Stem Rusts in Lodgepole pine provenance trials

By O. MARTINSSON

Department of Silviculture, Faculty of Forestry, Swedish University of Agricultural Sciences, S—901 83 Umeå, Sweden*)

(Received May 1979 / January 1980)

Summary

Incidences of three species of stem rust were studied in a provenance trial of *Pinus contorta* in British Columbia and the Yukon territory, Canada. Considerable differences in susceptibility were observed between provenances as well as between progenies within provenances. In the main experimental plantation an average of 22 % of the trees were attacked, however, in some provenances 50 % of the trees had one or more attacks. Several trees recently killed by stem rust were found and more are expected in the near future.

Key words: Lodgepole pine, stem rust, breeding for resistance to diseases

Zusammenfassung

In einem Provenienzversuch mit *Pinus contorta* wurde das Auftreten von Cronartium-Arten in British Kolumbien und dem Yukon-Gebiet in Kanada untersucht. Dabei wurden deutliche Unterschiede in der Empfindlichkeit sowohl zwischen Herkünften, als auch zwischen Nachkommenschaften innerhalb der Herkünfte beobachtet. Auf der Haupt-Versuchsfläche zeigten im Mittel 22 % der Bäume Befall, bei einigen Herkünften hatten 50 % der Bäume ein oder mehrere Befallsstellen. Es wurden verschiedene, erst kürzlich abgestorbene Bäume entdeckt, aber weitere werden in naher Zukunft erwartet.

Introduction

Lodgepole pine, *Pinus contorta* DOUGL., introduced from western Canada, has become an important tree species in Scandinavia during the last few years. In Sweden, 50 million lodgepole pine seedlings have been outplanted annually since 1976. The reason for the introduction of this foreign tree species is its superior productivity in Sweden. In comparison to Scots pine, *Pinus silvestris* L., lodgepole pine can be expected to produce 25—50 % more wood per hectare (REMRÖD 1977). This prognosis is made under the assumption of the present growing conditions. So far, the lodgepole pine regenerations in Sweden, especially in the nothern part, are surprisingly healthy. One reason for this extra vigour could be that some of the natural pathogens on lodgepole pine in North America are not present in Europe.

Among the most dangerous and destructive pathogens of pine are rust fungi, which cause stem cankers and gall formations (BOYCE 1961). In the area of natural distribution of lodgepole pine, four species of stem rust diseases are recognized:

Stalactiform blister rust caused by *Cronartium coleosporioides* ARTH.
Comandra blister rust caused by *Cronartium comandrae* PK.
Sweet fern blister rust caused by *Cronartium comptoniae* ARTH.
Western gall rust caused by *Endocronartium harknessii* Y. HIRATSUKA.

These rust fungi are not found outside the North American continent, although hard pines indigenous to Europe are susceptible. *E. harknessii* is autoecious. The other three rust species require alternate host plants to complete their life cycles (HIRATSUKA and POWELL 1976). These plants have existed in Europe for thousands of years. The absence of recognised infection by these rusts in Europe makes it unlikely that natural spread from North America will occur. However the frequency of air travel and other forms of transport greatly increases the risk of introduction of one more of these rusts into Europe, which would be a "man-made" problem in the same way as white pine blister rust, caused by *Cronartium ribicola* FISH ex RABH., became a big problem at the beginning of this century in North America.

Genetic improvement of Western and Eastern white pines, *Pinus monticola* DOUGL. and *P. strobus* L., for resistance to white pine blister rust has been successful (BINGHAM *et al. 1971*). Good results have also been achieved in breeding for resistance to fusiform blister rust, *Cronartium fusiforme* HEDGC. and HUNT, on southern hard pines, *Pinus eliottii* ENGELM. and *P. taeda* L.

