SEEDLING GRADE IN HARDWOODS

Charles D. Webb, Plant Geneticist
Southeastern Forest Experiment Station, Athens, Georgia

Our experience in planting billions of pine seedlings ias shown that seedling grade has a strong relationship to the success of plantations. We do not have as much experience in planting hardwood seedlings, but our limited planting confirms the strong relationship between seedling grade and plantation success. This morning I want to call to your attention some published accounts of research on grading hardwood seedlings and to tell about some results of our research with sycamore and sweetgum. I hope this will encourage you either to grow larger hardwood seedlings or to grade out the unplantable seedlings.

Root collar diameter is a better criterion of seedling grade than seedling height (Limstrom et al., 1955); McElwee and Johnson, 1966). It is easily measured and is proportional to the size of the root system. Almost irrespective of height, seedlings with small root collars perform poorly.

For yellow-poplar in the central states, Limstrom et al. (1955) found that survival improved greatly as root collar diameter increased from three-twentieths to six-twentieths of an inch. Survival dropped off slightly for seedlings with root collars of seven- and eight-twentieths of an inch. In this case, the effects of large root collar diameter were confounded by root pruning at lifting. They recommended culling seedlings with root collars less than four- to five-twentieths of an inch.

In the Piedmont of North Carolina, Rodenbach and Olson (1960) found a strong relationship between root collar diameter and subsequent survival, and height growth of planted yellow-poplar during the first three growing seasons. They recommended five-twentieths of an inch as the minimum acceptable root collar diameter.

Studies in other species tell the same story, but with one exception. Walnut seedlings with large root collars grew faster and survived better than seedlings with small root collars (Williams, 1965). In two European species of birch, 10-year-old trees from large seedlings were taller and had larger diameters than trees from small seedlings (Clausen, 1963). The only study encountered that showed no differences among hardwood seedling grades was recently reported for green ash grown in Wyoming (Howard, 1966). Seedlings were sorted into five grades according to height, not root collar diameter. After eight growing seasons, differences among the five seedling grades were not statistically significant.

Our project at Athens found that seedling size at planting time had important effects on the growth and survival of sycamore and sweetgum. Sycamore seedlings graded by root collar diameter showed striking differences in height growth during the first year. Differences in survival were less pronounced on this bottomland, old-field site, but were statistically significant (Ike, 1962; table 1). Seedlings with root collar diameters greater than one-half inch were nearly eight feet tall at the end of the first growing season. Needless to say, the largest seedlings were well above the competing herbaceous vegetation at the end of 1 year. But in this study, the smallest seedlings -- less than 0.3-inch in root collar diameter -- survived beneath the competing vegetation and were growing well at 5 years of age. However, trees from the larger seedlings were still taller and larger in diameter.

Table 1.--Summary of first year sycamore heights (from Ike, 1962)

Root collar diameter: (inches)	Height at end of first growing season	Survival
	Feet	Percent
less than 0.30	3.74	95
0.31 to 0.40	4.54	97
greater than 0.51	7.89	100

Our sweetgum study, now in its third growing season on a good river-bottom site, also shows strong effects of seedling grade. We sorted the 1-year-old seedlings into four grades according to root collar diameter (table 2). At the end of the second growing season, heights of the largest grade were almost twice that of the smallest grade. Because of favorable growing conditions following planting, differences among grades in survival, although apparent, are not great.

Table 2.--Second-year height and survival of four sweetgum seedling grades

Root collar diameter (inches)	Height	Survival
	Feet	Percent
less than 1/8	2.70	85.6
1/8 to 1/4	3.43	95.8
1/4 to 3/8	4.16	99.8
3/8 to 1/2	4.69	99.8

From these studies we see that seedlings with small root collars have much less chance of surviving and outgrowing competing herbaceous vegetation than larger seedlings. The actual minimum acceptable diameter will vary with species and with geographic locality. You will have to determine this by trial and error for yourselves in cooperation with your customers. In our section, it looks like one-fifth to one-quarter of an inch is a good minimum diameter for sycamore, yellow-poplar, and sweetgum.

On the other extreme, there are certain practical limitations to producing the largest seedling possible, even though they grow and survive the best in the plantation. Large seedlings are expensive to grow, costly to ship, and take longer to plant. Seventeen bundles were used to ship the 3,000 sycamore seedlings that Ike (1962) used in his seedling study and an associated planting. Only one bundle was used to ship the same number of sweetgum seedlings.

