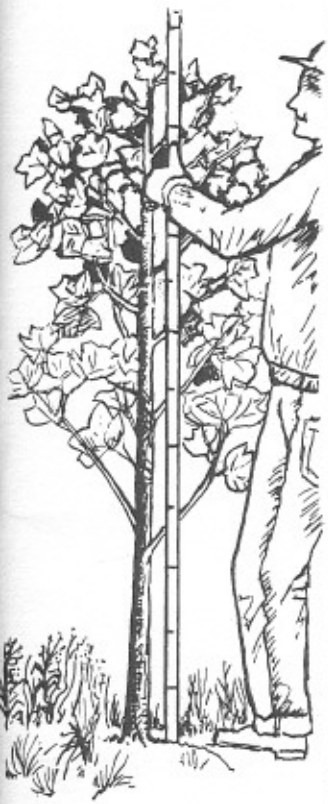
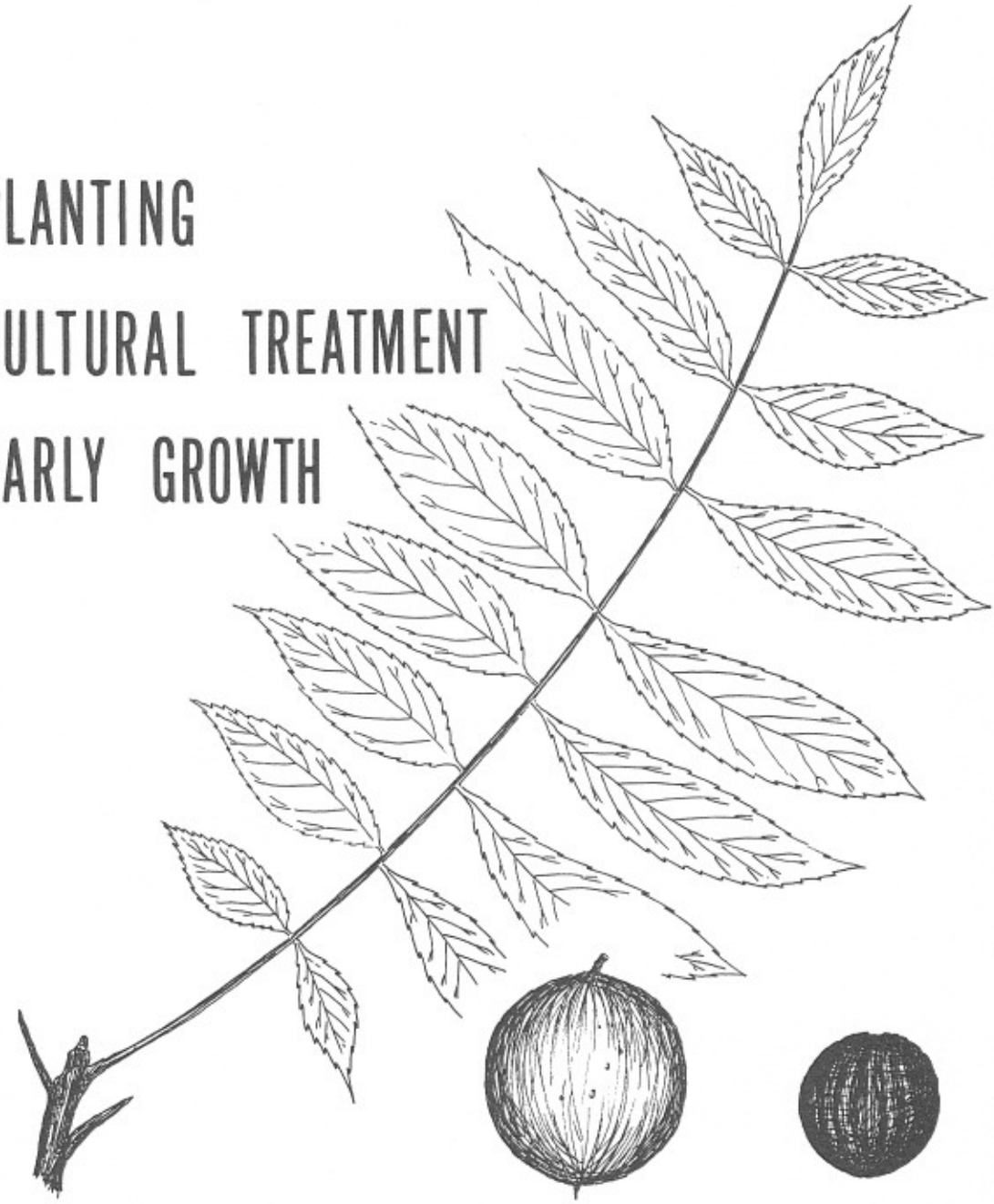


OCCASIONAL REPORT 57 JANUARY 1981

BLACK WALNUT

PLANTING
CULTURAL TREATMENT
EARLY GROWTH



Virginia Division of Forestry
Department of Conservation and Economic Development

EFFECTS OF SEEDLING SIZE, HERBICIDES, FERTILIZER, AND COPPICING ON SURVIVAL AND GROWTH OF PLANTED BLACK WALNUT SEEDLINGS

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ABSTRACT

Results are summarized from many black walnut planting studies installed between 1967 and 1974. The effects of initial seedling size, use of herbicides to control grass and weed competition, fertilization, and coppicing immediately after planting were studied.

