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PHYSIOLOGICAL AND MORPHOLOGICAL VARIATION AMONG FINNISH *GREMMENIELLA ABIETINA* ISOLATES

ANTTI UOTILA

SELOSTE

SUOMALAISTEN *GREMMENIELLA ABIETINA* -ISOLAATTIEN FYSIOLOGISESTA JA MORFOLOGISESTA VAIHTELUSTA

HELSINKI 1983

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Cover (front & back): Scots pine (*Pinus sylvestris* L.) is the most important tree species in Finland. Pine dominated forest covers about 60 per cent of forest land and its total volume is nearly 700 mil. cu.m. The front cover shows a young Scots pine and the back cover a 30-metre-high, 140-year-old tree.

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Variation in the growth rate and conidial morphology among Finnish *G. abietina* was studied. The growth rates of 26 isolates varied from 25 to 47 mm/35 days at 15 °C. The lengths of conidia varied from 14 to 56 µm. Combining differences in the septation of conidia and in growth rates appears to give two morphologically and physiologically quite distinct races of *G. abietina* in Finland. Race A has 4 -celled conidia and grows faster on an artificial medium than Race B. Race A is found mainly in Southern Finland in all kinds of pine forests. Race B has 4—8 -celled conidia and is found mainly on young pine sapling stands in Northern Finland.

The existence of intermediates or other Races than A and B is possible. Further knowledge of the distribution of the perfect state and the pathogenicity in relation to Races A and B is needed.

Gremmeniella abietina -sienen fysiologista ja morfologista vaihtelua tutkittiin maljakasvatuskokein ja kuromamittauksin.

26 isolaatin pesäkkeen halkaisijoiden keskiarvot vaihtelivat 25—47 mm:n välillä 35 vrk:n kasvatuksen jälkeen 15 °C:n lämpötilassa. Kuromien pituus oli 14—56 µm. Tulosten perusteella näyttää siltä, että Suomessa on *G. abietina* -sienellä kaksi fysiologisin ja morfologisin perustein erotettavaa rotua, jotka eivät kuitenkaan erotu toisistaan jyrkästi. Rotu A:lla on 4-soluiset kuromat, ja se kasvaa nopeammin keinoalustalla kuin Rotu B. Rotu A aiheuttaa tuhoa kaikenikäisissä männiköissä pääasiassa Etelä-Suomessa. Rotu B:llä on 4—8 -soluiset kuromat, ja se tuhoaa lähinnä nuoria männyntaimikoita Pohjois-Suomessa. Rotujen patogeenisuudesta ja suvullisen asteen esiintymisestä eri roduilla tarvitaan lisätietoja.

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CONTENTS

1. INTRODUCTION

In Finland, *Gremmeniella abietina* (Lagerb.) Morelet causes three diseases on Scots pine (*Pinus sylvestris L.*):

1. It is a major nursery pathogen, killing millions of seedlings almost every year.
2. In Northern Finland the causal fungus destroys young pine sapling stands, generally those 0.5 to 2 metres tall, after cold growing seasons, especially in the higher elevations (250—350m).
3. In Southern Finland *G. abietina* causes dieback disease in pole-stage pine forests, as well as in older pine forests, after cool and rainy growing seasons (Kurkela 1981). In Northern Finland this disease is rare.

In 1982, there was a very bad epidemic in Finland, and all types of damage caused by G. *abietina* were common.

G. *abietina* has also caused damage in *Pinus contorta* Loud. plantations (Kujala 1950). In addition, the fungus has been isolated from *Picea abies* Karst., *Pinus mugo* Turra, *P. cembra* L., *Pseudotsuga menziesii* Mirb. and *Larix* sp.. The wide host distribution and the different types of damage indicate that different physiological, morphological, and pathogenic races of *G. abietina* may exist in Finland. The occurence of a perfect state supports the possibility of a greater genetic variation. In Northern Finland *G. abietina* produces quantities of apothecia on the bark of young pine stems (Kujala 1950). Kujala (1950) found no pycnidia in Northern Finland; but in 1982 pycnidia were common in dead shoots from the previous year. In Southern Finland the perfect state is common, but there are much more pycnidia than apothecia on pine shoots. The same differences in the symptoms of the disease have also been noticed in the USA and Canada (Dorworth 1971, Skilling 1977, 1981 and Setliff et al. 1975). Roll-Hansen and Roll-Hansen (1973a) have described the distribution of the perfect state in Norway and in Great Britain. They suggested that climatic factors determine the presence of the perfect state.

