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Larch—A Fast-Growing Fiber Source For the Lake States and Northeast

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ABSTRACT—Preliminary comparisons between Japanese (Larix leptolepis *Gord.) and European larch* (L. decidua *Mill.) plantings indicate that these species, together with their hybrids, will outgrow pine and spruce, particularly on the better Lake States forest soils. Larch has adequate genetic diversity and grows rapidly. It also hybridizes readily, has good wood quality, is resistant to scleroderris canker and spruce budworm, and is adapted to a variety of soils. Recently, the Institute of Paper Chemistry, at Appleton, Wisconsin, established a cooperative larch tree improvement program using a seed orchard approach. Pulping studies indicate that 18- to 23-year-old larch and larch hybrids (Larix × eurolepis* Henry) *can produce higher kraft yields than 50- to 60-year-old jack pine* (Pinus banksiana *Lamb.) and with pulp strength properties similar to those of jack pine.*

Forests of the Lake States contain enough hardwood to sustain a considerable increase in the cut of pulpwood. Expanded use, however, depends on having an adequate amount of conifers. Unless some of the long, strong fibers of conifers are mixed in, hardwood pulps are too weak to allow paper machines to operate at economic speeds. Thus increased supply of softwoods would allow increased use of northern hardwoods.

The matter is of some urgency. The nation's pulpwood requirements are expected to be 2.4 times greater by the year 2030 than they were in 1976, with conifer fiber predicted to be in short supply by 1990 (USDA Forest Service 1982, p. 60–61). Unless adequate measures are taken, wood shortages will restrict growth of the pulp and paper industry.

Red pine, spruce, and balsam fir have been the primary source of conifer fiber, but susceptibility of these species to insect and disease attack has prompted forest managers to look for alternate sources. Red pine, which is widely planted in Michigan, Wisconsin, Minnesota, and the Northeast, is genetically uniform. Recent outbreaks of the European strain of scleroderris canker in pole-size stands in New York State and southeastern Canada have demonstrated that red pine has little or no natural resistance to this disease. Mortality in affected stands is high, and spread of the disease to the Lake States would cause severe damage in areas planted principally with red pine (Nicholls 1979). Similarly, the spruce budworm, which has caused extensive mortality and growth loss to spruce and balsam fir in the Northeast, has already reached the Lake States and is spreading there. Alternative sources of conifer fiber are a high priority for these regions. This article presents the various growth and papermaking criteria that led the Institute of Paper Chemistry, Appleton, Wisconsin, to decide to pursue larch as an alternative conifer fiber source.

Potential of Japanese and European Larch

One of the earliest European larch plantings in the United States was made about 1850 (Nyland 1965), but the majority of exotic larch plantings were established in the early 1900s in New York (Cook 1969), Pennsylvania (Grisez 1968), and other northeastern states (Hunt 1932, Baldwin 1958, and Genys 1960). These plantings had variable early survival, good form and growth, and few insect and disease problems. Diameters of 16 inches b.h. and heights of 100 feet were common at 50 years. Poor techniques for handling planting stock and failure to control competing vegetation probably accounted for most of the instances of poor survival.

Additional test plantings to compare geographic sources and determine climatic suitability and growth rate of European and Japanese larch were made in the early 1960s. These provenance tests, along with demonstration plantings, have confirmed earlier observations regarding exceptional growth and form (McComb 1955, Genys 1960, Kepler and Gatherum 1964, Gatherum 1966, Farnsworth et al. 1975, and Barnes 1977). The plantings were scattered throughout the Lake States and established in greater numbers in the Northeast.

Japanese and European larch are upland species (McComb 1955), not adapted to the wet sites commonly occupied by eastern larch (tamarack, *Larix laricina)*. On upland loamy sands, loams, and silt loam soils, they have quite consistently outgrown white and Norway spruce and red, white, and jack pine planted on the same site. They also have other advantages: (1) high genetic diversity, (2) ready hybridization, (3) good wood quality in terms of specific gravity and fiber length, (4) resistance to scleroderris canker and spruce budworm, and (5) adaptability to a variety of soils. *Figures 1* and *2* and *table 1* illustrate the growth advantage of European larch over red and white pine in southwestern Wisconsin. Japanese larch is more susceptible to frost injury than European larch but in suitable climates usually outgrows European larch. Larch is attacked by the larch sawfly, larch casebearer, and a needle-cast disease, but these pests appear to be more amenable to control than the scleroderris canker of red pine.

Hybrid Vigor

In mixed plantings, Japanese and European larch hybridize readily. *Larix eurolepis* (European × Japanese larch hybrid) has demonstrated rapid early growth and hybrid vigor. Holst (1974) described a small stand in Ontario as the oldest larch hybrid planting in North America; he reported that the hybrid had a 73-percent volume growth advantage over associated Japanese larch. MacGillivray (1969), in reviewing the potential of larch in eastern Canada, cited examples of hybrid vigor. *Table 2* compares the growth rate of hybrid larch with the parent species after three and four years in a Wisconsin trial.

Table 1. Larch plantation survey, Coulee Experimental Forest, Wisconsin.[1]

Species	Age	Trees per acre	D.b.h.	Height	Total volume	Growth advantage
	Yr	*No*	*In*	*Ft*	*Cu ft*	*Pct*
European larch	19	558	6.5	53	2,621	1.29
Red pine	19	823	5.8	36	2,122	1.04
White pine	19	598	6.3	40	2,035	1.00

[1]Each value is an average of seven plots. Age is years in field. Data provided by R.D. Jacobs, North Central Forest Experiment Station, USDA Forest Service, 1980.