Larger seedlings survived better, but did not grow faster, than smaller seedlings. The use of herbicides to control grasses and weeds had a variable effect on walnut growth, but in general, height gains from use of herbicides were small. Response to an application of 10-10-10 was also variable, but in general, height gains were small. Coppicing immediately after planting did not improve survival or subsequent growth.

Site quality had a far greater effect on walnut growth than any of the cultural treatments used. Growth was extremely variable, even for similar topographic positions and soils. Identification of high quality walnut sites prior to planting is very difficult.

INTRODUCTION

Between 1967 and 1974 the Virginia Division of Forestry installed 57 black walnut planting plots, widely scattered over the State. The majority of these plots included two or more 20 seedling rows of different initial root collar diameters. Starting in 1971, herbicides were used to control grasses and weeds on most of the plots, including the plots installed before 1971. Beginning in 1973, fertilizer was applied on a majority of the plots. On six plots installed in 1971, half of the seedlings were coppiced immediately after planting.

Only four of the plots were installed on sites where a timber stand had recently been harvested. All the rest were installed on abandoned farmland or pasture. A spacing of 6.6 x 6.6 feet was used on most of the plots; the remainder were planted at wider spacings ranging up to 13.2 x 13.2 feet. A shovel was used to plant the seedlings on most of the plots, but on six plots a tractor-mounted auger was used to bore holes and planting bars were used on two plots.

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The variation in growth among plots has been extreme. Some grew so well that crowns were beginning to touch by age five when they were thinned. Others grew so poorly that they were abandoned. Seedling heights were measured annually for at least five years on most plots, and have been measured for as long as 12 years on some. Height measurements were stopped when a plot was thinned, after which annual diameter measurements were begun. On some plots heights are still being measured.

This paper summarizes the results from these plots: the effects of seedling size, herbicides, fertilizer, and coppicing on survival and height growth of planted walnut seedlings.

SEEDLING SIZE

A total of 42 plots contained two or more 20 seedling rows in which each row was planted with seedlings of a different root collar diameter class. Diameter was actually measured one inch above the root collar and seedlings were separated into 1/16 inch classes, from a minimum of 2/16 to a maximum of 8/16 inch. The most numerous size classes were 4/16 and 5/16, and some plots contained only two rows, one of each of these two size classes. Table A in the Appendix contains, for all 42 plots, survival percent after the first season in the field, and survival percent and average height at the final measurement - by initial root collar diameter class.

Survival was related to initial root collar diameter - small seedlings did not survive as well as large seedlings. Survival after one season in the field was generally good, even for small seedlings, but in succeeding years the survival advantage of large seedlings over small seedlings became pronounced. Thirty-six of the 42 plots were measured annually through at least age five, and a summary of survival after one and five years is presented in Table 1. Table 1 is interpreted in this manner: 36 plots contained a row of 4/16 and a row of 5/16 inch seedlings that were measured annually for at least five years. Twenty-three of these 36 plots also contained a row of 3/16 inch seedlings. Finally, 11 of the 36 plots contained 3/16, 4/16, 5/16, 6/16, and 7/16 inch seedlings.

Table 1. Average survival percent after one and five seasons in the field and average height in feet after five seasons in the field, by initial root collar diameter.

Number of Plots	Size Classes	Age	Root Collar Diameter (1/16's) 3	4	5	6	7
36	4,5	1	--	95	97	--	--
		5	--	82	91	--	--
		5	--	4.0	4.4	--	--
23	3,4,5	1	93	95	97	--	--
		5	74	85	93	--	--
		5	3.6	4.1	4.3	--	--
26	4,5,6	1	--	93	97	99	--
		5	--	80	91	88	--
		5	--	4.5	4.8	5.1	--
17	3,4,5,6	1	91	94	97	99	--
		5	74	83	92	90	--
		5	4.2	4.6	4.8	5.1	--
16	4,5,6,7	1	--	91	97	99	99
		5	--	74	90	87	95
		5	--	3.8	3.9	4.3	4.7
11	3,4,5,6,7	1	89	91	96	99	100
		5	64	75	89	85	95
		5	2.8	3.4	3.3	3.7	4.0

Average height at age five increases with initial root collar diameter, with an average difference of about .3 feet between 1/16 inch diameter classes (Table 1). The differences in average height at age five may be due primarily to differences already existing at the time of planting (seedlings with larger root collar diameters are generally taller) rather than to differences in rate of growth after planting. The seedlings on the 11 plots on which 3/16, 4/16, 5/16, 6/16, and 7/16 inch seedlings were planted were measured immediately after planting (Table 2). Immediately after planting, 7/16 inch seedlings averaged 1.1 feet taller than 3/16 inch seedlings, and five years later they averaged 1.2 feet taller.

