NORTH CENTRAL FOREST EXPERIMENT STATION

Research Note NC-278

1992 FOLWELL AVE. ST. PAUL, MN 55108 FOREST SERVICE-U.S.D.A.

1982

A TIME STUDY OF PLANTING A SHORT-ROTATION INTENSIVELY CULTURED PLANTATION

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ABSTRACT.—Time study of planting a 3 ha short-rotation intensively cultured plantation on a 1- by 1-m spacing found a productivity of 0.52 ha/hour and planting cost of $97.87/ha.

KEY WORDS: Machine rates, *Populus,* energy plantation, biomass, tree planting

Analyzing the economic feasibility of short-rotation intensively cultured (SRIC) forestry systems requires data on all aspects of establishing, managing, and harvesting such plantations. Because the concept is still being developed and only a few large plantations have been established, accurate data on many of the operations involved have not been available. The USDA Forest Service's Research and Development Program on the Maximum Yield of Wood and Energy from Intensively Cultured Plantations has progressed from small-scale studies of biological principles to larger scale tests of developing technology for establishing SRIC plantations (U.S. Department of Agriculture 1980). Establishment of a 3 ha plantation in May 1980 provided an opportunity to obtain productivity and cost figures for planting a SRIC plantation. Our paper presents the results of a detailed time study of the establishment of that plantation.

The plantation is located on the Harshaw Experimental Farm near Rhinelander, Wisconsin. The farm, a former agricultural site, is now used for research on SRIC plantations. For this study, an area of sandy loam soil approximately 80 m (262 ft) by 372 m (1,220 ft) was selected for planting. Planting conditions were excellent: the terrain was reasonably level, relatively free of rocks that could interfere with machinery, and fairly dry at the time of planting. The long individual planting runs made this operation a good case study for obtaining accurate planting data that could be characteristic of commercial operations. A commercial operation was approximated by using a uniform 1- by 1-m spacing throughout the planting, and also by using the same planting stock, 20cm (8-inch) long hardwood cuttings of *Populus* clone 9922, primarily 6 to 13mm (¼ to ½ inch) in diameter, for the entire operation.

Four planting machines were attached to a common tool bar and towed by a White Field Boss, Model 2-85, 85-horsepower diesel tractor (fig. 1).[1] The units were Mechanical Transplanter, Model CT5, transplanters which utilize chain-driven plant holders to set the planting stock into a continuous furrow. The plant spacing is thus determined by the rotation of the packing wheel that moves the chain holding the

[1]*The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. It does not constitute an official endorsement or approval of a product or service by the United States Department of Agriculture.*

Figure 1.—*Equipment used to plant the 3 ha demonstration plantation.*

plant holders. A five-person crew is needed in the planting—a tractor operator and four planters, one of whom doubles as the field supervisor. Because of the long planting runs in this operation (372 m), only enough cuttings could be carried on the machines to make a run down the field and back. Therefore, the machines required loading each time they returned to the beginning end of the field.

RESULTS

Our time study showed that a total time of 5.59 hours was required to plant the 3 ha. Time spent in productive activities was 4.93 hours, or 88.2 percent, while 0.66 hours, or 11.8 percent, was consumed by delays (table 1).

Measurement of the planted area indicated a total plantation size of 2.92 ha (7.21 acres). We estimated that 30,388 cuttings were planted at an average spacing of 0.96 m (3.15 ft) within the rows. The between-row spacing was 1 m (3.28 ft) as determined by the planting machine position on the tool bar. The measured density was then 10,417 cuttings/ha (4,215 cuttings/acre), very close to the desired density of 10,000 cuttings/ha (4,047/acre). In inspecting the planted area, we saw that the planting was very efficient. We estimated that less than 1 percent of the cuttings were missed, and the cuttings were consistently in the ground to the right depth, covered, and adequately packed with soil.

Based on the time study and measurement of the planted area, the productivity calculated on total elapsed time was 0.52 ha/hour (1.29 acres/hour). Productivity based on actual operating time of the planters was 0.71 ha/hr (1.76 ac/hr). The planting speed was 1.78 km/hour (1.11 miles/hour).