Few attemps have been made on genetic improvement of disease resistance in lodgepole pine, simply because it has not been considered necessary. In naturally regenerated stands of lodgepole pine, the main problem is often overstocking. In such overstocked stands, some mortality, from whatever cause, can be beneficial to stand productivity. With artificially regenerated and managed stands, where every tree is expected to survive, any damage from deseases is, of course, detrimental.

In intensive forestry of lodgepole pine, it may be useful to include resistance to the most destructive diseases into the breeding program. Also, in view of potential risk of an accidental introduction of dangerous pathogens into Europe, it may be useful to consider the genetical factors involved in rust resistance of the introduced lodgepole pine gene-pool.

At the beginning of the 1970s a series of lodgepole pine provenance trials were established by the British Columbia Forest Service in a large number of locations in B.C. and the Yukon (ILLINGWORTH 1969).

During the summer of 1978 I had the opportunity to examine some of these experimental plantations.

The objective of my study was:

1. To identify the most pathogenic fungi in these provenance trials of lodgepole pine.
2. To investigate the variability in incidence of attacks by these fungi with the tentative assumption that the variability reflects differences in susceptibility.

In some of the experimental plantations natural attacks by pathogens occurred. Three species of stem rusts, *Endocronartium harknessii, Cronartium coleosporioides* and *C. comandra* had caused the most serious damage. Needle cast, caused by *Lophodermella montivaga* and *L. concolor*, was also observed to a high frequency in some plantations but the damage caused by these diseases was considered less detrimental.

*) The work was carried out during a transfer of work to the Pacific Forest Research Centre, Victoria, B. C., Canada.

Material and Methods

At Red Rock research centre, close to Prince George, B. C., 53 provenances of 4-year-old lodgepole pine seedlings were outplanted in 1973. Each provenance consisted of progenies of 15 open pollinated trees. The experiment has a randomized block design with three complete replications. Six trees per progeny are outplanted in each block, i.e. there are 90 trees per block from each provenance.

In June 1978 I made an inspection of nine provenances. Five of these were randomly selected and four were selected as being more attacked by stem rusts than the average, as judged by an initial sampling. All the three species of stem rusts mentioned above occured in the plantation. The occurrence of infections by each of these rusts was recorded for each tree examined. The data does not differentiate between comandra rust and stalactiform rust. Every gall or rust canker was assessed as either "severe" or "minor". Attack on a stem or a branch sufficiently close to permit the rust to reach the stem was considered as severe. The randomly selected provenances were: 36 Kinaskan, 43 Bison Lk., 69 Carbondale R., 71 Flyhills and 73 Manning Low. The four provenances selected as more severly attacked than average were: 23 Carmacks, 34 Takhini, 35 Atlin and 37 Cassiar. The proportion of the number of attacked trees per progeny and per provenance was calculated. Uniformity of rust incidences in the experimental area was tested through analysis of variance among and within the three blocks.

Rust infections were also observed at three other locations in northern B.C. and the Yukon, where provenance trials had been established. In these smaller experimental plantations, Watson Lake, Whitehorse und Liard site 3, all provenances were inspected. The seedlings on these locations were seven years old.

At Whitehorse there were 40 provenances
and 54 trees or less per provenance.
At Watson Lake there were 60 provenances
and 27 trees or less per provenance.
At Liard site 3 there were 60 provenances
and 18 trees or less per provenance.

