Occurrence and Development of *Mycosphaerella laricina* on Larch in the North Central United States

M. A. PALMER and M. E. OSTRY, Research Plant Pathologists, North Central Forest Experiment Station, K. ROBBINS, Plant Pathologist, Northeastern Area State and Private Forestry, and T. H. NICHOLLS, Research Plant Pathologist, North Central Forest Experiment Station, USDA Forest Service, St. Paul, MN 55108

ABSTRACT

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Needle cast caused by *Mycosphaerella laricina* resulted in premature defoliation of European larch (*Larix decidua*) and hybrid larch (*L.* × *eurolepis*) in 31 plantations in Michigan, Wisconsin, and Iowa. Trees from Austrian, French, and Italian seed sources were more severely diseased than those from Poland and Czechoslovakia. The first symptoms developed in early summer. Disease intensified as the season progressed, and trees became completely defoliated as early as July. Spores were dispersed throughout the growing season. Most ascospores were trapped from May through July, and most conidia were trapped in August and September. In a preliminary host range study, European larch was more severely diseased than tamarack (*L. laricina*) and Japanese larch (*L. kaempferi*).

There is increasing interest in intensive management of larch, particularly European larch (*Larix decidua* Mill.), because of its rapid growth, good wood properties, and favorable pulping characteristics. Recently, a needle cast disease caused defoliation of European larch in the north central United States (8). This disease has the potential to reduce tree growth.

We first observed needle cast of European larch in the mid-1970s on the Yellow River State Forest, Allamakee County, Iowa. The fungus causing the disease was recently identified as *Mycosphaerella laricina* (Hart.) Neg. (6). Needle cast caused by *M. laricina* had previously only been reported in Europe, where it caused defoliation of European larch (3).

Studies were begun in 1981 to determine the distribution, host range, and disease cycle of *M. laricina*. This paper describes and evaluates the occurrence and potential importance of needle cast of larch caused by *M. laricina* in the north central United States. Preliminary reports have been published (5,9).

Present address of third author: North Central Forest Experiment Station, St. Paul, MN 55108.

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MATERIALS AND METHODS

Disease distribution and host range. Sixty-nine larch plantations in Wisconsin, Michigan, and Iowa were surveyed in the summers of 1981 and 1982 to learn the incidence and severity of the disease. Tree species, seed source (if known), year planted, topographic aspect and percent slope, and occurrence of needle cast were recorded for each stand. Height, diameter, and volume measurements were obtained from R. Jacobs, USDA Forest Service, St. Paul, MN. Disease severity was rated as slight (diseased needles only on lower branches), moderate (less than half of crown diseased), and severe (more than half of crown diseased). Disease was confirmed by identification of conidiomata of *M. laricina* on needles.

Tamarack seedlings (*L. laricina* (DuRoi) K. Koch) were planted in September 1981 in plantations of diseased European larch at three study sites: Trempeleau County, Wisconsin; Coulee Experimental Forest, La Crosse County, Wisconsin; and the Yellow River State Forest, Iowa. Plantations were established in 1968 at the Trempeleau County site, in 1966 (approximately) at the La Crosse County site, and in 1959 at the Iowa site. Tamarack, European larch (seed source unknown), and Japanese larch (*L. kaempferi* (Lamb.) Carr.) (= *L. leptolepis* (Sieb. & Zucc.) Gord.) seedlings were planted in areas adjacent to the diseased European larch at both Wisconsin study sites in May 1982. Each species was planted in three 50-tree plots at each location. On 21 July 1982, larch branches with diseased needles and needle litter collected from under diseased trees were scattered on top of the seedlings to serve as an inoculum source. Seedlings were evaluated on 8 September 1982 for occurrence of needle cast.

Disease development. Observations were made in the three plantations of diseased European larch described before. Measurements of shoot and needle growth and descriptions of disease development on one branch from each of five larch trees were recorded weekly in 1981 and 1982 at all study sites.

