

BASSWOOD SEEDLINGS OUTGROW RED AND BUR OAK IN FULL LIGHT OR HEAVY SHADE

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Basswood generally outgrew red and bur oaks. Predominant branch growth was shown by vigorous sources. Growth of all species was greatly reduced under heavy shade. Basswood and bur oak sprouted in full light but not in shade.

Single-tree and group basswood (*Tilia americana* L.) seed collections were germinated and grown in a garden in Chicago for 2 years. Ground collections of red oak (*Quercus rubra* L.) and bottomland bur oak (*Quercus macrocarpa* Michx.) acorns were grown for 2 years and 1 year respectively. Selected seedlings were then transplanted to a garden at Murphysboro in southern Illinois. Rows of seven seedlings each from the several sources were grown in 95 percent shade under a frame covered with green saran shade fabric. Comparison groups plus additional seedlings were planted in full light. Slight temperature effects of the shading were measured. Average growing season soil temperatures at the 15cm to 20cm depth approximated 20° C.

Four basswood single-tree sources differed greatly in height at the end of two growing seasons in both full light and shade (table 1). These height differences may reflect genetic influences. Height growth of all sources was significantly reduced after 2 years in the shade. The percent reduction was less for the larger seedlings, because of their greater vigor. Similar variations were found in branch number, branch length, and dry weight. Variability in growth in response to heavy shading may help explain the lack

Table 1.— Average growth of four basswood sources in full light and 95 percent shade

Source	Height		Branch		Shoot Dry Weight
	Initial	Final	Number	Length	
	Centimeters	Centimeters		Centimeters	grams
Full Light					
Central NY	11	138	5.4	116	105
Northern NY	9	138	5.2	155	98
Northern NY	27	253	11.4	596	494
Northern NY	24	248	13.4	440	483
95 percent shade					
Central NY	10	14 ¹	0.0	0	0
Northern NY	14	26 ¹	0.3 ¹	2 ¹	1 ¹
Northern NY	29	77 ¹	1.9 ¹	31 ¹	12 ¹
Northern NY	28	68 ¹	2.0 ¹	24 ¹	8 ¹

¹ Growth under shade was significantly reduced compared to growth in full light.

of consistency in shade tolerance ratings for basswood (3).

Large differences in growth of several other basswood sources were found two growing seasons after planting in a Chicago garden study (1). Garden studies in Ontario which gave another indication of the importance of differing seed source and/or environment showed little effect of 87 percent shading on height growth of basswood seedling prior to 6 years of age (6). Growth also differed from the present study in that height growth was much less; shaded seedlings were tallest; and with full light the main stem grew more in length than the branches.

Ontario field studies showed variable survival and growth of basswood seedlings presumably related to size of nursery stock (8). Information on origin of the seed or on past history of the seedlings as sources of variability was not available.

Basswood Growth Compared To Red Oak And Bur Oak

Growth comparisons of basswood and red and bur oak have not given consistent results. At a cleared prairie site, bur oak seedlings outgrew red oak which outgrew basswood in height after 2 years (5). Species replacement during forest stand development in which all three species are found is typically bur oak, red

Table 2.—Average growth of basswood, red oak, and bur oak in full light and 95 percent shade

Source	Height		Branch		Shoot
	Initial	Final	Number	Length	Dry Weight
	Centimeters	Centimeters		Centimeters	Grams
Full Light					
Basswood (NY)	18	198	9.1	340	310
Red oak (IN)	25		High mortality		
Bur oak (IL)	16	120	4.4	124	114
95 percent Shade					
Basswood (NY)	20	49 ¹	1.1 ¹	15 ¹	6 ¹
Red oak (IN)	27	29	0.0	0	1
Bur oak (IL)	18	31 ¹	0.3 ¹	1 ¹	1 ¹
Sprout Growth in Full Light ²					
Basswood (NY)	—	223	10.2	952	427
Bur oak (IL)	—	129	5.9	239	122

¹ Growth under shade was significantly reduced compared to growth in full light.

² No sprouting took place under 95 percent shade.

oak, and lastly basswood (3). Red and bur oak have been rated intermediate in tolerance to shading on a scale of very tolerant, tolerant, intermediate, intolerant, and very intolerant. Basswood commonly has been rated tolerant but also intermediate

Basswood grew more than red or bur oak in the present study (table 2). In full light, basswood averaged a tenfold increase in height for all sources. Bur oak also grew well, essentially equalling the growth of the less vigorous basswood sources (tables 1 and 2). In both species, branch

growth exceeded that of the main shoot. High mortality of red oak in full light did not warrant inclusion of data.

Under heavy shade, the growth differences were much reduced. Red oak had the largest seedlings initially, and grew the least. Basswood made substantial growth, more than doubling in size. Bur oak less than doubled in height. Growth of both oaks approximated that of the less vigorous basswood sources. Dry weight of both basswood and bur oak seedlings in the shade was 25

percent that of seedlings in full light. Branch growth was also much reduced under shade.

