RESPONSE OF AMERICAN SYCAMORE SPECIFIC GRAVITY TO INTENSIVE CULTURE

James R. Olson and Robert F. Wittwer[1/]

Abstract.--The relationship of intensive cultural practices to wood specific gravity was examined in 5-year-old American sycamore seedlings and coppice. Significant differences in seedling specific gravity were obtained from changes in fertilizer treatment, spacing and site quality. Individually, the consequences of each intensive cultural practice was a lowering of the wood specific gravity. Sprout specific gravity was only affected by fertilization treatment. A combination of good bottomland sites, fertilizers and close spacings resulted in a seedling specific gravity decrease of more than 15 percent when compared with non-intensive practices. The same cultural treatments reduced sprout specific gravity 7 percent. The larger quantity of pulpwood or biomass produced using intensive cultural practices should more than compensate for the resulting reduction in specific gravity.

Keywords: Wood quality, *Platanus occidentalis* L.

INTRODUCTION

Intensive culture of selected hardwood species has been studied and practiced for a number of years. Fertilization, close spacings, irrigation and use of better sites in conjunction with short rotations and repeated harvesting of coppice stands are all intensive cultural techniques that can be employed with genetically improved planting stock. The utilization of some combination of these methods greatly increases height and diameter growth and consequently the quantity of usable pulpwood or biomass produced. Very large gains in biomass production have been found for short rotation sycamore using selected intensive cultural practices (Saucier et al. 1972, Wittwer and Hinton 1978). However, it has been shown that the pulp and paper quality of the wood is usually reduced if rotation ages less than eight years are used (Einspahr 1976).

The larger amount of wood obtained using intensive culture will normally more than outweigh any detrimental effects of accelerated growth rate on the pulping characteristics of the wood (Steinbeck 1974). One wood property that may be affected is specific gravity (SG). For many years this characteristic

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1/ Assistant Professor, Department of Forestry, University of Kentucky, Lexington, Kentucky, and Associate Professor, Department of Forestry, Oklahoma State University, Stillwater, Oklahoma.

The investigation reported in this paper (82-8-248) is in connection with a project of the Kentucky Agricultural Experiment Station and is published with approval of the Director. The authors wish to acknowledge the support and cooperation of Willamette Industries, Inc., Hawesville, Kentucky. This research was also supported in part by McIntire-Stennis funds.

has been called the key to wood quality (For. Prod. Lab. 1965). A few studies have examined the effect of intensive culture on the specific gravity of American sycamore (Platanus occidentalis L.). Most, however, have only studied one intensive cultural practice.

The influence of various fertilizer treatments applied during the first growing season to sycamore planted on a bottomland site in Georgia was evaluated for the three years following fertilization (Saucier and Ike 1969). Fertilizer treatments did not decrease specific gravity. Differential growth responses producing increased radial growth varied depending upon fertilizer treatment. Weighted average tree specific gravity was associated with growth rate; namely, wood of larger, more vigorous trees usually had higher specific gravity. Saucier and Ike concluded that the growth rate can be increased by fertilization without adversely affecting the important wood properties.

In another study Saucier and co-workers (1972) examined the effect of spacing on weighted specific gravity of sycamore seedlings and sprouts growing on a bottomland site. The specific gravity of 4-year-old seedlings planted at 0.3 x 1.2 m spacings was 8.7 percent lower than that using a wider spacing of 1.8 x 1.2 m. Decreases of 4.3 and 6.8 percent in specific gravity were obtained for 2- and 3-year-old sprouts, respectively.

Similar results were found by Geyer (1981) who determined that decreasing the spacing from 1.2 x 1.2 m to 0.3 x 1.2 m resulted in specific gravity decreases of 7.3 percent for both 2-year-old sycamore seedlings and sprouts. Average whole-tree specific gravities were the same for coppice and seedlings.

The response of specific gravity to intensive culture is a relationship that needs to be more clearly understood. Since the above studies have each considered only one type of intensive cultural practice, fertilization or close spacing, a study examining multiple practices is needed. The objective of this research then was to determine the effect of three major factors in intensive culture (spacing, fertilization and site quality) on the specific gravity of both seedling and coppice growth of American sycamore.

METHODS

The experimental design for this study has been described in previous papers (Wood et al. 1976, Wittwer et al. 1978). Two sites were studied; the first, a bottomland, is subject to frequent spring flooding, while the second occupies a terrace above the river that does not flood. Both sites have a long history of agricultural use, however the terrace site is less productive. Treatments on the two sites included three spacings (0.3 x 0.9 m, 0.9 x 0.9 m, and 1.8 x 0.9 m) and three fertilizer treatments (none, nitrogen (N), and combined nitrogen plus phosphorous (P)). Nitrogen treatment consisted of 169 kg/ha elemental N from ammonium nitrate (N), while the combined treatment included the N treatment in addition to 112 kg/ha elemental P from concentrated superphosphate (N+P). Fertilizer treatments were applied in late spring during each year of growth, except for the first year after harvest to minimize herbaceous competition for the coppice rotation. Preliminary analysis of the effect of the N+P treatment indicated no significant difference from the N treatment. The sprouts were thus fertilized with only the N fertilizer treatment.