Disease development was measured in 1982 in two plantations at the La Crosse County site and in one plantation at the Trempeleau County site in Wisconsin. Estimates of disease severity were recorded for branches at heights of 1.5 and 3 m above ground for 18 trees in each plantation. Needles on a branch segment measuring 15–20 cm in the four cardinal directions on each tree were examined and rated for disease severity according to the following scale: 0 = no disease, 0.1 = fleck, 1 = 1–10% of needles affected, 2 = 11–25%, 3 = 26–50%, 4 = 51–75%, 5 = 76–100%, 6 = 76–100% plus partial defoliation, and 7 = total defoliation. The four estimates were averaged for each height on each tree where disease was recorded. Disease estimates of the 18 trees in a study location were averaged for an overall estimate of disease severity for each date disease was observed. Observations were made on 25 June, 21 July, and 8 September 1982.

Spore trapping. Seasonal periodicity of dispersal of ascospores and conidia was studied by trapping with Vaseline-coated microscope slides mounted horizontally in wire holders (4). Six traps were placed at various locations under diseased larch trees at each study site. Slides were changed weekly from 13 April to 12 October in 1981 and from 12 April to 24 October in 1982. Ascospores and conidia of *M. laricina* were the predominant spores present on the slides. Only spores that corresponded to the description of *M. laricina* (6) were counted. The relative number of ascospores and conidia trapped on each slide was determined by counting spores along three transects across the slide at 430×. The percentage of ascospores or conidia trapped each week was calculated from the weekly spore counts and the total seasonal number of ascospores or conidia trapped to yield a summary of spore dispersal for each study site. Rainfall was measured each week with a rain gauge located near the spore traps.

Table 1. Survival, growth,[a] and needle cast severity in 20- and 21-yr-old *Larix* plantations on the Yellow River State Forest, Allamakee County, Iowa (summer 1981)

Species	Country of origin	Survival (%)	dbh (cm)	Basal area (m^2/ha)	Height[b] (m)	Volume (m^3/ha)	Needle cast[c]
L. decidua	France (96)[d]	15	5.1	0.9	5.2	0	Severe
	Austria (84)	10	15.2	5.3	13.1	24	Moderate
	Austria (85)	25	14.0	11.5	12.2	60	Moderate
	Poland (97)	64	15.7	36.6	16.5	259	Slight
	Poland (100)	53	16.3	33.4	16.8	228	Slight
L. × *eurolepis*	Denmark (103)	68	14.7	38.0	16.2	248	Very slight
L. kaempferi	Japan	77	18.8	35.2	17.4	234	None

[a] Unpublished data supplied by R. Jacobs, USDA Forest Service, St. Paul, MN.
[b] Heights of dominant and codominant trees.
[c] Severe = more than one-half of crown diseased, moderate = less than one-half of crown diseased, and slight = only lower branches diseased.
[d] Numbers in parentheses indicate seed source numbers used by Gatherum (2).

RESULTS

Disease distribution and host range. Needle cast was confirmed in 29 of 45 plantations of European larch and in two of five plantations of hybrid larch (*L.* × *eurolepis* Henry). None of the 16 Japanese larch plantations or three tamarack plantations surveyed showed symptoms of the needle cast.

Disease severity varied with seed source of European larch at the Iowa site. Larch from Alpine sources (Austrian, French, and Italian) were more severely diseased than those of provenances farther north in Europe (Czech and Polish). Survival and growth also varied with seed source (Table 1). Needle cast severity did not appear to be related to stand age, size, aspect, percent slope, or location of individual trees within a plantation. Disease was more severe in the lower crown and on smaller trees. In addition to identifications made in our survey, needle cast caused by *M. laricina* has been identified in several other larch stands and in one forest tree nursery in Wisconsin. The locations of all known occurrences of this disease identified by the authors or Wisconsin Department of Natural Resources personnel (7,8) as of November 1984 are given in Figure 1.