Dorworth and Krywienzyk (1975) divided *G. abietina* into three races on the basis of serological tests and symptoms of disease. There are two races of *G. abietina* in North America (Skilling 1981a). The "European" race is more virulent than the "North American" race (Skilling 1977).

In Switzerland *G. abietina* has two kinds of conidia. Normal four-celled conidia were found in the lower regions of the country, and 4—8 -celled conidia were found in the upper regions (Bazzigher 1971 and Ettlinger 1945.) In Austria 4—8 -celled conidia are produced on *Pinus cembra*, and normal 4-celled conidia are produced on other pines (Donaubauer 1974).

Further studies as to the reasons for morphological variation should be made. Morphological variation could indicate pathogenic variation. The theory of three continentally disjuncted races (Dorworth and Krywienzyk 1975) needs more data to be considered reliable. The physiological and pathogenic variations have not yet been described in detail, even though knowledge of these variations is important to the understanding and control of disease. The aim of this study was to investigate whether there are physiological and morphological differences among *G. abietina* isolates in Finland.

2. MATERIAL AND METHODS

The study was carried out in two parts: During 1981, mycelial growth and conidial production of ten *G. abietina* isolates were studied on petri dishes. During 1982, mycelial growth and conidial production of 14 new isolates of *G. abietina* were studied on an artificial medium; and the septation of conidia was studied from dried herbarium specimens and from fresh samples collected during the epidemic of 1982. The fungus was isolated from the samples by culturing mycelia, conidia, or ascospores. In Table 1 is the list of isolates used in growth experiments.

21. Inoculation on plates

In the 1981 experiments, the plates were kept for 35 days at five temperatures: 0, 5, 10, 15, and 20 °C. In 1982, only three temperatures were used: 0, 15 and 25 °C. *G. abietina* isolates were inoculated by cork borer from a spreading cultivation (Kurkela and Norokorpi 1979) into five (1981) or six (1982) 90 mm petri dishes for each temperature, using the procedure described by Dorworth and Krywienzyk (1975). The medium was composed of 1 % malt agar plus pine needle extract (Kurkela 1979). Other media were also tested: Hagem agar, Hagem agar + soluble sugars (arabinose, galactose, xylose, and mannose), Hagem agar + pine needle extract + soluble sugars. In 1981, the pine needle extract was sterilized by Millipore filter (0.22 μm), but in 1982, it was autoclaved. The autoclavisation didn't decrease the positive influence of pine needle extract to the fungus growth.

In addition, the growth of cultures isolated from Multia damage area was studied to discover if there was variation within the damage area.

The plates were kept in the dark. The colony

Table 1. The isolates used in growth experiments.
Taulukko 1. Kasvatuskokeissa käytetyt isolaatit.

Nr. Isolate *No. Isolaatti*	Coordinates *Koordinaatit*	Year of Isolation *Eristysvuosi*	Host *Isäntä*	Development Class *Kehitysluokka*
1. Parkano	690,28	1981	*P. sylv.*	Sapling stand
2. Helsinki	667,38	1977	*P. mugo*	
3. Juupajoki	686,35	1981	*P. sylv.*	Pole stage
4. Joutseno	677,58	1979	*P. sylv.*	Nursery
5. Kuru	687,32	1981	*P. sylv.*	Pole stage
6. Kolari	747,36	1977	*P. sylv.*	
7. Korpilahti	688,42	1977	*P. sylv.*	
8. Lieksa	702,65		*P. sylv.*	
9. Puolanka	719,53	1979	*P. sylv.*	
10. Virolahti	671,54		*P. sylv.*	
11. Multia	692,39	1981	*P. sylv.*	Pole stage
12. Sodankylä	752,45	1981	*P. sylv.*	Sapling stand
13. Rovaniemi mlk	735,48	1982	*P. sylv.*	Sapling stand
14. Rovaniemi mlk	737,43	1982	*P. sylv.*	Nursery
15. Kuusamo	733,60	1982	*P. sylv.*	Sapling stand
16. Sodankylä	752,48	1982	*Larix* sp.	Sapling stand
17. Siilinjärvi	699,70	1982	*P. sylv.*	
18. Ilomantsi	695,70	1982	*P. contorta*	Sapling stand
19. Suonenjoki	695,50	1982	*P. sylv.*	Pole stage
20. Längelmäki	684,37	1982	*P. sylv.*	Pole stage
21. Orivesi	685,35	1982	*P. sylv.*	Pole stage
22. Juupajoki	686,35	1982	*P. sylv.*	Pole stage
23. Korpilahti	688,42	1982	*P. sylv.*	
24. Kuru	687,32	1982	*Picea abies*	Pole stage
25. EAFV[1)]	M 1000	1981	*P. mugo*	
26. EAFV	M 1003	1981	*P. mugo*	

The coordinates are uniform coordinates used in Finland. The first coordinate is south-north coordinate and the second is west-east coordinate.

