EFFECT OF SEVERING METHOD AND STUMP HEIGHT ON COPPICE GROWTH

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Abstract.--In this study we evaluated the effect of stem severing method and stump height on coppice growth in a short-rotation intensively cultured Populus plantation 1, 2, and 3 years after cutting. Initially, stumps 46 cm high had smaller and significantly more sprouts than either 8 or 15 cm high stumps. However, the dominant sprouts were not affected by the stump height. After subsequent growing seasons, the dominant sprouts were the only ones to survive, and no effect of stump height was present. Severing method--shearing or chain sawing--did not affect coppicing as long as the stumps were not excessively damaged during the original harvest.

Short-rotation intensive culture (SRIC) of trees is a promising way to increase wood biomass productivity (U.S. Department of Agriculture, Forest Service 1980). The *Populus* genus has been shown to be extremely productive under SRIC and to be good raw material for reconstituted forest products.

Either rooted or unrooted poplar cuttings are usually planted for the first rotation of a SRIC plantation. Subsequent rotations result from coppice sprouts regenerating from the stumps that remain after the first harvest and from short sprout stubs after coppice rotations (International Energy Agency 1981). However, little information is available on the effect of stem severing method and stump height on subsequent coppice growth.

The objectives of this study were to evaluate the effect of two methods of severing trees--sawing and shearing--and three residual stump heights--8, 15, and 46 cm (3, 6, and 18 inches)--on the number of coppice sprouts per stump, average sprout height and diameter, and dominant sprout height and diameter.

MATERIAL AND METHODS

Populus 'Tristis #1' trees (*P. tristis* x *P. balsamifera*) were grown at the Hugo Sauer Nursery near Rhinelander, Wisconsin. The plot was cultivated, fertilized, and irrigated to maintain optimum growing conditions for 6 years at a 0.6- by 0.6-m (2- by 2-ft) spacing; it had 36 rows of 12 trees each, for a total of 432 trees. However, at the harvest the plot contained only 315 trees because some trees had died and some had been removed for biomass determinations. At harvest, nonborder trees averaged 7.2 m (23.6 ft) in height and 5.6 cm (2.2 in) in diameter measured at 0.3 m (1 ft) above ground.

The trees were harvested during the dormant season (February 24, 1979) by either sawing or shearing. The sawing was done with a chain saw, and the shearing was done with a thin-bladed shear. The stems were severed at three heights, 8, 15, and 46 cm. These stump heights were chosen to include a practical range for mechanized harvesting equipment (8 and 15 cm) and one that might be necessary under heavy snow conditions (46 cm).

The six treatment combinations were used in a factorial experiment. We used a randomized complete block design with two replications. Standard analysis of variance techniques were used to evaluate the effect of stump height, severing method, and replication on the measured output variables. The total subplot area of each treatment was harvested by the prescribed method, and four adjacent nonborder stumps within each treatment were designated for subsequent coppice measurement.

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After each of the first three growing seasons, all sprouts longer than 0.3 m (1 ft) were measured on each of 48 stumps (4 stumps/treatment x 6 treatments x 2 replications). The measurements were: total number of sprouts/stump, height (length) of each sprout from point of attachment to its tip, and diameter of each sprout measured at 0.3 m (1 ft) from point of attachment.

RESULTS AND DISCUSSION

Mortality

The method of severing the stems initially affected coppice sprout mortality. Five of the 48 stumps on which coppice growth was measured (24 sawn and 24 sheared) died before the first growing season. All of these dead stumps had been sheared. Although the stumps could have been killed by the shearing action itself, death was probably caused by physical damage inflicted during positioning of the shear. The shear used in this study was for larger trees and was so large that when one stump was being severed, its neighbors were occasionally damaged. The five stumps that died were also much smaller than average (2.4- to 4.7-cm stump diameters), which may have made them more susceptible to damage by the shear.

Two more stumps died, one sawn and one sheared, after the second growing season. These two stumps were also small (1.8 and 2.8 cm in diameter), and their death was probably due to increasing competition and not mechanical damage. In our opinion, the damage to residual stumps could be greatly reduced or eliminated by designing special harvesters for small trees grown in closely spaced plantations. (Mattson et al. in this proceedings). Recent data indicate that wider spacings may be more economically feasible for SRIC systems (Rose and DeBell 1978). Wider spacings would also reduce damage by allowing more area for harvesters to operate. A rectangular spacing with wider between-row spacing and closer within-row spacing could also be used to facilitate harvesting.