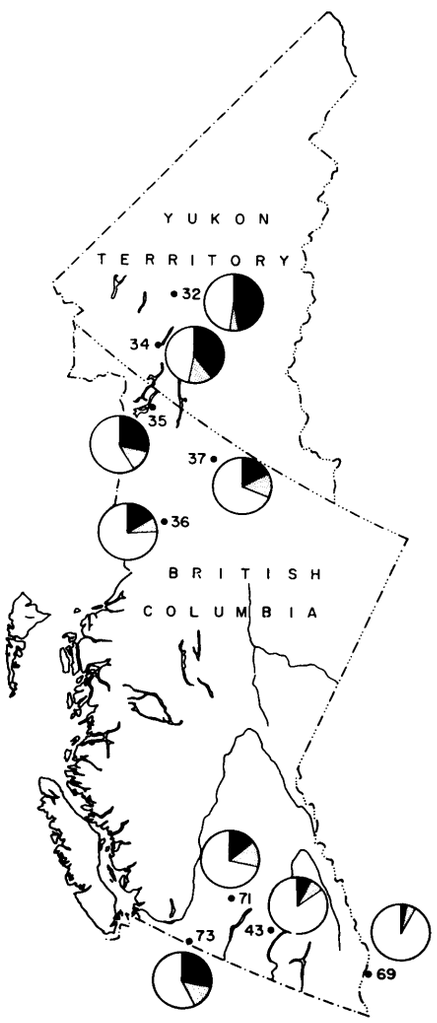

Figure 1. — Location of nine provenances of lodgepole pine and their average sesceptibility to stem rusts at Red Rock 1978.
Black component = Proportion of the number of trees with severe damage
Hatched component = Proportion of the number of trees with minor damage

Results

At Red Rock, a mean of 22 % of the trees were attacked. Considerable differences were observed among provenances *(Fig. 1)* as well as among progenies within provenances *(Fig. 2)*. No significant difference was found among blocks *(Table 1)*.

Among the non-randomly selected provenances, between 30 % and 50 % of the trees per provenance were attacked. A big number of these trees were severly attacked *(Fig. 1)*.

The random sample of the five provenances could represent the true mean of the entire trial at Red Rock; however, relatively big differences were observed also between those five. Only 8 % of provenance 69 Carbondale R. had been attacked, while in provenance 73 Manning Low, 42 % of the trees had one or more attacks. Also, within provenances differences were found among progenies *(Fig. 2)*. In provenance 34 Takhini, progeny No. 9 had five times as many attacked trees as progeny No. 7. In provenance 37 Cassiar the difference between progeny No. 12 and the rest is also worth attention. Most of the damage on 32 Carmacks, 34 Takhini and 73 Manning Low was stalactiform or comandra blister rust, while western gall rust was the most common rust on the other six provenances.

Table 1. — Analysis of variance of attacked trees. The analysis is based on percentage of attacked trees per provenance per block.

Source of variation	DF	F-values	
		Gall rust	Comandra + Stalactiform blister rust
Among provenances	8	3.70*	6.15***
Among blocks	2	0.24°	2.75°
Within blocks within provenances	16	-	-
Total	26		

*** significant at p = 0.001
* " " p = 0.05
° not significant

In the three locations in the north, the trees were three years younger, less vigorous and less frequently attacked

by rust. A complete comparison between the trial at Red Rock and those at the other three locations is not possible since southern provenances were not planted in the north. From *table 2,* however, it appears that the provenances severely attacked at Red Rock were also attacked at the other three locations more than the average.

Discussion and conclusions

Most of the gall rust attacks at Red Rock were located at the stem internode of the first or second year of height growth. This indicates that the seedlings probably were infected before the plantation was established on the experimental site. Attacks by stalactiform and comandra blister rust were, in most cases, initiated on branches of the lower branch whorls. All these attacks should not be considered as severe. Most of the severe damage was caused by gall rust. Many branches attacked by stalactiform and comandra blister rust will probably die before the rust reaches the stem, with concomitant death of the rust fungus. Gall rust on branches is not a