Table 2. Replicated larch planting at Laona, Wisconsin, on the Nicolet National Forest.[1]

Material	USDA Forest Service number	Height: Third year	Height: Fourth year
		- - - - *Feet*	- - - -
Tamarack	T7000	5.6	8.1
European × Japanese hybrid	7072	6.9	10.1
Japanese larch	7073	5.2	7.1
European × Japanese hybrid	7075	7.6	10.7
European larch	7085	6.2	8.7
Japanese × European hybrid	7250	6.8	9.0
European × Japanese hybrid	7254	6.6	9.3
Japanese × European hybrid	7377	6.6	9.2

[1]Planted April 20, 1976; tamarack was 2-0 stock and larch 3-0 stock. Values based on five replications of 16-tree plots. Survival of all material was 98 to 100 percent.

Figure 1. An 18-year-old planting of red pine (left) and European larch (right) near LaCrosse, Wisconsin, on the Coulee Experimental Forest. Larch consistently outgrows red pine on the better pine sites. The dominant and codominant larch in this planting had heights of 55–60 feet. The red pines were 30–40 feet.

Figure 2. A 19-year-old European larch selection in southwestern Wisconsin. The tree was 62 feet in height and 8.4 inches in d.b.h.

Wood and Fiber Quality

Mature European and Japanese larches have a tree specific gravity (0.49–0.48) greater than that of red pine (0.39) and jack pine (0.39). Comparisons on rapidly growing 18- to 25-year-old trees revealed an age-15 specific gravity of 0.38 for Japanese larch and 0.42 for European larch. Age-15 fiber lengths, sampled in the fifteenth annual ring at breast height, were 3.0 and 2.9 mm (Einspahr et al. 1982). Mature-tree fiber lengths have been reported to be similar to those of pine and spruce (*table 3*).

European and Japanese larch can be readily pulped by the kraft process, and the bisulfite and the two-stage Stora processes have also been successfully used. Literature reporting on the pulping of trees 50 to 80 years old has made pulp and paper producers reluctant to accept the two species. These older trees had a high proportion of heartwood and thus contained hot-water extractives in sufficient quantity to reduce pulp yields and cause difficulties in bleaching. Old, slow-growing tamarack gave similar results.

Growth measurements on European, Japanese, and hybrid larch growing in the Lake States indicate that pulpwood-size trees can be easily obtained in 18 to 24 years. These younger trees, when compared to larch greater than 50 years old, had less heartwood, lower specific gravity, shorter fibers, and about 50 percent less extractives. Eighteen- to 24-year-old larch, when compared with 50- to 60-year-old jack pine in a pulping study, had greater amounts of heartwood, similar levels of lignin and alcohol-benzene extractives, higher amounts of hot-water extractives, and slightly shorter fiber length. The larch pulped at rates similar to those of jack pine, had pulp yields ranging from 1 to 4 percent greater than jack pine, and had similar pulp strength (Einspahr et al. 1983). *Table 4* illustrates the magnitude of pulp yield and strength differences.

Table 3. Physical and chemical properties of conifers for planting in northern climates. Values are for mature trees.

Species	Wood density[1]		Fiber length	Lignin	Hot-water extractives	Alcohol-benzene extractives
	G/cc	*Lb/cu ft*	*Mm*	*Pct*		
Red pine	0.39	24.3	3.4	24.8	4.8	3.5
Jack pine	.39	24.3	3.5	28.3	3.0	4.0
Japanese larch	.48	30.0	3.6	29.3[2]	7–9	3.0[2]
European larch	.49	30.6	3.6	30.5	7–9	2.5
White pine	.34	21.2	3.0	26.6	4.8	6.5
White spruce	.37	23.1	3.3	29.4	2.6	2.0

Source: Isenberg 1980.
[1]*Wood density: g/cc = dry weight/green volume; lb/cu ft = dry weight/cu ft.*
[2]*Values from Institute of Paper Chemistry Group Project 3409 (22-year-old trees), values from bark-free, whole-tree chip samples.*

Tree Improvement Program

Recently, a program on the genetic improvement of larch was established at the Institute of Paper Chemistry. Objectives include providing a reliable source of high-quality larch and hybrid larch seed. Unimproved Japanese and European larch and larch hybrids are expected to have fiber production rates 20 to 30 percent greater than those of the native conifers. A seed orchard approach, similar to that used for southern pines (Kellison and Sprague 1981), is predicted to result in first-generation gains of 10 to 15 percent in volume growth. Similar gains are anticipated when second-generation seed orchards are established. It is risky to speculate on growth rates at this early stage, but there are indications that 20-year-old plantations produced from second-generation seed sources may average 180 to 220 cubic feet of growth per acre annually on loam to silt loam soils in the Lake States. ■

Table 4. Yield and physical properties of European and hybrid larch kraft pulp vs. jack pine kraft pulp.

Species and age	Kappa number[1]	Unscreened yield[2]	Sheet density	Burst factor	Tear factor	Breaking length
		Percent	*G/cc*			*Km*
European larch, 18 years	31.4	47.1	0.73	88.8	129	11.1
Japanese larch, 22 years	32.5	45.7	.72	89.6	126	11.4
Hybrid larch, 23 years	34.6	48.5	.73	88.1	130	11.2
Jack pine control, 55 years	34.4	43.8	.74	94.0	118	11.5

[1]*Kappa numbers relate to the amount of lignin left in the pulp. Decreasing numbers mean less lignin.*
[2]*Screen rejects ranged from 0.3 to 2.2 percent.*

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