Table 2. Relationship between initial root collar diameter and average height immediately after planting, for 11 plots.

1/16 inch Size Class	Height (feet)
3/16	1.1
4/16	1.2
5/16	1.5
6/16	1.7
7/16	2.2

HERBICIDES

Herbicides were first used to control grasses and weeds around the planted walnut seedlings during the late winter and early spring of 1971. At that time grass and weed control was added as a treatment to most of the plots installed prior to 1971 and to all of the plots installed in 1971 and later. Herbicides were applied to every other pair of seedlings in each row so that comparisons among rows (of different initial root collar diameters) could still be made.

Initially, the area within about a two foot radius around each seedling was treated. As seedlings grew larger the treated area was extended out to the drip line, which increased the treated area to a 3 or 4 foot radius. With the 6.6 x 6.6 foot spacing, treated areas around adjacent seedlings finally merged, resulting in treated swaths across adjacent rows. These swaths were two spaces wide (13.2 feet) and alternated with untreated swaths of the same width.

Simazine (80 percent wettable powder) and Paraquat were the herbicides used. The mixture was two level tablespoons of Simazine and one tablespoon of Paraquat, plus one teaspoon of a spreader-sticker, per gallon of water. An average of 15 to 20 spots were treated with a gallon of the spray mixture, and about 80 spots were treated per man hour.

Effectiveness of the herbicide treatment varied considerably from plot to plot, depending primarily on the species present. Grasses were usually controlled well. Many herbaceous species were also controlled well, but some were not. Control was only marginal on some plots, especially on the better sites, because of vines and weeds that were either resistant to the herbicides used or became established after the susceptible species had been killed. Also on the better sites, shading by tall weeds outside the treated spots often was severe.

Table B in the Appendix includes the following information on response to herbicides for 38 different plots:

1. age and average height when herbicides were first applied
2. number of years that herbicides were applied
3. age and average height at final or latest measurement

This information is summarized in Table 3 for 28 of the 38 plots that were measured for at least four years after herbicide treatment was started.

Table 3. Response to herbicides by age at which first applied.

Year Planted	Age at Which Herbicides Started	Number Years Applied	No. Plots	Height Gain (in feet) 1/ Average	Range
1967	4	4	3	.9	.6 to 1.3
1968	3	4 or 5	5	1.4	.0 to 3.1
1969	2	4 or 5	8	1.2	.2 to 2.3
1971-74	0	4 or 5	12	2.6	.8 to 5.9

Response to herbicide treatment was extremely variable, ranging from no effect up to an increase in height on one plot (Nelson, 1971) of 5.9 feet. In general, the gain from applying herbicides was small, less than two feet on 19 of the 28 plots in Table 3. Herbicide treatment seemed to be more effective when started at the time the seedlings were planted, but even on these plots the gain was less than two feet on 7 of the 12 plots.

Herbicide treatment improved survival slightly. For the 12 plots in Table 3 on which herbicide treatment was started at the time of planting, survival averaged 2.9 percentage points better for herbicide treated trees at the final measurement.

FERTILIZER

Fertilizer was applied on 33 plots, starting in the spring of 1973. Either a half or one pound of 10-10-10 was applied one time in a band around individual seedlings. The one-half pound rate was used on 28 plots and the one pound rate on 5 plots. The only exceptions to the one time application were the 1967 Jolly plot, on which one-half pound was applied at age six and one pound at age seven, and the 1971 Farrier plot (rows two and three) on which one-half pound was applied at age two and one pound at age three.

The age at which fertilizer was applied ranged from one to six years after planting. Fertilizer was applied to half of the seedlings that had been treated with herbicides. On 8 of the 33 plots, fertilizer was also applied to half of the seedlings that had not been treated with herbicides. Table C in the Appendix includes the following information on response to fertilizer for the 33 plots on which fertilizer was applied:

1/ Average difference, at the final or latest measurement, between treated and check seedlings (adjusted for the average difference existing at the time herbicides were first applied). The final or latest measurement was made from four to nine years after herbicides were first applied.

1. age and average height when fertilizer was applied
2. application rate (one-half or one pound)
3. age and average height at the final or latest measurement

This information is summarized in Table 4 for 30 of the 33 plots that were measured for at least two years after fertilizer was applied.

Table 4. Response to fertilizer by age at which applied.

Year Planted	Age When Fertilizer Applied	No. Plots	Height Gain (feet)[1] Average	Range
	--seedlings treated with herbicide--			
1967	6	3	.9	.1 to 1.5
1968	5 or 6	4	.6	-1.3 to 2.3
1969	4	4	.8	- .3 to 1.9
1971-74	1 to 3[2]	19	1.3	- .6 to 4.7
	--seedlings not treated with herbicide--			
1968	6	1	-1.3	--
1971	3	1	5.8	--
1973 & 74	1	4	1.0	- .2 to 2.1

Response to fertilizer was about the same whether or not seedlings were also treated with herbicide. This can be seen in Table C of the Appendix by comparing the check, herbicide only, fertilizer only, and herbicide plus fertilizer treatments for the eight plots that had all four treatments.