Number of Sprouts per Stump

After the first two growing seasons, residual stump height affected the number of coppice sprouts per stump (table 1). The shortest stumps (8 and 15 cm) had significantly fewer sprouts than the tallest stumps (46 cm). However, sprout numbers were not significantly different between the 8 and 15 cm stumps. These results were expected because shorter stumps have less surface area for originating sprouts.

By the third growing season, the number of sprouts per stump was significantly less. The average number of sprouts had decreased from 13 to 3 and no effect of stump height remained (fig. 1). This decrease was expected because competition between the sprouts caused the weaker sprouts to die back. Similar to the results reported by DeBell and Alford (1972), the point of attachment of the surviving sprouts after three growing seasons was always on the top portion of the residual stump (fig. 2). This indicates that no advantage is gained by leaving higher stumps. In fact, the higher stumps could increase the possibility of stump decay in later years. Severing method did not significantly affect the number of sprouts per stump.

Average Sprout Height and Diameter

Residual stump height also initially affected both average coppice sprout height and diameter (fig. 3). For the first 2 years the 8- and 15-cm stumps had significantly taller sprouts of larger diameter than the 46 cm stumps. But average sprout height and diameter between the 8- and 15-cm stumps were not signifiantly different.

These results may have a logical physiological explanation. Assuming each residual root system has equal or similar amounts of stored photosynthate (or energy), then the sprouts on the shorter stumps may receive more energy for early growth because of the fewer sprouts on the shorter stumps. Also, because the stumps themselves utilize part of the stored energy for respiration and growth, the taller stumps would require more energy than the shorter stumps, leaving less energy available for coppice growth on the taller stumps. Severing method did not significantly affect average sprout height or diameter.

Height and Diameter Of Tallest Sprouts

Neither residual stump height nor severing method significantly affected the height of the tallest sprout on each stump (fig. 4). These results appear to conflict with the previous explanation for the differences observed in average sprout height and diameter. However, when the sprouts develop their first leaves, they cease to be sinks for stored photosynthate from the root system and begin to be sources of photosynthate. Because the tallest sprouts are dominant, they produce more photosynthate than other sprouts on the same stump and photosynthate can be used to accelerate height growth. The original effect of stump height becomes masked by the rapid height growth of these dominant sprouts.

Table 1.--Effects of stump height and severing method on growth of SRIC Populus 'Tristis #1'coppice.

Severing Method: and stump height	Year	Number of stumps	Average of all sprouts Number	Average of all sprouts Height	Average of all sprouts Diameter	Average of tallest sprouts Height	Average of tallest sprouts Diameter
				cm	cm	cm	cm
Sawn:							
8 cm	1	8	11.1 (4.8)[1]	119 (20.4)	0.88 (.20)	190 (36.9)	1.52 (.34)
	2	8	8.8 (3.4)	201 (48.7)	1.22 (.32)	390 (118.0)	2.40 (.84)
	3	7	3.9 (2.0)	371 (83.4)	2.24 (.62)	483 (46.9)	3.07 (.67)
15 cm	1	8	9.9 (3.6)	125 (15.8)	.92 (.13)	219 (20.9)	1.70 (.19)
	2	8	7.5 (3.4)	213 (39.1)	1.33 (.27)	446 (57.6)	2.90 (.64)
	3	8	2.2 (.89)	424 (82.7)	2.78 (.65)	496 (81.1)	3.43 (.99)
46 cm	1	8	13.6 (2.8)	116 (15.0)	.76 (.14)	208 (17.8)	1.50 (.21)
	2	8	11.0 (3.9)	182 (35.2)	1.06 (.22)	427 (36.4)	2.80 (.56)
	3	8	3.5 (.93)	342 (43.1)	2.06 (.36)	488 (50.2)	3.42 (.92)
Sheared:							
8 cm	1	6	8.3 (3.6)	118 (18.7)	1.0 (.15)	196 (27.2)	1.84 (.23)
	2	6	6.0 (3.3)	239 (34.8)	1.66 (.26)	446 (63.4)	3.40 (.50)
	3	6	3.0 (1.8)	387 (54.6)	2.82 (.33)	518 (75.3)	4.23 (.73)
15 cm	1	5	14.0 (8.5)	120 (15.4)	.89 (.19)	207 (44.0)	1.63 (.20)
	2	5	12.0 (6.7)	202 (51.7)	1.26 (.29)	417 (50.7)	2.80 (.84)
	3	5	4.2 (2.2)	352 (65.4)	2.27 (.61)	470 (74.2)	3.48 (1.2)
46 cm	1	8	20.1 (9.1)	98 (15.1)	.68 (.10)	184 (34.0)	1.42 (.32)
	2	8	14.9 (7.2)	160 (26.6)	.95 (.17)	402 (107.0)	2.70 (.87)
	3	7	4.0 (1.0)	361 (30.0)	2.33 (.31)	499 (44.0)	3.90 (.75)