I might add that the sycamore plantations from these seedlings were very successful. The sweetgum plantation, however, was marginal. Survival in the sweetgum was only 70 percent after 5 years, but it is finally beginning to look like a plantation. The tallest sweetgum was 24 feet in height; the tallest sycamore was over 40 feet.

Kimberly-Clark Corporation in Alabama is experimenting with a unique approach to the problem of growing large sycamore seedlings without too much expensed" Through heavy fertilization and watering, they grow 1-year seedlings to heights around five feet and root collars greater than one-half inch. They cut off the tops of the seedlings and plant the tops as cuttings. The bottoms of the seedlings are root-pruned both before and after lifting so they can be planted with dibbles, So far, they have had good success and they are continuing to experiment with this method.

You, as nurserymen, with your experience and ingenuity, are in the best position to find ways of growing hardwood seedlings with a minimum number of small-diameter seedlings but with the maximum number of plantable seedlings per foot of nursery bed. Ideally, this can be done by regulating sowing rates and thence seedling density in the nursery. Some species, such as sycamore and sweetgum, can be sown mechanically and offer better chances for regulating sowing rates. For species requiring manual sowing, regulation is difficult, and the seedbeds must be thinned by hand if a particular seedling density is to be achieved. But hardwoods are variable, and even at high densities, some seedlings will be large enough to plant. If no attempt is made to regulate sowing rate or seedling density, the smallest seedlings must be culled

1/ Personal conversation with Herschel Webb and Walt Chapman, Kimberly-Clark Corporation, Coosa Pines, Alabama.

at the nursery or by the planter. With the current costs of equipment and labor, the best solution is to regulate sowing rate where possible and to cull unplantable seedlings during lifting and bundling.

To summarize, seedling size, reflected by root collar diameter, has a strong bearing on the success of hardwood plantations. The largest seedlings usually have the best growth and survival. In order to ship out seedlings that will consistently perform well, you will have to eliminate the smallest seedlings by (1) controlling seedling density in the nursery beds through regulating sowing rate or through thinning: or (2) culling the smallest seedling grades during the lifting and bundling process.

LITERATURE CITED

Clausen, Knud E.
1963. Nursery selection affects survival and growth of birch. U. S. Forest Serv. Lake States Forest Expt. Sta. Res. Note TS-31.

Howard, Gene S.
1966. Height growth of seedling green ash. J. Forestry 64:544, 546.

Ike, Albert F., Jr.
1962. Root collar diameter is a good measure of height growth potential of sycamore seedlings. Tree Planters' Notes No. 54: 9-11.

Limstrom, G. A., R. F. Finn, and G. H. Deitschman.
1955. Planting stock grades for yellow-poplar. J. Forestry 53: 28-32.

McElwee, R. L. and J. W. Johnson.
1966. Two-year results: sweetgum seedling size and spacing study. Memo. to cooperators, Hardwood research program, School of forestry, N. C. State Univ., Raleigh.

Rodenbach, Richard C. and David F. Olson, Jr.
1960. Grading yellow-poplar planting stock is important. U.S. Forest Serv., South. Forest Expt. Sta. Res. Note 147.

Williams, Robert D.
1965. Plant large black walnut seedlings for best survival and growth. U.S. Forest Serv. Central States Forest Expt. Sta. Res. Note CS-38.

Discussion

Q. (Larkin) Have you had enough experience to recommend densities for these species?

A. (Webb) My only experience is with sweetgum. With this species, 15 to 25 seedlings per square foot will give you the maximum number of plantable seedlings and a minimum number of culls. There is a density where the number of plantable seedlings level off. Beyond this point, that **is**, the greater the density, the number of plantable seedlings decrease. I'm planting for a density of 15 per square foot at Athens.

COMMENTS (McElwee). We feel that for all hardwoods, a density of 15 to 20 provides a satisfactory number of plantable seedlings per foot.

COMMENTS (Jordan). We are planting for 15 seedlings per foot.

Q. (Carter) What is the lower limit on root collar diameter of sycamore?

A. (Webb) I don't have enough experience with that species to know what it would be at 15 seedlings per square foot.