The response to fertilizer was variable, ranging from no response (or a negative response) up to an increase in height on one plot (Will, 1971) of

1/ Average difference, at the final or latest measurement, adjusted for the average difference existing at the time fertilizer was first applied. For the upper part of the Table the difference is between seedlings receiving herbicide plus fertilizer and seedlings receiving only herbicide. In the lower part of the Table the difference is between seedlings receiving just fertilizer and seedlings receiving neither herbicide or fertilizer.

2/ Thirteen plots fertilized after the first season, two plots after the second season, and four plots after the third.

5.8 feet. The response in general was small, averaging about a one foot gain in height. Height was increased by more than two feet on only 5 of the 30 plots in Table 4.

The response to fertilizer was short-lived. Most of the gain in height from fertilizer took place within two years following application. The response was essentially complete one year after fertilization on a third of the plots, and on three plots the response lasted for three years (Miller 1968, Cralle 1971, and Plentovich 1971). On three plots the final measurement was too soon (two years after fertilization) to tell whether the response was essentially complete or not.

Soil samples were taken prior to applying fertilizer and standard soil analyses were done for 28 of the 33 fertilized plots. Height gains were plotted over pH and pounds per acre of CaO, P_2O_5, and K_2O. Simple linear regressions were fitted, and these regressions explained little of the variation in height gains (Table 5). Consequently, preliminary soil analyses were not helpful for predicting on which plots the seedlings would respond to fertilizer.

Table 5. Average values and ranges for pH, CaO, P_2O_5, and K_2O on 28 plots; and the proportion of the variation in height gains accounted for by the regressions.

Variable	Mean	Range	r^2
pH	6.0	4.8 - 7.6	.076
pounds of CaO per acre	1,927	220 - 3,301+	.068
pounds of P_2O_5 per acre	58	0 - 275+	.164
pounds of K_2O per acre	200	36 - 377+	.015

COPPICING

Coppicing at the time of planting was superimposed on a study installed on six different tracts in 1971. The study included 20 seedling rows of three or four different root collar diameter classes, and these diameter classes were replicated three times in randomized blocks on each tract. Herbicide and herbicide plus fertilizer treatments were assigned to each 20 seedling row in a balanced manner. Herbicide was applied to every other pair of seedlings, starting at the time of planting and continuing for five years. Fertilizer was applied once, after one season in the field, to about half of the herbicided pairs of seedlings. Every other seedling in each row was coppiced immediately after planting to a height of two to three inches. Consequently, coppiced and non-coppiced seedlings included equal numbers of seedlings that received herbicide, herbicide plus fertilizer or no other treatment (controls).

Coppiced trees were considerably shorter than non-coppiced trees after the first season in the field, but after two seasons they had almost caught up. At age five, averaging over the six tracts, coppiced trees were slightly shorter and had not survived quite as well as non-coppiced trees (Table 6).

Table 6. Survival after one and five seasons and height after five seasons, for coppiced and non-coppiced seedlings.

Tract	Coppiced	Survival Percent 1 Year	5 Years	Average Height After 5 Years (feet)
Cralle	Yes	100	88	3.7
	No	100	87	4.1
Mullins	Yes	99	92	4.7
	No	100	98	4.4
Nelson	Yes	98	96	7.3
	No	97	94	7.3
Plentovich	Yes	96	76	4.0
	No	98	87	4.0
Richardson	Yes	97	93	8.5
	No	95	92	9.2
Williamson	Yes	94	72	3.2
	No	98	83	3.4
Means	Yes	97	86	5.2
	No	98	90	5.4

SITE EFFECTS

The foresters who installed the plots discussed in this report were requested to select planting sites they thought would be suitable for walnut. On a few plots soil conditions were later discovered that indicated the site was not suitable for walnut (Anderson 1967, Aylor 1968, Armstrong 1968, and Hodge 1969). But the remaining plots were on sites that could reasonably be expected to be good sites for upland hardwoods, and (hopefully) at least fair for black walnut. The extreme variation in growth among plots is impossible to explain. Growth has, in some cases, been disappointing on sites that appear to be excellent, and the reverse is also true - growth has been excellent on some sites that appear to be only fair for walnut.

Table 7 includes average heights at age five for check trees (not treated with herbicide or fertilizer) on 43 plots. An average height at age five, of five feet or better was only achieved on 12 of the 43 plots. The plots in Table 7 are separated into three topographic positions - alluvial, colluvial, and upland. Great variation in five year heights occur within each topographic position, but overall, the best growth occurred on colluvial soils, and the worst on alluvial soils, with upland soils intermediate. The poor growth on most alluvial sites is especially puzzling, when 9 of the 11 plots were on well to moderately well-drained soils and on only 2 of these 9 plots was growth acceptable.

