THE EFFECTS OF PLANTING TOOL ON PLANTING PRODUCTIVITY AND SURVIVAL OF LONGLEAF PINE BARE-ROOT SEEDLINGS

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Abstract—An evaluation was made of the effects of hand planting tool (shovel or dibble) on planting productivity and survival of longleaf pine *(Pinus palustris)* seedlings on two adjacent sites in the upper Coastal Plain of Alabama. In addition, the effects of storage time between lifting and outplanting on survival were measured. Seedlings were planted with both shovels and dibbles on each of two sites harvested in 1995. Site A was clearcut, broadcast-burned in December of 1995, and the site prepared with a Savannah 3-in-1 plow. Site B was clearcut and aerially sprayed with a tank mix of 18 ounces of Arsenal (imazapyr) and 25 ounces of Garlon (triclopyr) per acre in October of 1995. A broadcast burn was performed in December 1995 and the site bedded with the Savannah 3-in-1 plow later that month. Planting began in January of 1996. On each day, shovels and dibbles were used to plant simultaneously on the site. Seedlings were stored at 55 °F between lifting and planting. Storage time ranged from 0 days (planted on the day of lifting) to 13 days. Planting productivity differences were statistically insignificant, averaging 146.8 seedlings per man per hour with shovels and 141.8 seedlings per man per hour with dibbles. Survival at the end of one year also did not differ between implements on individual sites or overall on both sites. Survival on site A was 85 percent with shovels and 86.25 percent with dibbles. On site B, mean survival was 71.88 percent with shovels and 71.46 percent with dibbles. Overall survival was 78.44 percent with shovels and 78.95 percent with dibbles. Due to study design, statistically linking survival to storage time was impossible, but survival of seedlings planted with shovels 0, 1, 3, 6, 7, 9, 10, and 13 days after lifting averaged 87.5 percent, 82.5 percent, 76.25 percent, 81.25 percent, 62.5 percent, 73.75 percent, 72.5 percent and 65 percent, respectively. Survival of seedlings planted with dibbles on the same dates was 87.5 percent, 85 percent, 66.25 percent, 75 percent, 70 percent, 60 percent, 77.5 percent and 80 percent. One year after planting, 22 percent of shovel-planted seedlings had initiated height growth, as had 23 percent of seedlings planted with dibbles. The incidence of height growth initiation declined as storage time increased up to 7 days of storage.

INTRODUCTION

Although there is little documentation, many foresters believe that longleaf pine bare-root seedlings are best planted by planting machine. Machine planting, however, requires a level of site preparation not necessary for hand planting. Less intensive site preparation can lessen adverse effects on the site and often lowers costs. Hand planting is commonly accomplished in the Southeast with dibbles or planting bars. Other tools occasionally used by planters include hoedads and planting shovels. In this study, planting productivity and seedling survival were compared for dibbles and planting shovels.

STUDY AREA

The Solon Dixon Forestry Education Center is located in the upper Coastal Plain of south-central Alabama approximately 60 miles north of the Gulf Coast. The 5,350-acre teaching and research forest ranges from xeric ridges to forested wetlands, and from bottomland hardwood stands to upland longleaf pine stands. The two sites chosen for this study are adjacent and were occupied by similar, mature, mixed pine/hardwood stands prior to clearcutting in 1995. The soils are loamy sands and moderately well drained. There is a slight slope on each site and both have northeastern aspects. Each was site prepared in 1995 using broadcast fire and a Savannah 3-in-1 plow pulled behind a crawler tractor equipped with a V-blade. Both operations took place in December of that year. In addition, one site (site B) was aerially sprayed with a tank mixture of 18 ounces of Arsenal (imazapyr) and 25 ounces of Garlon (triclopyr) per acre prior to the fire. The plow incorporated soil, organic matter, and some coarse woody debris into beds spaced approximately 10 to 12 feet apart and standing 1 to 1.5 feet high.

METHODS

Planting

The beds were planted in 6-foot intervals with bare-root longleaf pine seedlings obtained from the E.A. Hauss nursery, operated by the Alabama Forestry Commission and located approximately 70 miles from the Dixon Center. All seedlings used in the study were lifted on January 21, 1996 and stored at 55 °F in a refrigerated cooler until outplanting. Planting began on site A on January 21 with freshly lifted seedlings. Planting was done by staff of the Dixon Center, all experienced hand planters. On each day, half of the crew planted with shovels and half with dibbles. On the next planting day, the implements were exchanged to eliminate differences in planting speed or ability. The shovels were used very much like dibbles, i.e., a planting slit was created rather than a dug hole (Blake and South 1991). At the end of each day, the number of seedlings planted with each implement was recorded, seedlings per man-hour calculated, and the block marked with pin flags to assist in subsequent tracking. The planting continued across the two sites until both were planted. Planting took place on the day the seedlings were lifted and 1, 3, 6, 7, 9, 10, and 13 days after lifting. In each case, daily productivity

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was calculated and the blocks identified by day of planting and implement used.