The machine costs for the White 2-85 Field Boss and the Mechanical Transplanter CT5 were calculated as $13.60 and $2.55/hour, respectively, or a combined cost of $16.15/productive hour (table 2) (Miyata 1980). Based on the field study and the machine costs, estimated costs are shown for a typical 8-hour day with 6 productive hours of actual plant-

Table 1.—*Time study results on planting*

Productive time	Hours	Percent
Productive time		
Planting	4.09	73.2
Turning around	.20	3.6
Loading cuttings	.64	11.4
	4.93	88.2
Delays		
Rearranging cuttings in holding trays	0.16	2.9
Covering cuttings to avoid moisture loss	.02	.4
Rocks stuck in machine	.09	1.6
Changing personnel	.06	1.1
Breaks	.26	4.6
Start-up	.07	1.2
Sub-total (delays)	.66	11.8
TOTALS	5.59	100.0

ing (table 3). Production would be 4.26 ha (10.56 acres) for this typical day.

The results of our study can be used to estimate the potential productivity and cost of planting SRIC plantations at various other spacings. If similar equipment is used, the following assumptions form the basis for calculating the productivity of planting at other spacings. From observing the planting in our study, we estimated that the planting machine operators were working at an optimum rate for this type of work; therefore, the rate observed was assumed to be the maximum allowable. We also assumed that the tractor speed could be increased by a factor of three without affecting the working conditions of the operators. So, for a within-row spacing of 3 meters, the tractor speed could be tripled because the rate at which the operators would be functioning would remain the same. The physical limitations on the equipment indicate that a tool-bar length of 4 meters would be maximum without encountering structural problems or turning difficulties. This restriction defines the number of planting machines that can be used on a given between-row spacing as tabulated below.

Between row spacings (meters)	Planting machines (number)	Strip width planted (meters)
1	4	4
2	3	4
3	2	3

Table 2.—*Itemized machine rates*
(In January 1981 dollars)

Machine	Initial cost	Cost/hr (without labor)		
		Fixed	Operating	Total
White 2-85 Field Boss	29,260	6.53	7.07	13.60
Mechanical Transplanter CT5 (4 units)	2,945	2.32	.23	2.55

We also assumed that the planting machines are in operation 75 percent of the total scheduled time, and the other 25 percent of the time is spent in loading, turning, and various delays. Based on these assumptions, the projected productivity for planting SRIC plantations on various spacings are as follows:

(meters between rows × meters within rows)	Productivity	
	hectares/hr	(acres/hr)
1 × 1	0.53	(1.32)
1 × 0.5	.27	(0.66)
2 × 2	1.60	(3.95)
2 × 1	.80	(1.98)
3 × 3	2.41	(5.95)
3 × 2	1.60	(3.95)
3 × 1	.80	(1.98)

The cost of planting SRIC plantations on these spacings, based on the results of our case study, would be as follows (January 1981 dollars):

Spacing	Cost	
	dollars/ha	($/acre)
1 × 1	97.87	(39.48)
1 × 0.5	193.00	(78.95)
2 × 2	28.54	(11.56)
2 × 1	57.08	(23.06)
3 × 3	16.27	(6.59)
3 × 2	24.51	(9.93)
3 × 1	49.01	(19.80)

Table 3.—*Planting costs*
(In January 1981 dollars)

	Total	Cost/ha	Cost/acre	Percent
Machine cost	96.90	22.75	9.18	23.3
Labor[1]	224.00	52.58	21.21	53.7
Supervision[1]	96.00	22.54	9.09	23.0
TOTALS	416.90	97.87	39.48	100.0

[1]Labor rates are assumed to be $6/hr for planters, $10/hr for operators, and $12/hr for supervisors, all rates including 30 percent for fringe benefits.

DISCUSSION

The operation studied was obviously very efficient. The planting machines operated almost 75 percent of the time, and the delays, excluding rest breaks, were only about 7 percent of the total time. This indicates both a well-trained, experienced crew and good field conditions.

Labor was the major cost of this operation, comprising more than 50 percent of the planting cost. For any significant reduction in the planting costs, automated planting equipment would be needed to reduce the number of operators required on the planting machines. In addition to reducing cost, automated planting equipment could increase productivity. There is only about a 2-month season for planting SRIC plantations in the Lake States. Based on our case study, one planting crew could plant only about 180 ha (445 acres) on a 1- by 1-m spacing in this time. If a wider tree spacing, such as 2 by 2 m, proves economically feasible, the planting acreage would increase. However, for planting large acreages per year, such as may be required commercially, planting technology must be improved.

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☆U. S. GOVERNMENT PRINTING OFFICE: 1982—566-864. 84