Table 7. Overall mean heights (in feet) for check trees at age 5 by topographic position[1/]

ALLUVIAL			COLLUVIAL			UPLAND		
Tract		Height	Tract		Height	Tract		Height
67 Anderson	(b)	.7	67 Carter II	(a)	7.2	67 Carter III	(a)	7.7
Richmond	(a)	2.0	Jolly	(a)	2.6	Carter IV	(a)	5.1
			Paul Forest	(b)	3.0			
68 Aylor	(b)	1.7	Rouse	(b)	7.4	68 Armstrong	(b)	2.6
Howell	(a)	1.6	Smith Lbr. Co.	(a)	2.8	Miller	(b)	2.6
						Powell	(a)	.6[2/]
69 Aylor	(a)	2.1	68 Lagather	(b)	9.5	Williams	(a)	2.8
Highway Dept.	(a)	1.6	Richardson	(a)	5.7			
Howell	(a)	1.8	Rouse	(b)	10.3	69 Carter	(a)	5.7
Nat'l Humane	(a)	8.8				Overman	(a)	2.7
Richmond	(a)	2.5	69 Benfield	(b)	2.9			
			Happy Hollow	(b)	2.4	71 Sullivan	(c)	2.5
71 Augusta F.C.	(a)	5.4[2/]				Will	(c)	3.7
Williamson	(a)	2.6	71 Lesesne	(b)	4.0[2/]	Cralle	(c)	2.7
			Mullins	(b)	3.2	Plentovich	(c)	2.8
			Nelson	(a)	4.5	Farrier	(b)	5.8
			Richardson	(b)	6.8			
						72 Farrier	(b)	4.4
			72 Lesesne I	(b)	5.1[2/]	Harding	(a)	4.6
			Lesesne II	(b)	4.5[2/]			
			Lesesne III	(a)	8.1[2/]			
Average		2.8	Average		5.3	Average		3.8

1/ The letters in parenthesis after each tract give additional information about the site:

Alluvial
(a) well to moderately well-drained
(b) somewhat poorly to poorly drained

Colluvial
(a) coves
(b) lower slopes

Upland
(a) ridge tops and upper slopes
(b) middle slopes
(c) coastal plain terraces - nearly level and well-drained

2/ All trees on these plots were treated with herbicides, so herbicided trees are considered to be the check trees.

DISCUSSION AND CONCLUSIONS

1. Seedling Size - seedlings 5/6 inch in root collar diameter and larger should be favored, primarily because smaller seedlings do not survive as well. Larger diameter seedlings are also taller, and this initial height advantage persists after planting.

2. Herbicides - the application of herbicides would be hard to justify based on the results from these studies, but on some plots herbicide improved growth considerably. If used, herbicides should be started when the seedlings are planted, and continued for only two or three years to hold down costs.

3. Fertilizer - a single application of one-half or one pound of fertilizer per tree would be considerably less expensive than applying herbicides for two or three years. Even though the average response to fertilizer was small, fertilizer made a big difference on some plots.

4. Coppicing - coppicing at the time of planting was of no benefit in these studies.

5. Site Selection - planting seedlings on a site well suited for walnut will do more to attain good growth than any of the cultural measures discussed. And yet, picking a suitable site is difficult. These studies suggest that colluvial soils are the best bet, but even on colluvial soils an average height of five feet in five years was attained on only half of the plots. Where a large walnut planting is being considered, it might be wise to plant one or two test rows across the planting site and observe them for a few years before planting the entire area. On suitable sites, walnut seedlings usually begin to make vigorous growth within a few years after planting, and planting of a large tract could be delayed until good growth is observed in the test rows.

TABLE A. Survival percent after the first season in the field, and survival percent and average height (in feet) at the final or latest measurement, by initial root collar diameter class.

Year Planted	Tract		Initial Root Collar Diameter (16ths inch) 2	3	4	5	6	7	8
1967	Anderson	% - age 1			95	100			
		- age 5			65	65			
		ht - age 5			.5	.8			
	Carter I	% - age 1		100	95	100	100		
		- age 2		100	95	95	100		
		ht - age 2		.9	1.0	1.2	1.5		
	Carter II	% - age 1		95	95	95	100		
		- age 6		90	95	95	100		
		ht - age 6		8.4	10.3	11.0	11.4		
	Carter III	% - age 1		85	100	100	95		
		- age 6		75	100	100	95		
		ht - age 6		9.9	10.3	10.2	11.0		
	Carter IV	% - age 1		100	100	100	100		
		- age 8		100	100	100	100		
		ht - age 8		11.2	9.4	12.1	12.8		
	Jolly	% - age 1			90	100			
		- age 11			80	100			
		ht - age 11			8.0	9.1			
	Paul Forest	% - age 1		90	95	95	100	100	
		- age 7		75	95	95	95	95	
		ht - age 7		2.9	3.6	3.0	4.1	5.4	
	Richmond	% - age 1			100	100			
		- age 8			90	100			
		ht - age 8			2.9	3.0			
	Rouse	% - age 1			100	100			
		- age 6			100	90			
		ht - age 6			11.7	13.2			
	Smith Lbr. Co.	% - age 1		95	100	100	100	95	
		- age 5		65	80	90	75	90	
		ht - age 5		2.2	2.8	2.3	3.4	3.5	
1968	Armstrong	% - age 1		100	100	100			
		- age 8		95	95	100			
		ht - age 8		3.9	6.0	6.4			