A split-plot design, incorporating three replications on each of two sites, was utilized with treatments randomly assigned to plots within each replication. All seedlings were harvested from the plots after five years. Four sample trees, 1 small, 2 medium, and 1 large, representing typical trees of the sizes found on the plot, were selected. A 2-cm thick specific gravity sample was removed from each at approximately 10 cm from the ground-line. Five years later all sprouts were harvested. However, at this time only three representative sprouts (small, medium and large) were sampled. Sample sprouts were always selected from different rootstocks. In order to eliminate edge effects, the outside rows from each plot were excluded from seedling as well as sprout sampling. The diameters at the base and height of each sample stem were measured.

Specific gravity was determined by the water immersion method. Bark was removed prior to measurement. After ovendrying to constant weight at 103°C, the specific gravity was calculated on a green volume, ovendry weight basis.

Split-plot analyses of variance were used to determine the significance of the treatment combinations.

RESULTS AND DISCUSSION

A comparison of the coefficients of variation for the 5-year-old seedling and sprout data of Table 1 shows that both sprouts and seedlings were very variable in size. The average diameter at the base was lower for seedlings, 4.26 cm, than for sprouts, 4.97 cm. A comparison of height data indicates a similar trend, higher for sprouts, 5.76 m, and lower for seedlings, 5.13 m.

Table 1.--Averages, coefficients of variation (CV) and ranges of seedling and sprout properties.

Property	Seedlings				Sprouts			
	No. of Samples	Average	CV	Range	No. of Samples	Average	CV	Range
Diameter at Base (cm)	213	4.26	35.20	1.60-9.70	107	4.97	38.00	2.00-9.80
Height (m)	216	5.13	25.68	1.74-7.56	108	5.76	23.21	3.05-8.75
Specific Gravity	213	0.469	6.35	0.407-0.560	106	0.447	5.87	0.398-0.514

Average specific gravities for seedlings and sprouts were 0.469 and 0.447, respectively. An analysis of variance comparing these means showed a significant difference at the one percent level, indicating that 5-year-old seedlings have higher specific gravities than coppice growth of the same age.

Mean specific gravities of seedlings and sprouts are found in Tables 2 and 3, respectively, for each treatment analyzed. Analysis of variance utilizing these results showed the significance of site, fertilization and spacing

Table 2.--Average specific gravity[1/] of 5-year-old sycamore seedlings as affected by site, fertilization and spacing.

Replication	Control			N Fertilized			N-P Fertilized		
	.3x.9	.9x.9	1.8x.9	.3x.9	.9x.9	1.8x.9	.3x.9	.9x.9	1.8x.9
Terrace Site									
1	.504	.515	.520	.457	.485	.492	.453	.478	.473
2	.497	.473	.520	.460	.455	.463	.464	.482	.471
3	.477	.460	.529	.461	.461	.469	.450	.455	.494
$\bar{X}$	.493	.483	.523	.459	.470	.474	.456	.471	.480
Fert. $\bar{X}$		.500			.467			.469	
Site $\bar{X}$					.479				
Bottomland Site									
1	.471	.485	.494	.431	.475	.463	.440	.435	.472
2	.466	.471	.470	.445	.451	.470	.438	.456	.485
3	.461	.435	.462	.450	.472	.455	.442	.451	.452
$\bar{X}$	.466	.464	.475	.442	.468	.460	.440	.447	.474
Fert. $\bar{X}$		.468			.457			.452	
Site $\bar{X}$					.459				

[1/] Each value for a given replication represents an average of four seedlings.

Table 3.--Average specific gravity[1/] of 5-year-old sycamore sprouts as affected by site, fertilization and spacing.

Replication	Control			N Fertilized		
	.3x.9	.9x.9	1.8x.9	.3x.9	.9x.9	1.8x.9
Terrace Site						
1	.476	.478	.457	.460	.458	.429
2	.430	.460	.449	.441	.415	.464
3	.475	.464	.489	.446	.448	.442
$\bar{X}$	.469	.467	.465	.449	.440	.445
Fert. $\bar{X}$		.467			.445	
Site $\bar{X}$			.456			
Bottomland Site						
1	.445	.487	.459	.436	.437	.432
2	.432	.426	.437	.432	.422	.428
3	.439	.452	.429	.456	.430	.421
$\bar{X}$	.439	.455	.442	.443	.429	.427
Fert. $\bar{X}$		.445			.433	
Site $\bar{X}$			.439			

[1/] Each value for a given replication represents an average of three sprouts.

treatments on the specific gravity of seedlings and sprouts. The analyses, using a split-plot design, are given in Table 4. All interaction terms for both seedling and sprout analyses were found to be insignificant ($\alpha = 0.05$). A comparison of seedling and sprout means for the different treatments is given in Table 5.

Table 4.--Analyses of variance for seedling and sprout specific gravity as affected by site, fertilization and spacing.