Both basswood and bur oak sprouted vigorously from the stumps of cut seedlings in full light, exceeding in 1 year the previous shoot growth. Basswood sprouts greatly outgrew the bur oak sprouts. Growth of branches was pronounced on the sprout growth. The height of control seedlings of basswood and bur oak in full light exceeded that of the sprouts, however, with basswood twice as tall as bur oak. No sprouting took place in the shade. The lack of sprouting points to a substantial reduction of growth by the root system in shade.

Red oak's lack of vigor in full light is in agreement with its usual absence as a pioneer tree species. Under varied field conditions in southern Illinois, red oak of the same source also had high mortality (2). The occurrence of growth variations in juvenile oak (4) must be recognized in comparisons of basswood with red and bur oak.

Although the growth performances of the three species under shade were in agreement with their usual relative tolerance ratings, their ability to grow for 2 years in 95 percent shade suggests somewhat greater shade tolerance. This greater tolerance may be associated with the

favorable garden soil conditions and with an absence of the competition and breakage found under shaded forest conditions. In a sense the seedlings were expressing physiological rather than ecological tolerance. The lack of sprouting in the present study under heavy shade helps account for the virtual absence of established seedlings of these species under many closed forest canopies. The importance of repeated dying back and sprouting by seedling basswood and oaks in reproduction of hardwood forests has recently been emphasized (2,7).

Growth Duration and Correlation

A growth index of considerable importance is the duration of shoot growth. All basswood seedlings had an initial growth flush. Those in full light had a second flush with all of the seedlings growing throughout June. Many continued in growth through July, or grew later in the season. In contrast, only one-third of the shaded basswood seedlings were growing in early June and very few at the end of July. A consequence of this unequal growth period was that by July the seedlings in full light averaged 33 leaves and those in shade only 12. Similarly, the periods of active shoot growth by bur oak were diminished in the shade. Seedlings in full light averaged 20 leaves, and those in

Table 3.— Correlation coefficients of shoot dry weight with height, branch number, and branch length. The dashes indicate that coefficients were not applicable because branching was a discontinuous variable for plants in the shade

Species and Light Regime	Height	Branch	
		Number	Length
2-Year Experimental Growth			
Bur oak			
Full light	0.36	0.65	0.73
Shade	0.40	—	—
Basswood			
Full light	0.78	0.74	0.91
Shade	0.85	—	—
Sprout Growth (Full Light Only)			
Bur oak	0.33	0.66	0.74
Basswood	0.76	0.89	0.97

the shade 9 Red oak had a limited growth period in the shade and averaged 6 leaves by July.

Dry weight represents the net growth of a tree seedling. Because it is impractical to measure shoot dry weight in the field, three other indices were evaluated. These were the readily observable field characters of height, branch number, and branch length. Of these, branch length had the highest correlation coefficients with dry weight (table 3). The correlation coefficients of dry weight with branch number were, with one exception, also greater than for height. Seedling branches do not

persist on vigorous seedlings in developing stands. The additional plantings of the basswood sources had virtually no lower branches when 5 m tall after 5 years in the study. Their average number of canopy branches had, however, the same ratio to height as did the basswood seedlings reported in table 1.

All correlation coefficients with dry weight were higher for basswood than for bur oak, over twice as high for height and relatively less high for branch number or length. Coefficients were similar in full light and shade for both species. These findings support the concept that

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central Louisiana from plantation trees of unknown seed sources. Virginia pine (*P. virginiana Mill.*) seeds were collected from clones in the Hiwassee Land Company's seed orchard in Tennessee.

About 100 full seeds from each of 5 trees per species were sown in sand flats and kept in an air conditioned greenhouse at 75° F. The seeds from one tree constituted a lot, and all lots were kept separate.

As soon as seedcoats were shed, the cotyledons on each seedling were counted. On 10 randomly selected seedlings from each lot, the lengths of cotyledons and hypocotyls and the diameter of hypocotyls at ground line were measured. Color and straightness of hypocotyls also were observed on these seedlings.

Results

Number and length of cotyledons and length of hypocotyls overlap among the species and vary widely within species (table 1), even between seedlings from the same mother tree. Conclusive identification of individual seedlings, therefore, is impossible. However, if at least 10 seedlings are sampled, shortleaf pine can be distinguished by length of hypocotyls together with number and length of cotyledons; slash, loblolly, and Virginia pines cannot be distinguished from each other. Hypocotyls averaged 2.1 cm for shortleaf, 3.7 cm for slash and Virginia, and 3.9 cm for loblolly. Shortleaf averaged six cotyledons that were 1.9-cm long; the other species had more and longer cotyledons.

The hypocotyls of all species were the same shade of purple and had about the same diameter. It is often claimed that shortleaf is easy to recognize because young seedlings have a crook in hypocotyls near the groundline. Of 50 seedlings for each species, however, those with deformed hypocotyls totaled 1 for slash and Virginia pines, 3 for shortleaf, and 5 for loblolly.

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branch development is a better indicator of dry weight and vigor than height, and is a better indicator in basswood than in bur oak

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