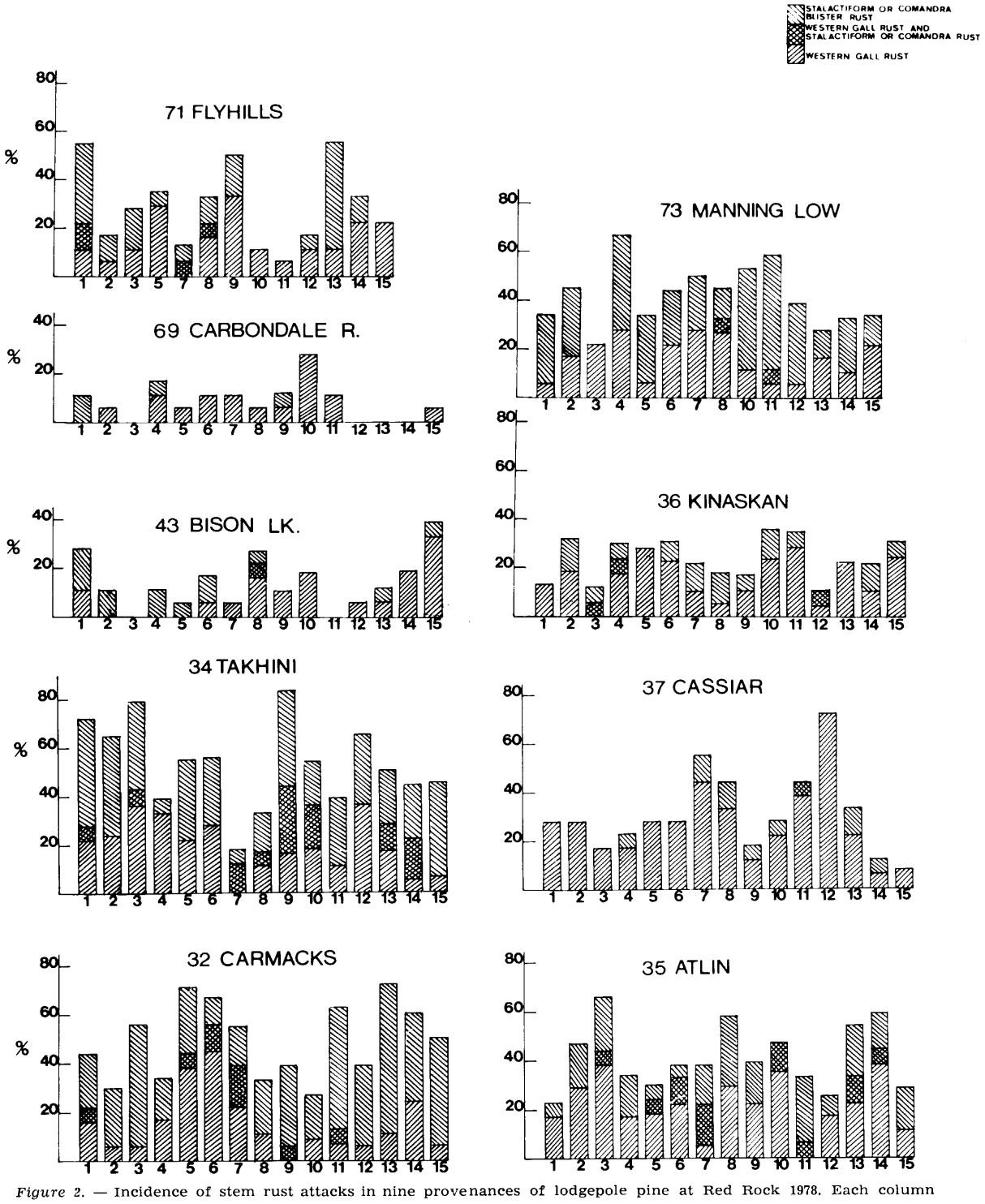

Figure 2. — Incidence of stem rust attacks in nine provenances of lodgepole pine at Red Rock 1978. Each column represents a half-sib family of 18 trees.

Table 2. — Number of seedlings attacked by stem rusts on three locations.