[1)] EAFV = Eidgenössische Anstalt für das gesamte Forstwesen (Zürich).

diameters were measured after 7, 14, 21, 28 and 35 days. The diameters after a growth of 35 days were compared using a two-way analysis of variance. LSD (least significant difference) was counted from the results of 15 °C.

22. Conidia production and measuring

Light was provided as described by Dorworth and Krywienzyk (1975) to encourage conidial production. After two months the plates were examined, and microscopic slide preparations were made by breaking pycnidia to release conidia. Fifty randomly selected conidia from each isolate were measured. The same number of conidia from the pycnidia taken from nature was also measured, and their septation counted. We examined 69 specimens; most of which are now kept in the HFR herbarium.

3. RESULTS

31. Influence of medium

On pure malt or Hagem agars, *G. abietina* soon stops growing without reaching the edge of the plate; but if pine needle extract is added to the medium, the fungus keeps on growing, producing a regular, round, fluffy colony. The compounds in the pine needle extract which cause the increment are not known. There are also differences between isolates in the way they react to the medium. Isolate 5 grew faster than Isolate 6 on malt agar and pine needle extract, but slower than Isolate 6 on Hagem agar plus pine needle extract and soluble sugars. The soluble sugars alone have no effect on growth (Table 2). On Hagem agar and pine needle extract, *G. abietina* produced larger pycnidia than on malt agar plus pine needle extract. The appearance of the colony depends decisively on the medium and illumination. The colonies of *G. abietina* are fluffier on 1 % malt extract agar containing pine needle extract than on Hagem agar containing pine needle extract.

Table 2. The average growth of Isolates 5 and 6 on different media.
Taulukko 2. Isolaattien 5 ja 6 keskikasvu eri ravintoalustoilla.

Medium *Ravintoalusta*	Colony diameter in mm. after 35 days. *Pesäkkeen halkaisija, mm, 35 vrk.*			
	Temperature — *Lämpötila* 5 °C		15 °C	
	5	6	5	6
Hagem agar	10.2	14.2	11.2	14.8
Hagem agar + soluble sugars + *liukoiset sokerit*	9.4	14.0	11.8	15.6
Hagem agar + needle extract + soluble sugars + *neulasuute* + *liukoiset sokerit*	16.4	21.0	23.8	30.4
Malt agar + needle extract *Mallasagar* + *neulasuute*	14.8	14.0	42.6	25.0

Influence of medium:
Ravintoalustan vaikutus: $F = 32.1^{***}$ df (3, 108)

Interaction between isolates and medium:
Isolaatin ja ravintoalustan yhteisvaikutus: $F = 9.7^{***}$ df (3, 108)

32. Mycelial growth on plates

G. abietina grew rather slowly: the diameter of the colony after 35 days varied from 24 to 51 mm at 15 °C (Table 3). In samples from the same diseased stand (Multia), the colony diameter varied between 36 to 48 mm in the five isolates.

There were statistically significant differences in mycelial growth between isolates. The interaction of isolates and temperatures was also statistically significant. Finnish *G. abietina* isolates may be roughly divided into two groups on the basis of mycelial growth: Group 1 (Race A) includes isolates 1, 3, 4, 5, 11, 20, 21, 22, 23, 24, 25 and 26. Group 2 (Race B) comprises isolates 2, 6, 9, 12, 13, 14, 15, 16 and 17. Purely on the basis of mycelial growth, it was difficult to classify the rest of the isolates (7, 8, 10, 18 and 19) as belonging to either of these groups. The grouping was grounded on the least signifi-

Table 3. The average colony diameters of isolates at temperatures of 0, 5, 10, 15, 20 and 25 °C after 35 days' growth. (1 % malt agar + pine needle extract).

Taulukko 3. Isolaattien pesäkkeiden halkaisijoiden keskiarvot 0, 5, 10, 15, 20 ja 25 °C lämpötilassa 35 vrk:n kasvatuksen jälkeen. (1 % mallasagar + neulasuute).