[1]Entries are average values for the given number of stumps (observations). Number in parentheses is the standard deviation.

After three growing seasons, the dominant sprouts have clearly emerged. Of the 41 living stumps, 37 had from 1 to 3 sprouts that were taller than 400 cm. These dominant sprouts were similar in height and diameter. The taller sprouts were also usually the larger in diameter and vice versa. Of the 41 tallest sprouts, 37 were also the largest in diameter.

CONCLUSIONS AND RECOMMENDATIONS

Stump height initially affected the number of coppice sprouts per stump and average sprout height and diameter. However, after only three growing seasons, the smaller, weaker sprouts had already become victims of competition and from one to three dominant sprouts had emerged. We expect these dominant sprouts to survive despite the increasing competition. Each stump, regardless of its height or how it was severed, would have from one to three sprouts containing nearly all of the areal portions of biomass in the plot. We recommend not leaving high stumps unless deep snow conditions during harvest require it because they lose more biomass and have a higher possibility of stump decay than short stumps. Severing method did not affect the sprouting of the stumps unless they were severely damaged during harvesting.

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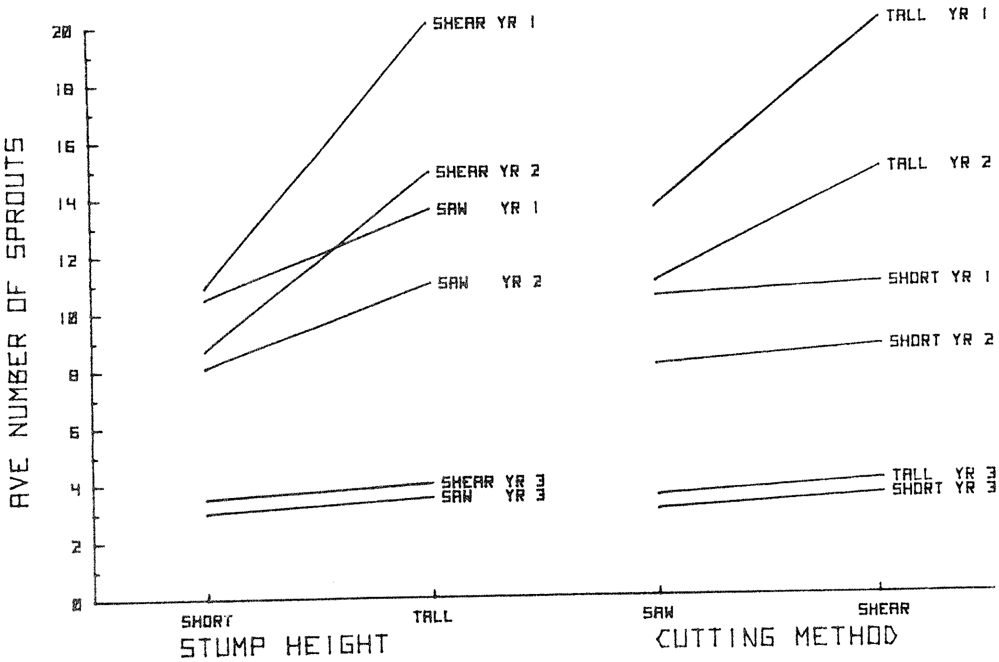

Figure 1.--Average number of spouts per stump for Populus 'Tristis #1' coppice by cutting method and stump height 1, 2, and 3 years after harvest.