Provenance	Liard site 3	Watson lake	Whitehorse
25 Hudson Hope		1	
28 Tetsa R			4
29 Muncho L		1	1
32* Carmacks	3		3
33 Ethel L		2	1
34* Takini R			5
35* Atlin	1		2
36* Kinaskan			5
37* Cassiar	2		2
38 Jachfish Cr			3
39 Redwillow R		1	
40 McLeod L.		1	
64 Wendle Park		1	
66 Stone Mt		1	
88 Yakutat		2	
93 Beaver L.	**	1	
94 Sitka	**	1	
95 Petersburg	1	***	****
96 Thorne R.	**	2	
98 Gravina I.	1		
99 Annette	**	1	
102 Nass R.		1	
103 Kalder L.		1	
141 Hawk Hills		1	2

* present at Red Rock (see Figure 1)
** not present in Liard site 3
*** not present in Watson Lake
**** not present in Whitehorse

threat to the survival of tree, but is a source of inoculum. Gall rust on the stem is more serious on these young trees but need not necessarily kill the tree. Some trees with stem galls are known to survive and grow for many years after gall formation, although lumber quality and growth rate will be affected (HIRATSUKA and POWELL 1976).

The abundance of paintbrush, *Castilleja miniata*, an alternate host to stalactiform blister rust, must have contributed to the inoculum of this fungus throughout the plantation.

Investigations by other authors have suggested that individual trees in planted and managed forests are more severely attacked by rust fungi than trees in naturally regenerated forests (HIRATSUKA and POWELL 1976; KREBILL 1973). My impression agrees with this. In the trial at Red Rock, several trees recently killed by stem rust were found, and more are expected in the near future. Most of the attacked trees were growing very well a couple of years ago.

On the three northern locations, the individual galls or cankers were mostly small and undeveloped. Probably the inspection was made too early for reliable determination of rust resistance. More attacks could be expected later.

The conclusion of this pilot study is that stem rust can be a serious threat to plantations of lodgepole pine. This threat is probably more serious to artificial regeneration than to natural stand, since within the natural range of lodgepole pine this tree species have been adapted to a high stand density; i.e., most seedlings must be killed in one way or another before the stand reaches maturity (HOFF and MCDONALD 1972). The study also indicates that variability in lodgepole pine susceptibility to these stem rusts exist which can be ascribed to genetical factors.

Acknowledgements

This investigation was supported by the Svedish Research Council for Forestry and Agriculture and the Swedish Cellulose Industry Foundation for Research in Technology and Forestry. The experimental plantations are a part of the B. C. Forest Service provenance trials of lodgepole pine initiated by Mr. KEITH ILLINGWORTH, who generously gave me permission to make this study. I also thank Drs JOHN HOPKINS and LES SAFRANYIK of the Pacific Forest Research Centre in Victoria, B. C. for valuable support of the work and reviewing the manuscript.

References

BINGHAM, R. T., R. J. HOFF and G. I. MCDONALD: Disease resistance in forest trees. Annu. Rev. Phytopath. 9: 433—452 (1971). — BOYCE, J. S.: Forest pathology, McGraw-Hill 3rd Ed., New York, 572 p. (1961). — DINUS, R. J.: Testing for Fusiform rust resistance in Slash pine. Biology of rust resistance in forest trees. Proc. of NATO-IUFRO adv. st. inst. 1969. (1972). — HIRATSUKA, Y. and J. M. POWELL: Pine stem rusts of Canada. Dep. of Env. CFS, For. Techn. Rep. 4 (1976). — HOFF, R. J. and G. I. MCDONALD: Stem rusts of conifers and genetics of tree rust resistance. Biology of Rust Resistance of Forest Trees. USDA For. Ser. Misc. publ. 1221 (1972) . — ILLINGWORTH, K.: Studies of geographic variation in *Pinus contorta*. B. C. Forest Service E. P. 657 (1969). — KREBILL, R. G.: Lodgepole pine's fungus-caused diseases and decays — management of Lodgepole pine ecosystems. Proc. Wash. State Univ. Pullman (1973). — REMRÖD, J.: Contortatallen — Skogs — och Lanbruksakademiens Tidskrift 1977 (3) (1977).