Needle cast symptoms, fruiting bodies, and spores of *M. laricina* were observed on seedlings of all larch species planted in all locations. European larch was the most severely diseased species. Japanese larch and tamarack were slightly diseased. This is the first report of tamarack as a host of *M. laricina*.

Disease development. Growth of shoots and needles of European larch and seasonal progression of needle cast caused by *M. laricina* were similar in all study locations. In both years, shoot elongation occurred from mid-April to early July and needle elongation occurred from mid-April to late May. In 1981, needle lesions and chlorosis first developed from late May to early June. Conidiomata developed in July, and by late July, severely diseased trees had lost most of their foliage. Needles of a second flush in August also became diseased. Generally, the disease was less severe in 1982. The first symptoms were not observed until mid-June or early July, and fruiting bodies were observed in late July. Many trees retained foliage in the upper crown until the end of the growing season. Disease development in the La Crosse County site in 1982 (Fig. 2) is representative of all study sites. The greatest increase in disease severity at the two Wisconsin sites occurred between 21 July and 8 September in 1982 (Fig. 3).

Spore trapping. Seasonal periodicity of spore deposition was similar in all study areas in 1981 and 1982. Spore trapping results for the La Crosse County site in 1982 are shown in Figure 2. Ascospores and conidia were trapped throughout the growing season, although most ascospores were trapped from May through July and most conidia were trapped in August and September. Spores were trapped only during weeks when rain fell.

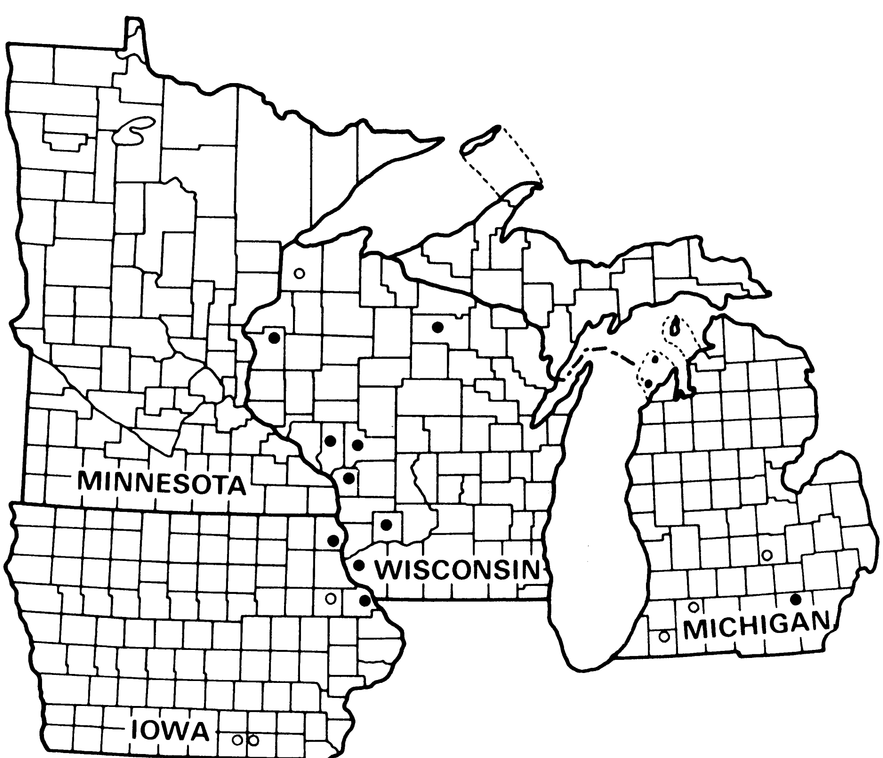

Fig. 1. Locations of plantations surveyed and occurrence of needle cast caused by *Mycosphaerella laricina* in Minnesota, Iowa, Wisconsin, and Michigan as of 1984. ● = Needle cast present and o = needle cast absent. Each symbol represents one or more locations within a county.