Subsequent Measurements

One year after planting, the sites were sampled to determine survival by day of planting and implement. In addition, data were collected on the incidence of height growth initiation in each block. Evaluation of differences in height growth incidence and survival between sites and among storage time blocks was complicated because of confounding effects, and no conclusions could be reliably drawn.

RESULTS

Planting Productivity

Productivity (trees per man per hour) varied on a day-to-day basis both by implement and by day (table 1). Mean planting productivity with shovels and dibbles was 146.8 and 141.8 trees per man per hour, respectively. Daily rates ranged from highs of 174 trees per man per hour with the shovel and 175 trees per man per hour with the dibble to lows of 121 trees per man per hour with the shovel and 123 with the dibble. Figure 1 depicts this data graphically.

Seedling Survival

Overall survival with each implement across both sites was remarkably similar. On site A, mean survival after 1 year of seedlings planted with shovels was 85 percent. On the same site, mean 1-year survival of dibble-planted seedlings was 86.25 percent. Survival on site B averaged 71.88 percent for seedlings planted with shovels and

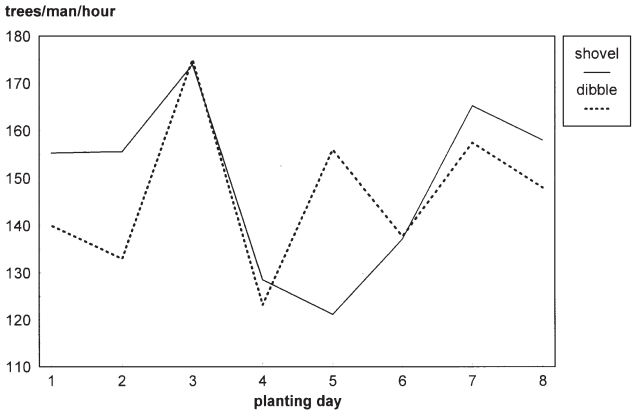

Figure 1—Planting productivity for shovels and dibbles by day.

71.46 percent for seedlings planted with dibbles. Overall survival after 1 year across sites was 78.44 percent for shovel-planted trees and 78.95 for dibble-planted seedlings.

Survival by implement by days of storage is indicated in table 2 and graphically depicted in figure 2. Because the sites were not planted simultaneously and site preparation treatment varied between sites, comparisons cannot safely be made between sites. However, survival on site A was 88.1 percent for seedlings planted on the day of lifting, and 84.4 percent for seedlings planted 1 day later. Seedlings planted on those days with shovels survived at the rates of 88.75 percent and 85 percent, respectively. Those planted on the same days and same site with dibbles survived at

Table 1—Planting productivity

Day	Site	Implement	Trees/man/hour
1	A	Shovel	155.3
	A	Dibble	140.0
2	A	Shovel	155.6
	A	Dibble	133.0
3	B	Shovel	174.0
	B	Dibble	175.0
4	B	Shovel	128.5
	B	Dibble	123.2
5	B	Shovel	121.0
	B	Dibble	156.0
6	B	Shovel	137.2
	B	Dibble	137.7
7	B	Shovel	165.3
	B	Dibble	157.5
8	B	Shovel	158.0
	B	Dibble	148.0
Mean productivity:		Shovel	146.8
		Dibble	141.8

Table 2—Year seedling survival by implement and storage time

Site	Days of storage	Implement	Survival rate
			Percent
A	0	Shovel	87.50
	0	Dibble	87.50
A	1	Shovel	82.50
	1	Dibble	85.00
B	3	Shovel	76.25
	3	Dibble	66.25
B	6	Shovel	81.25
	6	Dibble	75.00
B	7	Shovel	62.50
	7	Dibble	70.00
B	9	Shovel	73.75
	9	Dibble	60.00
B	10	Shovel	72.50
	10	Dibble	77.50
B	13	Shovel	65.00
	13	Dibble	80.00

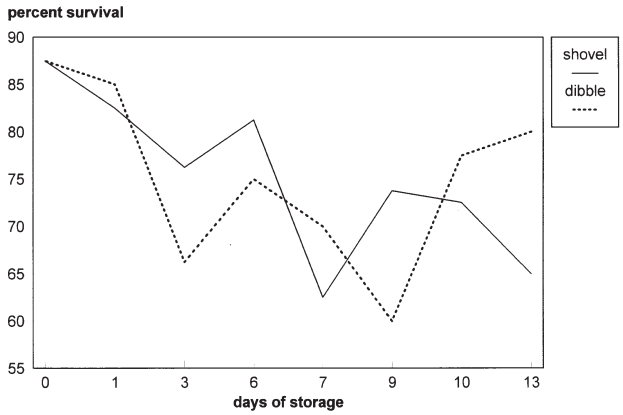

Figure 2—Seedling survival after 1 year by planting implement and storage time.