Isolate[1] *Isolaatti*	Colony diameter in mm after 35 days *Pesäkkeen halkaisija, mm, 35 vrk* Temperature °C — *Lämpötila °C* 0°C	5°C	10°C	15°C	20°C	25°C	Isolate[1] *Isolaatti*	Colony diameter in mm after 35 days *Pesäkkeen halkaisija, mm, 35 vrk* Temperature °C — *Lämpötila °C* 0°C	5°C	10°C	15°C	20°C	25°C
1.	10.5	15.2	39.4	45.2	48.2		14.	9.5			30.2		25.3
2.	10.0	13.2	26.6	31.4	34.0		15.	9.8			28.2		29.7
3.	7.8	14.2	35.2	40.2	45.4		16.	11.8			33.2		22.8
4.	11.2	17.4	32.8	40.0	49.0		17.	10.2			35.3		21.7
5.	9.4	14.8	31.6	42.6	47.6		18.	8.8			39.2		13.7
6.	10.6	14.0	21.6	25.0	27.8		19.	5.8			37.5		8.0
7.	9.8	17.6	36.3	38.0	28.8		20.	8.5			44.0		19.7
8.	10.4	15.0	38.2	34.2	43.2		21.	9.2			44.7		9.8
9.	7.6	14.2	26.8	35.0	30.8		22.	11.3			47.0		13.2
10.	6.6	12.8	31.7	32.8	40.4		23.	7.7			44.3		11.2
11.				42.3			24.	11.0			42.0		24.8
12.				32.0			25.	9.3			44.2		25.5
13.	10.3			32.0		27.5	26.	13.7			43.0		24.0

F-values: 1. Isolates 1—10
among isolates $F = 79.8^{***}$ (df 4, 200)
interaction $F = 22.8^{***}$ (df 9, 200)
LSD = 12.3 mm (at 15°C).

2. Isolates 13—26
among isolates $F = 22.2^{***}$ (df 13, 210)
interaction $F = 41.2^{***}$ (df 26, 210)
LSD = 6.5 mm (at 15 °C).

[1] Isolate numbers are defined in Section 2.

F-arvot: 1. Isolaatit 1–10:
Isolaattien välillä $F = 79.8^{***}$ *(v.a. 4, 200)*
Yhdysvaikutus $F = 22.8^{***}$ *(v.a. 9, 200)*
PME = 12.3 mm (15°C:ssa).

2. Isolaatit 13–26:
Isolaattien välinen $F = 22.2^{***}$ *(v.a. 13, 210)*
Yhdysvaikutus $F = 41.2^{***}$ *(v.a. 26, 210)*
PME = 6.5 mm (15°C:ssa).

[1] *Isolaattien numerot on määritelty kappaleessa 2.*

cant difference at 15 °C. The mean growth in Group 1 was 43.2 mm and in Group 2 it was 31.4 mm. The isolates of Group 2 come from Northern Finland, except isolate 2, and the isolates of Group 1 come from Southern Finland and Switzerland. Isolates 2, 6, 9 and 10 could have degenerated, since they had been preserved in storage tubes for 2 to 4 years.

The optimum temperature for the growth of isolates varied between 15—25 °C. The optimum temperature and the reaction to high temperature (25 °C) varied between isolates independent of racial variation.

33. Two types of conidia in Finland

Finnish *G. abietina* isolates produced conidia in light 2—4 months after inoculation. Two types of macroconidia exist: In Southern Finland conidia were usually 4-celled (Race A); and in Northern Finland conidia were usually 4—8 -celled (Race B) (Fig. 1 and 2). An isolate is classified as Race B (4—8 -celled type) if it has at least one 7-or 8-celled conidium in a sample of 50 conidia. Microconidia were also found in ten isolates. The septation of conidia seems to be genetically determined, because it was the same on both artificial medium and on shoots, with one exception (18) (Table 4). Our findings also suggested that there may be mainly only one type of conidia in the pycnidia of the same shoot or damage area. The distribution of septation varied between pycnidia in the same isolate. In this study, only qualitative differences in septation were examined.

The size of conidia varied between 14—56 X 3—4 μm (Table 4). Some isolates (15, 16, 18 and 23) produced deformed conidia on the artificial medium. The deformed conidia on petri dishes often had an expanded cell and were shorter than normal conidia.

Four to eight celled conidia (Race B) were found all over the country, but the 4-celled conidium type (Race A) has been found only twice in Northern Finland (Fig. 3).