continued

TABLE A - Page 2

Year Planted	Tract		Initial Root Collar Diameter (16ths inch) 2	3	4	5	6	7	8
	Aylor	% - age 1		100	100	100			
		- age 7		55	100	100			
		ht - age 7		3.7	4.0	3.7			
	Howell	% - age 1		100	100	100			
		- age 7		80	90	100			
		ht - age 7		3.1	2.5	3.2			
	Lagather	% - age 1	85	100	95	100	100		
		- age 6	85	85	85	90	90		
		ht - age 6	9.9	11.5	12.1	12.7	11.1		
	May & Duncan	% - age 1		90	95	85			
		- age 2		80	75	65			
		ht - age 2		1.2	1.8	2.2			
	Miller	% - age 1		95	100	95	100		
		- age 11		80	100	95	95		
		ht - age 11		10.0	7.3	12.2	9.5		
	Powell	% - age 1		100	100	100			
		- age 6		30	35	65			
		ht - age 6		.6	.5	.7			
	Richardson	% - age 1		90	95	95			
		- age 7		75	85	85			
		ht - age 7		11.4	14.0	13.8			
	Rouse	% - age 1		100	100	100	100		
		- age 5		100	100	100	100		
		ht - age 5		8.8	10.4	11.0	11.1		
	Williams	% - age 1		100	100	100			
		- age 12		95	100	100			
		ht - age 12		12.5	10.1	12.6			
	Wilsher	% - age 1		100	95	95			
		- age 4		85	85	90			
		ht - age 4		.7	.9	1.2			
1969	Aylor	% - age 1		95	100	100	100	100	
		- age 6		75	95	70	95	95	
		ht - age 6		2.8	4.6	2.1	2.0	4.6	

continued

TABLE A - Page 3

Year Planted	Tract		Initial Root Collar Diameter (16ths inch) 2	3	4	5	6	7	8
	Benfield	% - age 1		100	100	100	100	100	95
		- age 8		80	85	90	85	100	95
		ht - age 8		4.2	3.4	4.0	5.7	5.6	8.4
	Carter	% - age 1	40	95	70	95	95	100	100
		- age 8	30	85	65	95	95	100	100
		ht - age 8	9.7	12.1	10.4	13.6	11.4	11.3	13.3
	Happy Hollow	% - age 1		85	85	90	100	100	
		- age 6		70	60	85	85	100	
		ht - age 6		3.0	4.0	3.4	4.3	3.4	
	Highway Dept.	% - age 1		70	90	85	100	100	
		- age 6		60	80	70	90	85	
		ht - age 6		2.7	2.9	2.2	3.1	2.7	
	Walt Hodge	% - age 1					100	100	100
		- age 4					95	90	90
		ht - age 4					1.4	1.7	1.8
	Howell	% - age 1		100	95	100	100	100	
		- age 6		25	80	90	60	80	
		ht - age 6		1.7	2.9	2.7	2.7	2.9	
	National Humane	% - age 1		80	100	100	100	100	
		- age 5		30	35	50	70	90	
		ht - age 5		5.6	7.9	8.8	8.9	9.0	
	Overman	% - age 1		85	65	90	95	100	100
		- age 8		70	55	85	75	100	90
		ht - age 8		4.7	6.2	6.8	7.8	8.5	8.8
	Richmond	% - age 1		85	100	100	100	100	
		- age 6		45	85	95	85	85	
		ht - age 6		3.1	3.4	3.5	3.7	3.8	
	Saufly	% - age 1		45	65	95	95	95	
		- age 2		35	60	85	85	90	
		ht - age 2		.5	.9	1.5	1.2	1.6	
1971	Cralle	% - age 1				100	100	100	
		- age 8				78	85	85	
		ht - age 8				6.0	4.6	7.5	
	Mullins	% - age 1			98	100	100		
		- age 9			90	92	93		
		ht - age 9			6.0	6.9	8.2		