Figure 2.--Typical sprouting on 46 cm high Populus 'Tristis #1' stumps after three growing seasons.

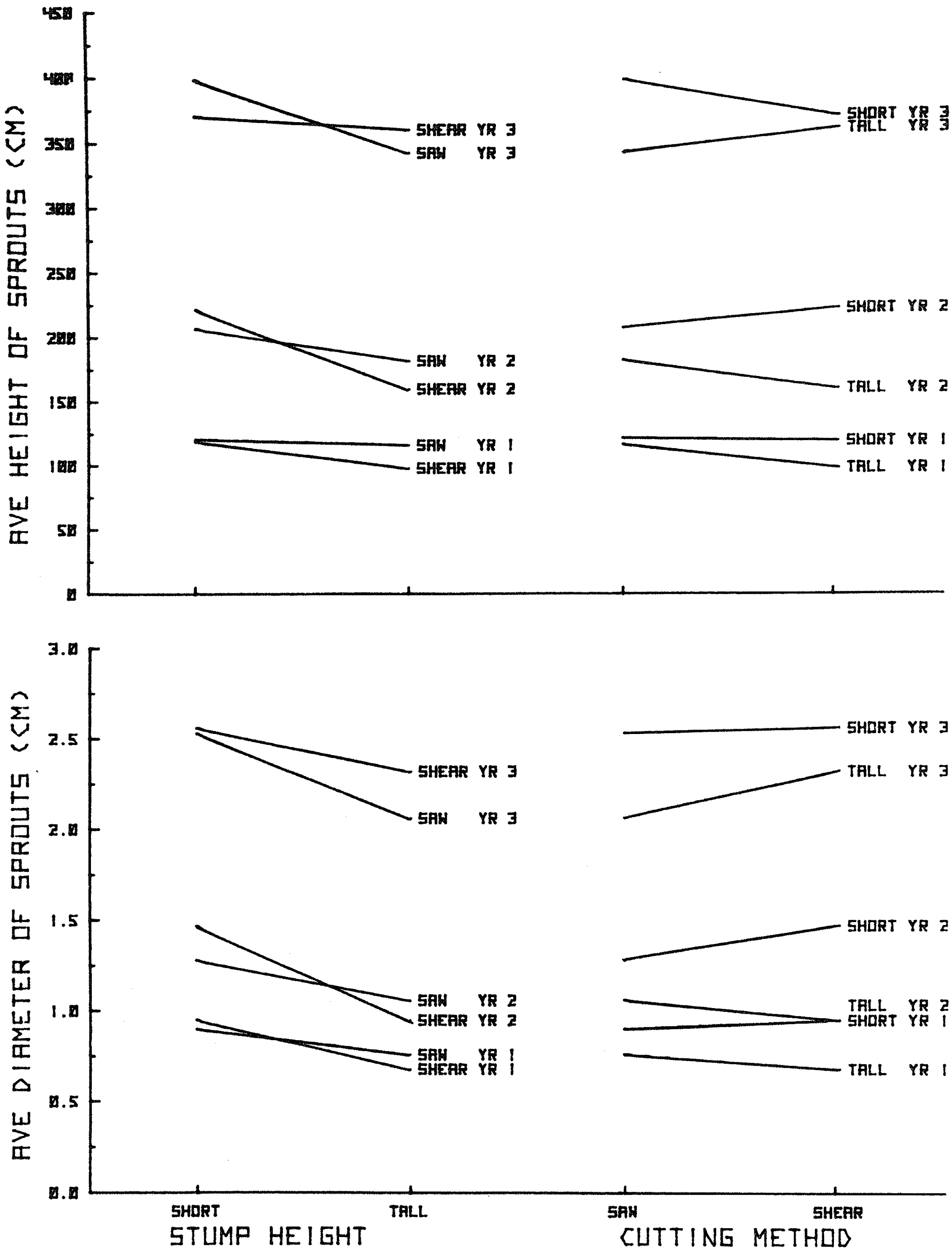

Figure 3.--Average sprout height and diameter for Populus 'Tristis #1' coppice by cutting method and stump height 1, 2, and 3 years after harvest.