Source	Seedlings			Sprouts		
	df	MS	F	df	MS	F
Site (A)	1	1.98759[1/]	14.11*	1	0.78030	5.67
Replications Within Sites (error A)	4	0.14086		4	0.13750	
Fertilization (B)	2	1.21743	15.02**	1	0.81467	12.60**
Spacing (C)	2	0.87303	10.77**	2	0.02252	0.35
AxB	2	0.21549	2.66	1	0.06163	0.95
AxC	2	0.03617	0.45	2	0.02072	0.32
BxC	4	0.13941	1.72	2	0.06980	1.08
AxBxC	4	0.10018	1.23	2	0.02684	0.42
Experimental Error (subplot error)	32	0.08105		20	0.06465	
Within Plot Error	159	0.05215		70	0.05151	
Total	212			105		

[1/] Divide by 100 for actual mean squares.

*Significant at $\alpha = 0.05$; **Significant at $\alpha = 0.01$.

Table 5.--Effect of spacing, site and fertilization on average specific gravity.[1/]

Effect of:	Treatment	Seedlings		Sprouts	
		No. of Samples	Average SG	No. of Samples	Average SG
Spacing	1.8x.9 m	70	.481a	35	.450a
	.9x.9 m	72	.467b	35	.448a
	.3x.9 m	71	.459b	36	.445a
Site	Terrace	107	.479a	54	.456a
	Bottomland	106	.459b	52	.439a
Fertilization	Control	72	.484a	53	.456a
	N	72	.462b	53	.439b
	N+P	69	.461b		

[1/] Data evaluated for each treatment type individually for seedlings and sprouts. Means with same letter in each group are not significantly different ($\alpha = 0.05$).

The effect of spacing on sprout specific gravity was not significant ($\alpha = 0.05$). It is difficult to accurately assess the influence of spacing because of the rapid closure of the canopy during the early years of sprout growth. The test is confounded by the multiple sprouting that was allowed on the 5-year-old rootstocks. Differences between treatments were thus small.

In the seedling analysis, on the other hand, spacing significantly ($\alpha = 0.01$) affected specific gravity. In this case the single stem seedlings had less space to grow in the close spacings when compared with the wider ones. Larger differences between the treatments could thus be analyzed. The specific gravity obtained with wide spacings was higher than that from the two closer spacings.

Fertilizer treatment significantly ($\alpha = 0.01$) affected specific gravity for both seedlings and sprouts. The unfertilized control had a higher specific gravity than the nitrogen fertilized treatment. Site was also determined to be a significant ($\alpha = 0.05$) factor on seedling specific gravity, but not for sprouts. The bottomland site had a lower seedling specific gravity than that of the less productive terrace site. Because of the few replications tested at each site, it is difficult to explain the effect of site on specific gravity of sprouts. Significance probabilities were 0.075 and 0.020 for site differences with sprouts and seedlings, respectively.

A summary of the effects of intensive culture on seedling and sprout specific gravities is given in Table 6. A comparison can be made of intensive and non-intensive culture in order to assess the effect of multiple intensive cultural practices. Intensive culture would use the best sites (bottomland), fertilization and close spacings to maximize the quantity of wood produced. Non-intensive culture would not include fertilization and would utilize less productive sites (terrace) and any spacing (normally wide to minimize planting costs).

Table 6.--Change in specific gravity as affected by combined intensive cultural practices.

Effect of:	Non-Intensive Cultural Treatment (NIC)	Intensive Cultural Treatment (IC)	Seedlings			Sprouts		
			SG_{NIC}	SG_{IC}	Percent Change	SG_{NIC}	SG_{IC}	Percent Change
Spacing	1.8x.9 m	.3x.9 m	.481	.459	-4.6	.446	.450	n.s.
Site	Terrace	Bottom-land	.479	.459	-4.2	.456	.439	-3.7
Fertilization	None	N-Ferti-lized	.484	.462	-4.6	.456	.439	-3.7
Combined Treatments	All of Above	All of Above	.523	.442	-15.5	.467	.433	-7.3

Individually, spacing, site and fertilization account for 4.6, 4.2 and 4.6 percent decreases in specific gravity of seedlings, respectively. If combined, they are responsible for a 15.5 percent decrease. Sprout specific gravity is reduced 7.3 percent, only half that of seedlings. However, it is expected that the larger amount of pulpwood or biomass produced per hectare using intensive culture will more than make up for the resulting decrease in specific gravity for both seedling and coppice growth.

CONCLUSIONS

For intensive culture of 5-year-old American sycamore seedlings and sprouts the following conclusions can be made:

1. The specific gravity of seedlings is higher than that of sprouts.

2. If better sites are utilized, the specific gravity of seedlings decreases.

3. When closer spacings are used, the specific gravity of individual seedlings is reduced.

4. Spacing and site did not affect sprout specific gravity.

5. When the site is fertilized, the specific gravity of both seedlings and sprouts decreases.

6. When intensive cultural practices are combined, specific gravity is decreased, exceeding 15 and 7 percent for seedlings and sprouts, respectively.

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