DISCUSSION

M. laricina caused premature defoliation of susceptible European larch in several plantations. The first symptoms occurred on lower branches in early summer after the peak period of ascospore dissemination. As the growing season progressed, symptoms progressed rapidly upward to the crown. This increase in disease was associated with abundant dissemination of conidia. In 1981, many trees were completely defoliated by late July. This suggests that optimum conditions for spore dissemination and disease development occurred in early to midsummer. Warm temperatures and abundant rainfall during this period probably favored this disease. The midseason increase in disease presumably

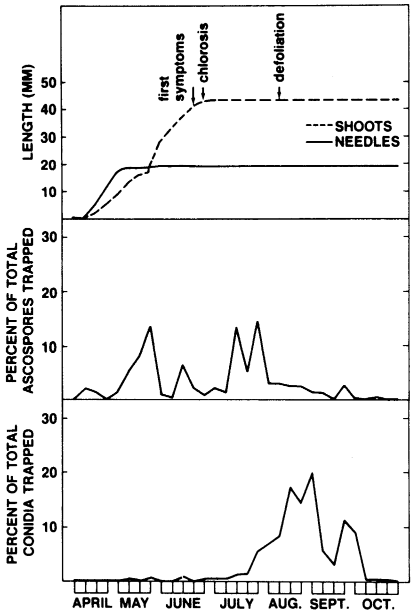

Fig. 2. Growth of *Larix decidua*, seasonal development of needle cast, and spore dispersal of *Mycosphaerella laricina* in 1982 at the Coulee Experimental Forest in La Crosse County, Wisconsin. Length of shoots and needles is the average of five measurements. Percent ascospores and conidia trapped determined from the sum of weekly spore counts and the total seasonal number of ascospores or conidia.

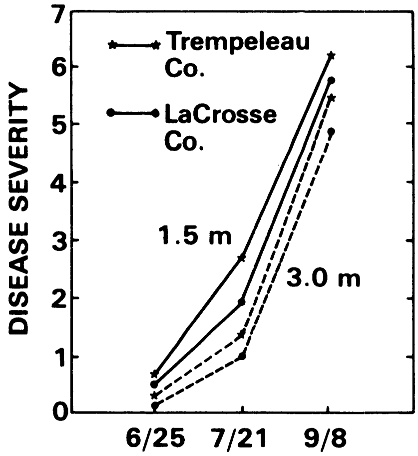

Fig. 3. Seasonal development of needle cast caused by *Mycosphaerella laricina* on branches 1.5 and 3 m above ground in Trempeleau and La Crosse counties of Wisconsin in 1982. 0 = No needle cast symptoms and 7 = total defoliation.

resulted from secondary cycles of infection as reported by Hartig (3).

Needle cast symptoms of varying severity were observed on European, Japanese, and hybrid larches and on tamarack. Among the different European larch seed sources, trees of the most severely diseased sources showed the poorest growth. Some of the growth differences can be attributed to genetic differences among seed sources as observed in other plantations not affected by needle cast (1,2). However, a substantial loss of photosynthetic area caused by needle cast would presumably result in reduced potential fiber production.

Infection of Japanese larch and tamarack occurred only on seedlings outplanted in the study areas. These seedlings were exposed to high inoculum levels. In 1982, we observed 16-yr-old tamarack trees growing adjacent to diseased larch in Oneida County, Wisconsin. Although larch branches with diseased needles were touching those of the adjacent tamarack, no symptoms were visible on the tamarack. Similarly, a stand of Japanese larch growing within 30 m of severely diseased European larch (French seed source) at the Iowa study site showed no symptoms of the needle cast. This variation in apparent susceptibility among species and trees of different seed sources within a species suggests potential for control through selection or breeding of resistant larches.

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