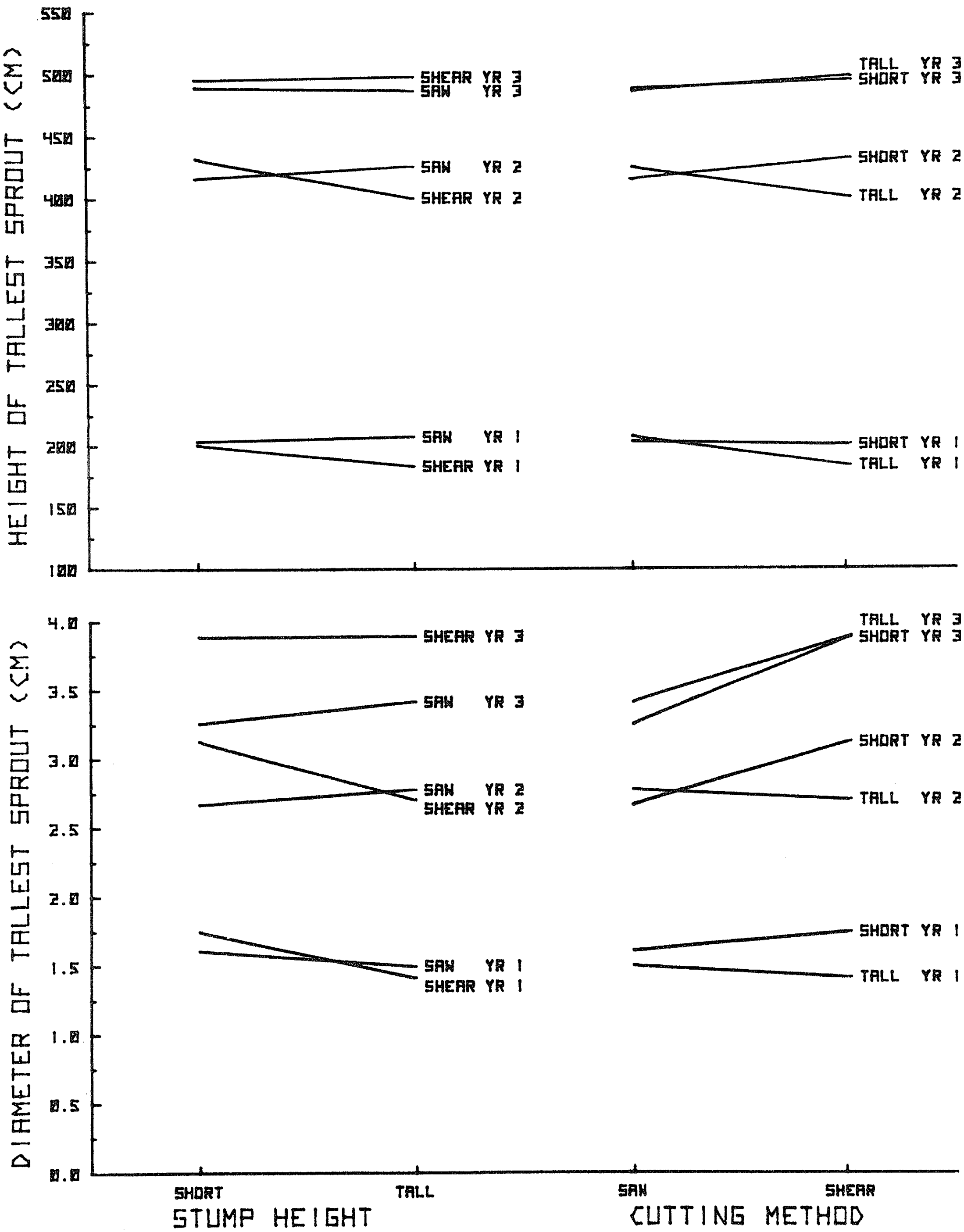

Figure 4.--Height and diameter of tallest sprouts for Populus 'Tristis #1' coppice by cutting method and stump height 1, 2, and 3 years after harvest.