Effect of Stem Rust Fungi on 45-yr-old Jack Pine

D. W. FRENCH, Professor and Department Head, DALE L. K. SMELTZER, Research Assistant, and N. A. ANDERSON, Professor, Department of Plant Pathology, University of Minnesota, St. Paul 55108

ABSTRACT

French, D. W., Smeltzer, D. L. K., and Anderson, N. A. 1983. Effect of stem rust fungi on 45-yr-old jack pine. Plant Disease 67:26-28.

A plantation of jack pine (*Pinus banksiana*) surveyed for stem rust infections in 1958 when 25 yr old had 34% of the trees with sweetfern rust (*Cronartium comptoniae*) infections on the main stem. In 1978 this stand was sampled again, and 49% of the trees had sweetfern rust cankers on the main stem. A signficant number of sweetfern rust cankers were not visible until 1978. Cross sections through a sample of these "latent" cankers indicated that the infections had been present since the trees were very young. Diameter of infected trees at 1.4 m was reduced with increased stem circumference affected by the sweetfern rust. Trees with pine-oak rust (*C. quercuum*) infections had slightly higher mortality and slightly smaller diameters than rustfree trees. The incidence of decay was low in 25 sampled trees.

In 1958, the incidence of stem rust fungi and their effect on height and diameter of jack pine (*Pinus banksiana* Lamb.) were determined for a plantation established in 1933 with 1-0 stock on the Washburn District of the Chequamegon National Forest in Wisconsin (1,2). Sweetfern rust (SFR), caused by *Cronartium comptoniae* Arth., and pine-oak rust (POR), caused by *C. quercuum* (Berk.) Miyabe ex Shirai f. sp. *banksianae*, were the dominant stem rust diseases in the plantation. Stalactiform (cowwheat) rust, caused by *C. coleosporioides* Arth., was present on a few trees in the plantation. In 1972 and 1978, these same trees were reexamined to determine the effect of the rust fungi during the intervening 14 and 20 yr, respectively.

Paper 11,791, Scientific Journal Series, Minnesota Agriculture Experiment Station, St. Paul 55108.

Accepted for publication 7 May 1982.

The publication costs of this article were defrayed in part by page charge payment. This article must therefore be hereby marked "*advertisement*" in accordance with 18 U.S.C. § 1734 solely to indicate this fact.

0191-2917/83/01002603/$03.00/0

MATERIALS AND METHODS

The same five rows of jack pine studied in 1958 were surveyed again in October 1972 and June 1978. Originally, 574 trees in these five rows were examined in 1958, but only 306 of these trees were found in 1972 and 1978. Two additional rows, selected at random, were surveyed in 1972 and brought the total number of trees in the study to 531. Mortality, prevalence and identity of the rust fungi, amount of stem circumference affected, and diameter of the trees were determined. Diameter was measured at breast height (1.4 m), which was well above most SFR cankers. Only rust infections on the main stem were recorded. The age of SFR infections not detected in 1958 and 1972 was determined by sectioning the oldest part of cankers on 11 randomly selected trees and counting the disrupted growth rings. Four SFR infections detected in 1958 were also handled in this manner.

The presence of decay in trees with and without SFR was determined in 1978. In

the same plantation, 25 trees (12 with and 13 without SFR) were selected at random (but not from the seven sampled rows) and sectioned in at least three places. When present, the type of decay was recorded, but no attempt was made to identify wood-rotting fungi or to measure the volume of wood affected.

RESULTS

We found 20.3% more SFR infections in 1978 than were noted on the same trees in 1958. Of the trees with visible infections in 1978, 14% (13/93) with SFR only and 35% (14/40) with both SFR and POR infections on the main stem were not visibly infected in 1958. A smaller percentage of SFR infections was not visible in 1972: 9% (7/81) with SFR only and 3% (1/31) with SFR and POR. Sections through selected trees with SFR infections not detected in 1958 and 1972 indicated that the infections had been present since the trees were less than 10 yr old. All or nearly all growth rings were disrupted by the rust when the section was taken near the oldest part of the canker.