continued

TABLE A - Page 4

Year Planted	Tract		Initial Root Collar Diameter (16ths inch) 2	3	4	5	6	7	8
	Nelson	% - age 1			93	97	100	100	
		- age 6			85	97	98	98	
		ht - age 6			7.6	9.0	9.4	9.6	
	Plentovich	% - age 1			93	100	100	95	
		- age 9			63	95	78	88	
		ht - age 9			6.7	6.3	6.8	7.8	
	Richardson	% - age 1			88	97	98	100	
		- age 6			77	82	88	100	
		ht - age 6			10.2	10.7	11.1	12.3	
	Williamson	% - age 1			85	100	100	100	
		- age 5			45	87	87	92	
		ht - age 5			2.0	2.6	3.6	4.2	
1973	Lesesne Virginia, Tennessee	% - age 1			96	98	100	100	
		- age 7			92	98	100	100	
		ht - age 7			3.4	3.8	3.8	4.5	
1974	Frith	% - age 1			97	97	100		
		- age 6			37	73	63		
		ht - age 6			5.4	6.9	5.9		
	Mitchell	% - age 1			90	93	97		
		- age 6			83	93	70		
		ht - age 6			3.0	3.0	3.2		
	Trail	% - age 1			93	87	93		
		- age 6			80	67	80		
		ht - age 6			3.3	3.2	3.5		

TABLE B. Effect of Herbicides on Height Growth.

Year Planted	Tract	Age Started	Years Applied	1/ No. of Rows	2/ Treatment	Mean Ht. at Start	Final Measurement Age	Final Measurement Mean Ht.
1967	Carter II	4	4	4	Ck.	5.6	6	10.2
					H.	5.2		10.4
	Carter III	4	4	4	Ck.	5.5	6	10.1
					H.	5.2		10.7
	Carter IV	4	4	4	Ck.	3.9	8	10.4
					H.	3.9		11.2
	Jolly	4	4	2	Ck.	2.1	11	7.6
					H.	2.2		9.0
	Paul Forest	4	3	5	Ck.	2.6	7	3.8
					H.	2.5		3.9
	Richmond	4	4	2	Ck.	1.8	8	2.7
					H.	2.0		3.5
	Rouse	4	4	2	Ck.	4.6	6	12.4
					H.	4.2		12.5
1968	Armstrong	5	3	3	Ck.	2.6	8	4.7
					H.	2.5		5.2
	Aylor	3	4	3	Ck.	1.4	7	3.1
					H.	1.4		4.4
	Howell	3	4	3	Ck.	1.0	7	2.6
					H.	1.0		2.9
	Lagather	3	2	5	Ck.	3.9	6	11.5
					H.	3.3		11.4
	Miller	3	5	4	Ck.	1.4	11	7.3
					H.	1.4		10.4
	Richardson	3	4	3	Ck.	2.1	7	13.0
					H.	1.9		12.8
	Rouse	3	4	4	Ck.	2.6	5	10.3
					H.	2.2		10.4
	Williams	3	5	3	Ck.	1.8	12	11.8
					H.	1.7		13.9
1969	Aylor	2	4	5	Ck.	1.7	6	2.5
					H.	1.7		4.0
	Benfield	2	5	6	Ck.	1.9	8	4.2
					H.	2.0		5.9

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Year Planted	Tract	Age Started	Years Applied	1/ No. of Rows	2/ Treatment	Mean Ht. at Start	Final Measurement Age	Final Measurement Mean Ht.
	Carter	2	5	7	Ck. H.	2.3 2.3	8	11.7 11.9
	Happy Hollow	2	4	5	Ck. H.	1.4 1.5	6	2.8 4.0
	Highway Dept.	2	4	5	Ck. H.	1.5 1.4	6	1.6 3.8
	Walt Hodge	2	3	3	Ck. H.	2.0 2.0	4	1.8 2.0
	Howell	2	4	5	Ck. H.	1.4 1.4	6	2.6 2.8
	National Humane	2	4	5	Ck. H.	2.8 2.3	5	8.8 8.1
	Overman	2	5	6	Ck. H.	1.9 1.9	8	5.8 7.8
	Richmond	2	4	5	Ck. H.	1.7 1.7	6	3.3 3.7
1971	Sullivan	0	5	2	Ck. H.	1.4 1.3	8	3.6 7.5
	Will	0	5	4	Ck. H.	1.4 1.2	9	6.3 10.4
	Cralle	0	5	9	Ck. H.	3/	8	5.2 6.1
	Mullins	0	5	9	Ck. H.	3/	9	4.4 8.6
	Nelson	0	5	12	Ck. H.	3/	6	5.5 11.4
	Plentovich	0	5	12	Ck. H.	3/	9	5.6 7.5
	Richardson	0	5	12	Ck. H.	3/	6	9.3 13.4
	Williamson	0	5	12	Ck. H.	3/	5	2.7 4.5
1973	Lesesne Virginia, Tennessee	0	4	6	Ck. H.	1.4 1.4	7	2.0 2.8

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Year Planted	Tract	Age Started	Years Applied	1/ No. of Rows	2/ Treatment	Mean Ht. at Start	Final Measurement Age	Final Measurement Mean Ht.
1974	Buckingham S.F. White Pine S.O.	0	3	3	Ck.	2.2	3	2.2
					H.	2.2		2.8
	Frith	0	4	12	Ck.	3/	6	5.6
					H.			6.7
	Mitchell	0	4	9	Ck.	3/	6	1.9
					H.			3.3
	Trail	0	4	12	Ck.	3/	6	1.8
					H.			3.0

1/ Rows contain 20 seedlings with the exception of the 1974 Frith, Mitchell, and Trail plots on which rows contain 10 seedlings.