87.5 percent and 83.75 percent. On site B, seedlings were planted after 3, 6, 7, 9, 10, and 13 days of storage. Overall survival rates for those days was 71.25 percent, 78.1 percent, 66.25 percent, 66.88 percent, 75 percent, and 72.5 percent, respectively. Seedlings planted on site B with shovels had the following survival rates: 3 days storage: 76.25 percent; 6 days: 81.25 percent; 7 days: 62.5 percent; 9 days: 73.75 percent; 10 days: 72.5 percent; and 13 days: 65 percent. For seedlings planted on the same site on the same days with dibbles, survival rates were 66.25 percent, 75 percent, 70 percent, 60 percent, 77.5 percent, and 80 percent.

Height Growth Initiation

Height growth initiation was recorded 1 year after outplanting. Height growth was exhibited by 23 percent of seedlings planted with shovels and 22.4 percent of seedlings planted with dibbles after one growing season. Height growth initiation by implement by day is detailed in table 3 and depicted graphically in figure 3.

DISCUSSION

General Conditions

This study was begun just prior to a major catastrophic event, Hurricane Opal, which caused the compression of the site preparation treatments and subsequent outplanting into a much shorter time frame than desired. Planting only 1 month after the bedding operation allowed very little settling of the beds and was a cause of concern. In addition, the burn was conducted only 2 months after the herbicide treatment, likely compromising the effectiveness of the chemicals. Good rains accompanied and followed the planting operation, with 1 inch falling on the day before planting began and nearly 2 more inches falling during the 2-week planting period. Nearly a month passed before the next rainfall on March 7.

Planting Productivity

Planting productivity varied widely from day to day but mean planting productivity did not differ significantly between implements. Variations might best be explained by within- and between-site variations (amount of coarse

Table 3—One-year height growth initiation by implement and by storage time

Implement	Storage time	Height growth
		Percent
Shovel	0	51.4
Dibble	0	34.3
Mean	0	42.9
Shovel	1	36.4
Dibble	1	39.7
Mean	1	38.1
Shovel	3	10.5
Dibble	3	28.3
Mean	3	19.4
Shovel	6	12.0
Dibble	6	31.7
Mean	6	21.9
Shovel	7	7.9
Dibble	7	12.5
Mean	7	10.2
Shovel	9	7.6
Dibble	9	8.3
Mean	9	8.0
Shovel	10	10.0
Dibble	10	11.3
Mean	10	10.7
Shovel	13	11.1
Dibble	13	7.8
Mean	13	9.5
Mean (shovel)		23.0
Mean (dibble)		22.4

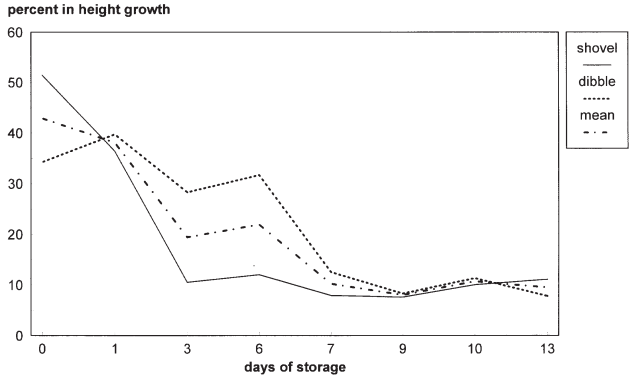

Figure 3—Height growth initiation by planting implement and storage time after one growing season.

woody debris, etc.), weather conditions, individual planter capability, and varying enthusiasm for the project. Suggestions that the less-productive crew always seemed to include the principal investigator I choose to discount as scurrilous rumor.

Survival

Survival was at acceptable levels for operational purposes throughout the study. Survival at 1 year did not differ for implements across both sites and no significant trend could be detected for storage time. Survival did drop after 1 day of storage, but trees stored longer were planted on a different site. Survival of trees with longer storage times varied so much that no statistically significant trend could be identified.

Height Growth Initiation

Early height growth is generally deemed desirable for longleaf seedlings. Decreased exposure to brown spot needle blight *(Scirrhia acicala)* is one result, and early height growth is often thought to be an indicator of continued vigor through the life of the tree (Boyer 1988). Although the confounding effects of site and site preparation differences make statistical analysis risky, there is a relatively strong indication of an inverse relationship between storage time and early height growth initiation. There was no difference in rate of height growth initiation between seedlings planted with shovels and those planted with dibbles.

CONCLUSIONS

Machine planting of these sites was impossible because of the amount of coarse woody debris incorporated into the beds by the Savannah 3-in-1 plow. Hand planting was accomplished successfully with both shovels and dibbles and no differences were detected between implements in planter productivity, seedling survival, or height growth initiation. Survival was best when seedlings were outplanted quickly after lifting, although no compelling trend was noted. Height growth initiation seemed to be linked fairly strongly to storage time, with early outplanting leading to increased incidence of first-year height growth. The combination of the Savannah 3-in-1 plow treatment, high-quality seedlings, good seedling care and proper planting techniques, and good soil moisture conditions can yield success in establishment of longleaf stands using bare-root seedlings and hand planters.

LITERATURE CITED

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