Fig. 1. 4-celled conidia type, Race A (x 1200).
Kuva 1. 4-soluinen kuromatyyppi, rotu A (x 1200).

Fig. 2. 4—8 -celled conidia type, Race B (x 750).
Kuva 2. 4–8 -soluinen kuromatyyppi, rotu B (x 750).

4. DISCUSSION

On the basis of the mycelial growth and the septation of conidia, Finnish *G. abietina* isolates can be classified as two races according to the definition of Browder et al. (1980).

Race A is found mainly in Southern Finland and causes damage in the pole stage and in mature pine forests in Southern Finland. The conidia of Race A are almost all 4-celled. Race B is distributed all over Finland and has 4—8 -celled conidia. Race B causes damage mainly in pine sapling stands in Northern Finland. Both races kill pine seedlings in nurseries. It seems that the pathogen races are independent from host species. Hypothetical pathogenic differences were not examined.

The growth of colony diameter has been considered as a reliable method for the comparison of fungal growth (Brancato and Goldin 1953). Race A grew faster at 15 °C than Race B. According to Skilling (1981) the virulent "European" race grew faster at high temperatures than the "North American" race. When classifying fungal races based on the growth of a colony we must take into account the possible degeneration of, and virus or bacterial infections in, the mycelia. Hollings (1982) has described the effects of mycoviruses on plant pathogens. In this study, the possible role of mycoviruses was not investigated.

The medium and illumination determine the appearance of the colony on the plate.

For this reason, the appearance of the colonies in this test cannot be compared to those described earlier by Dorworth and Krywienzyk (1975). The growth rates in this study were in the middle range of those in the earlier study of Dorworth and Krywienzyk (1975). *G. abietina* in Finland is a facultative psychrofil.

The results on the size of the conidia agree well with those of earlier studies (Dorworth and Krywienzyk 1975, Ettlinger 1945 and Stephan 1978). Kujala (1950) states that the range of conidial length in Finland is between 29 and 46 µm, while in this study the range was from 14 to 56 µm. The degree of septation is related to the length of the conidia, that is, the longer the conidia, the greater the number of septa.

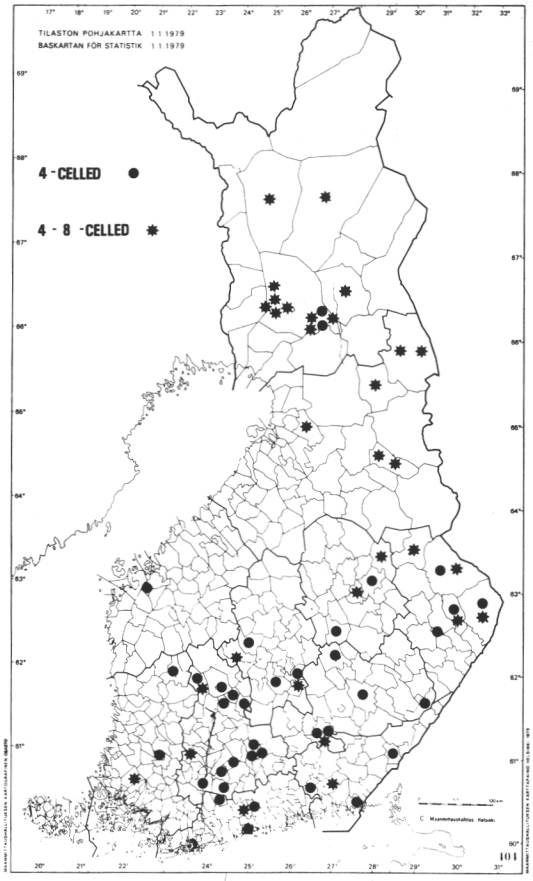

Fig. 3. The geographical distribution of 4-celled (Race A) and 4—8 -celled (Race B) conidium types.
Kuva 3. 4-soluisten (rotu A) ja 4–8 -soluisten (rotu B) kuromatyyppien maantieteellinen jakautuminen.

The "North American" race has generally 4-celled conidia and the "European" race in the USA has 4—8 -celled conidia (Dorworth and Krywienzyk 1975). Thus the conidia of Race A resemble the conidia of the "North American" race, but the presence of the perfect state and growth rates resemble those of the "European" race. The results of this study do not agree exactly with the theory of three continentally disjuncted races. Two isolates from Switzerland resembled Race B on the basis of conidial septation; but they resembled Race A in mycelial growth. The existence of intermediate races or races other than A and B is also possible. Skilling (1981) has described the development of an intermediate race in North America. The distinctions of races A

Table 4. The distribution of septation, mean length, and range of length of 50 conidia on shoots (a) and artificial medium (b.)
Taulukko 4. 50:n kuroman solumäärän jakauma, keskipituus ja pituuden vaihteluväli versoilla (a) ja keinoalustalla (b).