2/ Ck. = Check
H. = Treated with Herbicides

3/ Seedlings were not measured immediately after planting.

TABLE C. Effect of Fertilizer on Height Growth.

Year Planted and Tract	No. of Rows	1/ Treatment	Fertilizer Applied			Final Measurement	
			Age	2/ Rate	Mean Ht.	Age	Mean Ht.
1967 Carter IV	4	H	6	1	6.9	8	11.2
		H & F			7.7		13.2
Jolly	2	H	6 & 7	½ & 1	3.1	11	9.0
		H & F			2.8		10.2
Richmond	2	H	6	½	2.8	8	3.5
		H & F			2.0		2.8
1968 Armstrong	3	H	6	½	3.9	8	5.2
		H & F			4.0		6.3
Aylor	3	Ck	6	½	2.2	7	3.1
		H			3.4		4.4
		F			2.4		3.0
		H & F			2.3		4.6
Howell	3	H	5	½	1.6	7	2.9
		H & F			1.8		3.6
Miller	4	H	5	½	3.7	11	10.4
		H & F			3.8		12.8
Powell	3	H	5	½	.6	6	.6
		H & F			.6		.7
Richardson	3	Ck	6	1	8.6	7	13.0
		H			9.2		12.8
		F			7.4		11.7
		H & F			9.8		14.6
Williams	3	Ck	6	½	4.2	12	11.8
		H			5.6		13.9
		F			2.9		9.2
		H & F			3.7		10.7
1969 Benfield	6	H	4	½	2.8	8	5.9
		H & F			2.2		6.5
Happy Hollow	5	H	4	½	2.2	6	4.0
		H & F			2.5		4.8

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Year Planted and Tract	No. of Rows	1/ Treatment	Fertilizer Applied Age	2/ Rate	Mean Ht.	Final Measurement Age	Mean Ht.
Highway Dept.	5	H	4	½	2.0	6	3.8
		H & F			1.9		3.4
Overman	6	H	4	½	2.3	8	7.8
		H & F			2.5		9.9
1971 Augusta F.C.	8	H	3	1	3.2	5	5.2
		H & F			3.1		5.3
Lesesne Virginia, Pennsylvania	8	H	1	½	1.4	9	7.2
		H & F			1.5		9.0
Will	4	Ck	3	1	1.9	9	6.3
		H			2.7		10.4
		F			2.7		12.9
		H & F			3.1		13.4
Cralle	9	H	1	½	1.8	8	6.1
		H & F			1.8		9.0
Mullins	9	H	1	½	1.6	9	8.6
		H & F			1.6		9.2
Nelson	12	H	1	½	1.8	6	11.4
		H & F			1.8		13.1
Plentovich	12	H	1	½	1.6	9	7.5
		H & F			1.6		9.3
Richardson	12	H	1	½	1.7	6	13.4
		H & F			1.7		13.4
Williamson	12	H	1	½	1.3	5	4.5
		H & F			1.3		3.9
Farrier Rows 2 & 3	2 3/	H	2&3	½ & 1	2.2	6	10.4
		H & F			2.3		15.2
Farrier Rows 6 & 7	2 3/	H	3	1	1.4	6	4.8
		H & F			2.6		9.7

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Year Planted and Tract	No. of Rows	1/ Treatment	Fertilizer Applied Age	Fertilizer Applied 2/ Rate	Fertilizer Applied Mean Ht.	Final Measurement Age	Final Measurement Mean Ht.
1972 Farrier	3 3/	H	3&5	½ & 1	2.3	7	5.8
		H & F			2.6		7.6
Harding	4	H	2	½	1.4	7	5.5
		H & F			1.3		6.1
Lesesne	20 4/	H	1	½	1.7	8	6.4
		H & F			1.6		7.4
1973 Lesesne	6	Ck	1	½	1.2	7	2.0
Virginia,		H			1.3		2.8
Tennessee		F			.9		3.8
		H & F			1.3		3.7
1974 Buckingham	3	H	1	½	2.0	3	2.8
S. F.		H & F			2.3		2.8
Frith	12 3/	Ck	1	½	1.4	6	5.6
		H			1.4		6.7
		F			2.0		6.0
		H & F			1.5		6.3
Mitchell	9 3/	Ck	1	½	1.5	6	1.9
		H			1.6		3.3
		F			1.0		2.5
		H & F			1.5		3.9
Trail	12 3/	Ck	1	½	1.4	6	1.8
		H			1.2		3.0
		F			1.6		2.9
		H & F			1.4		5.0

1/ Ck = Check - no herbicide or fertilizer
H = Herbicide only
F = Fertilizer only
H & F = Herbicide and Fertilizer

2/ Either 1/2 or 1 pound of 10-10-10 per tree

3/ 10 seedling rows

4/ 15 seedling rows