Mortality was highest for trees infected only with SFR as shown in Table 1. Between 1958 and 1978, trees without main stem rust infections had the lowest mortality. However, between 1972 and 1978, trees infected with POR had a slightly lower mortality than trees without main stem infections. Because all SFR infections detected in 1978 were not visible in 1958 and 1972, mortality based only on the infections visible in those years is higher than the actual mortality (Table 1). The mortality in 1978 of the trees that had noticeable SFR and POR main stem infections in 1958 was 69%.

In 1978, 34% of the total 306 trees surveyed since 1958 (Table 2) had SFR infections only, and 13% had both SFR and POR infections; a total of 47% in the plantation were infected with SFR. This is a higher percentage than when the trees were surveyed in 1958 (1,2) because not all infections were visible then. Also, not all the trees were found and resurveyed in 1972 and 1978. POR-infected trees made up 35% of the 306 total trees, including those with SFR infections. No main stem rust infections occurred in 31% of the trees. Of the trees surveyed only since 1972 (Table 3), a higher percentage (41%) was without main stem rust infections, and SFR infections were less frequent (total of 33%). Because these trees were originally surveyed in 1972, trees that had died and decayed since 1958, when the other trees were surveyed, were probably not all included in the sample.

Trees with both SFR and POR infections usually had slightly larger diameters than the other trees (Table 4). Trees with POR infection had smaller diameters than trees without main stem infections in 1972 and 1978. When a greater percentage of their main stem circumference was invaded by SFR, the trees always had smaller diameters than when less of the stem was invaded.

Decay was not as prevalent in 1978 as it was in 1958 (1,2). Eight percent (1/13) of the trees without main stem rust infections, sectioned to determine decay, had decay within the stem, which was associated with a wound or crack in the bark. One of three trees with POR had decay, but it was only in the lower portion of the tree, which was not infected. Decay

Table 1. Percentage of mortality of jack pine with sweetfern rust (SFR) and pine-oak rust (POR) cankers on the main stem based on actual and visible infections in 1958 and 1972

Rust disease on main stem	Live trees in 1958 that were dead in 1978 (%)	Live trees in 1972 that were dead in 1978 (%)[a]
SFR		
Actual[b]	60 (56/93)[c]	23 (19/81)[d]
Visible[e]	70 (56/80)	26 (19/74)
SFR and POR		
Actual	45 (18/40)	17 (6/31)
Visible	69 (18/26)	20 (6/30)
POR	38 (24/63)	8 (8/96)
None	19 (17/88)	9 (13/147)

[a] Includes all trees surveyed in 1958 and 1972.
[b] Based on actual number of infected trees as determined by 1978 survey.
[c] (No. of trees that died since 1958/total living trees in 1958).
[d] (No. of trees that died since 1972/total living trees in 1972.)
[e] Based on only those trees visibly infected in 1958 and 1972.

Table 2. Mortality due to sweetfern rust (SFR) and pine-oak rust (POR) on 306 jack pine in a plantation established in 1933 with 1-0 stock and surveyed for infection in 1958, 1972, and 1978

Rust disease on main stem[a]	Total trees (no.)	Dead trees					
		1958		1972		1978	
		No.	%[b]	No.	%	No.	%
SFR only	105	12	11.4	55	52.4	68	64.8
SFR and POR	40	0	0	13	32.5	18	45.0
POR only	66	3	4.5	22	33.3	27	40.9
None	95	7	7.4	22	23.2	24	25.3

[a] Based on infections visible in 1978, even when they were not visible in 1958 and 1972.
[b] Based on total trees in category.

