs after the trees were allowed to stand for 22 months are also shown in Table 1. Those measurements show that the percent of dark colored wood ranged from 49% to 86%. The mean ratio of dark colored wood to total wood is approximately 73%. This average ratio based on cut logs is 8% higher than might have been expected based on increment core readings taken at the time of girdling.

Table 2. Comparison of the change in dark wood content as a percentage and an actual distance averaged over the width of the log face.

Location	Ref./Log Number	DBH (cm)	Ratios		Color Change	Dark Wood (cm)		Change (cm)	Avg Change (cm)
			Inc. Borer	Log		Inc. Borer	Log [†]		
Row 4 - #22	I	24.6	71.6%	86.4%	14.8%	7.8	8.8	1.0	1.4
							9.6	1.8	
Row 4 - #18	II	24.9	71.4%	67.1%	-4.2%	7.1	6.8	-0.3	0.0
							7.5	0.4	
Row 4 - #14	III	28.7	49.1%	49.5%	0.4%	6.7	6.6	-0.1	-0.5
							5.8	-1.0	
Row 2 - #16	IV	23.4	77.9%	77.5%	-0.4%	7.4	6.7	-0.7	-0.5
							7.2	-0.2	
Row 2 - #18	V	27.2	72.3%	80.7%	8.3%	8.1	10.3	2.2	2.0
							9.9	1.8	
Row 2 - #20	VI	25.9	56.0%	80.8%	24.8%	7.0	10.2	3.2	2.0
							7.9	0.9	
Row 2 - #22	VII	27.4	No reading	72.5%	---	No Reading	10.4		---
							8.9		
Row 2 - #25	VIII	22.6	71.6%	76.5%	4.9%	7.3	7.0	-0.3	0.1
							7.8	0.5	
Row 3 - #19	IX	26.4	62.5%	69.1%	6.6%	6.3	7.9	1.7	1.0
							6.6	0.4	
Row 3 - #24	X	26.9	50.5%	65.8%	15.3%	5.3	7.3	2.0	1.9
							7.1	1.8	

[†] Log measurements are taken for both radii of the colored wood on the open face of the cut log.

Looking at the difference in dark wood to total wood ratios (table 2) for both the increment borer samples taken at the time of girdling and the log readings taken 22 months later, it is evident that some of the logs experienced increases in the amount of dark wood. Logs VI, I, and X showed the most difference in dark wood to total wood ratio. Log VI had a difference in colored wood of nearly 25%, whereas logs I and X had a difference of approximately 15%. However, looking at log VI, there were 7 cm of heartwood at the time of girdling and 22 months later the log had 7.9 cm measuring from one side of the log center and 10.2 cm measuring from the other side. On log VI it is unclear from which side of the log the increment bore sample was taken: however, the side that had 10.2 cm of dark wood was the side that had significant bark loss. The other side had only gained 86 cm in dark wood. Dividing that growth rate by nearly 2 years makes that a 0.43 cm increase in dark wood per year. Table 2 shows the amount of heartwood measured on the increment borer samples compared to the amount of dark wood measured in both directions from the center of the logs 22 months after girdling. Logs VI, V, and X showed the greatest differences in dark wood content, averaging about a 2 cm increase in colored wood. The remaining logs showed very little difference in the amount of colored wood, with some logs even showing a loss in colored wood percentage.

A t-test of pre- and post-girdling mean measurements of colored wood did not identify any differences as significant at an alpha=0.05. For the same alpha, the power of the test was 0.325.

Discussion

In sampling wood to measure color changes, the results of this study would point to the need for a sampling procedure that allows for repeated measurements to be taken within close proximity to one another. This is desirable since tree growth does not occur equally on all sides of the tree. Additionally, due to the growth habits and resulting log character traits (crookedness), the procedure used in this study did not cut the logs exactly parallel to the original increment borer sample location, and thereby may have introduced differences in colored wood measurements due to a lack of concentric tree growth.

By either taking repeat samples from a point close to the original core, or by cutting parallel to the initial core sample, any differences in tree growth and colored wood development may have been better accounted for.

Although several of the logs showed an increase in colored wood, this same increase could possibly have been achieved by allowing the trees to grow for another 22 months. Prior to girdling, these trees grew in diameter at a rate of approximately 1 cm per year. Therefore, it stands to reason that following another two growing seasons, the amount of heartwood in each tree would likely have increased.

A factor that would have improved this study would have been to increase the size of the sample. Additionally, enhancement would have resulted from having controls that were not subjected to girdling. Following a final harvest and processing, these trees would have provided a comparison for the growth rate occurring over a given time and any changes in the amount of their heartwood as a percentage of total wood.

Seven of the nine logs that were compared showed at least a slight increase in the proportion of dark wood to total wood. However, out of the seven logs showing an increase in dark colored wood, it was visually evident that none of the logs had experienced a consistent color change throughout their length. In fact, the only visible color increase in log VI was present in an area approximately 33 cm long and only on one side of the log. This increase in colored wood was in the area of the log where bark had separated and fallen off at some time following girdling, yet prior to final harvest. This study was in no way designed to test the effect of bark removal on wood coloration, but may raise the question as to the response of wood coloration following bark removal.

The inconsistency in the color along the length of the log leads to the second question regarding the economic potential for this type of treatment. If the color is inconsistent along the length of the log, then the log is no more valuable than it was before the treatment was applied.

While value is most often attributed to the amount of heartwood present in black walnut, a trees defects and damage resulting from other agents may decrease its value. This should be an additional concern when deciding whether or not to leave a deadened tree on the stump to cure. From this study, a visible factor that is likely to affect marketability of the logs was the distinct presence of insect damage. Finally, stain, or spalt, was noticed in the wood of these logs even though they had been stored in a dry, protected building after they were felled. This too is typically associated with a reduction in log value.

In conclusion, it appears that increasing dark colored wood in eastern black walnut by girdling the trees and leaving them standing for up to 2-years is not likely to increase the marketability of the log or the market value of the tree. Any increases in dark wood formation would likely be nullified by the increased risk of insect infestation and stain formation. Steaming the logs to increase dark wood formation would be the recommended method of increasing marketable wood. However, research is needed to find cheaper methods of increasing dark colored wood than by steaming, and for improving the utilization of small diameter black walnut logs.

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