Table 3. Mortality due to sweetfern rust (SFR) and pine-oak rust (POR) on 225 jack pine in a plantation established in 1933 with 1-0 stock and surveyed for infection in 1972 and 1978

Rust disease on main stem[a]	Total trees (no.)	Dead trees			
		1972		1978	
		No.	%[b]	No.	%
SFR only	58	27	46.6	33	56.9
SFR and POR	15	7	46.7	8	53.3
POR only	59	7	11.9	10	16.9
None	93	19	20.4	30	32.3

[a] Based on infections visible in 1978.
[b] Based on total trees in category.

Table 4. Average diameter (cm) at 1.4 m (DBH) of trees in a jack pine plantation established in 1933 and surveyed in 1958, 1972, and 1978

Rust disease on main stem	1958		1972		1978	
	DBH	Trees (no.)	DBH	Trees (no.)	DBH	Trees (no.)
SFR[a]						
0[b]	12.0	13	17.3	3	···	0
5–45	11.2	34	16.6	18	18.1	5
50–100	9.5	46	15.0	29	17.9	32
SFR and POR						
0	13.0	14	18.4	4	···	0
5–45	12.5	12	18.0	6	20.6	5
50–100	10.5	14	15.0	17	16.3	17
POR	11.1	63	15.3	44	16.5	39
None	11.0	88	16.6	73	18.2	71

[a] SFR = sweetfern rust. POR = pine-oak rust. Rust categories are based on infections visible in 1978.
[b] Percentage of main stem circumference visibly invaded by SFR.

was associated with SFR infections in two of 12 (17%) trees sectioned. All decay was a red rot, probably caused by *Phellinus pini* (Thor ex. Fries) Ames.

During the analysis of samples collected to determine decay incidence, it was observed that two trees considered to be rustfree were infected with SFR. The infections were basal and could only be observed in cross section. The exact age of the cankers was not determined.

DISCUSSION

In 1978, 49% of the 45-yr-old trees had SFR infections, but only 33.8% of the trees had detectable cankers when 24 yr old (1958). This indicates that evaluations for incidence of SFR in the 25-yr-old jack pine plantation were conservative. The number of infections that are not detected seems to depend on whether the tree has a main stem POR infection as well, and on the age of the plantation. Trees with both SFR and POR infections usually had larger diameters and less mortality than trees with only SFR infections, especially before 1978. These trees also had a greater percentage of SFR infections not visible in 1958. Perhaps because of more rapid growth, these trees have been able to limit development of SFR, at least in their first 45 yr.

The relative lack of decay associated with SFR infections in 1978 compared with 1958 (1,2) suggests that most of the SFR-infected trees that were subjected to decay had died by 1978. The mortality of all SFR-infected trees since 1958 was 59%.

A significant aspect of this study has been the ability to measure the same trees over a period of 20 yr. Other studies of the effects of stem rusts on jack pine (3,4) have only measured the trees at one time, and so the past history of those trees is unknown. This study indicates that the percentage of actual SFR infections that can be visually detected varies depending on the age of the trees. Based on the present data, it is expected that even more SFR infections will become apparent on these surveyed trees and that even greater mortality of rust-infected trees will occur in future years.

The high mortality in the rustfree trees is a matter of concern. Root rot fungi have been observed and may be an important part of the problem. This matter is now being investigated.

LITERATURE CITED

1. Anderson, N. A. 1960. Studies on the effects of the Cronartium stem rusts on jack pine and the epidemiology of these fungi. Ph.D. thesis. University of Minnesota, St. Paul. 97 pp. Diss. Abstr. 21:721.
2. Anderson, N. A., and French, D. W. 1964. Sweetfern rust on jack pine. J. For. 62:467-471.
3. Cross, H. L., Patton, R. F., and Ek, A. R. 1978. Reduced growth, cull and mortality of jack pine associated with sweetfern rust cankers. Can. J. For. Res. 8:47-53.
4. Guilkey, P. C., Rudolph, V. J., and Shepherd, G. 1958. Effects of sweetfern rust on the growth of young jack pine in northern lower Michigan. J. For. 56:900-903.