Isolate *Isolaatti* Nr/*No*	Distribution, cells in conidia *Jakauma, soluja kuromassa* 2	3	4	5	6	7	8	Mean length *Keskipituus* µm	Range of length *Vaihteluväli* µm
13 a	—	2	31	6	5	5	1	30.0	22—41
b	1	1	16	7	8	10	7	29.3	18—41
14 a	—	—	22	5	5	9	9	35.2	25—49
b	—	—	37	9	2	1	1	29.8	25—41
15 a	—	1	25	13	5	5	1	29.5	25—37
b	2	2	45	—	—	—	1	26.8	14—34
16 a	—	—	10	12	16	5	7	35.5	25—49
b	6	7	29	4	2	—	2	26.3	14—41
17 a	—	—	28	8	11	2	1	33.2	25—41
b	1	—	35	9	4	1	—	28.8	22—41
18 a	—	—	36	8	4	1	1	30.7	22—45
b	1	1	48	—	—	—	—	28.7	18—34
19 a	—	3	46	—	1	—	—	26.6	18—37
b	2	3	44	1	—	—	—	27.2	14—37
20 a	1	2	46	1	—	—	—	27.9	18—41
b	1	—	49	—	—	—	—	26.9	22—34
21 a	1	1	46	1	1	—	—	29.5	18—37
b	1	—	49	—	—	—	—	27.4	22—34
22 a	—	3	47	—	—	—	—	27.3	18—34
b	—	2	45	3	—	—	—	31.5	25—41
23 b	2	1	47	—	—	—	—	26.7	22—34
24 b	2	4	43	—	1	—	—	25.8	10—30
25 b	—	—	9	10	7	7	17	39.8	33—56
26 b	—	—	5	9	16	11	9	40.8	22—56

and B are not unambiguous, because there were so many intermediate isolates.

Only ten isolates of the total 69 were examined as to whether they produced the same type of conidia on artificial medium as on shoots. However, the septation of conidia is likely to be genetically determined.

The influence of climatic factors on the presence of the perfect state is still unclear (Roll-Hansen and Roll-Hansen 1973 a). Further knowledge of the distribution of the perfect state in relation to Races A and B is needed. More knowledge is also needed on the different types of damage caused by *G. abietina*, especially with respect to Races A and B. Race A could be a virulent strain in Finland similar to the "European" race in North America.

So far, it has not been possible to produce the sexual stages of *G. abietina* in the laboratory. This forms an obstacle for the investigation of interbreeding between different morphological and physiological races. An interesting question is the role of microconidia in the life cycle of *G. abietina;* nothing is known about it although Roll-Hansen and Roll-Hansen (1973 b) described them a decade ago.

REFERENCES

BAZZIGHER, G. 1971. Triebsterben an föhren und lärchen. Phytopathologie 63. 5 p.

BRANCATO, F. P. & GOLDIN, N. S. 1953. The diameter of the mold colony as a reliable measure of growth. Mycologia 45: 848—864.

BROWDER, L. E., LYON, F. L. & EVERSMAYER, M. G. 1980. Races, pathogenicity, phenotypes and type cultures of plant pathogens. Phytopathol. 70(7): 581—583.

DONAUBAUER, E. 1974. Über das Kieferntriebsterben in Österreich. (*Scleroderris lagerbergii* und *Cenangium ferruginosum* Fr.). 100 Jahre Forstliche Bundesversuchsanstalt. 67—98.

DORWORTH, C. E. 1971. Diseases of conifers incited by *Scleroderris lagerbergii* Gremmen; A review and analysis. Can. For. Service Publ.: 1289.

— & KRYWIENZYK, J. 1975. Comparisons among isolates of *Gremmeniella abietina* by means of growth rate, conidia measurement, and immunogenic reaction. Can. J. of Bot. 53(21): 2506—2525.

ETTLINGER, L. 1945. Über die Gattung Crumenula sensu Rehn mit besonderen Berücksichtigung des Crumenula — Triebsterben der Pinus — Artens. Beitr. Kryptogamenfl. Schweiz 10: 1—73.

HOLLINGS, M. 1982. Mycoviruses and plant pathology. Plant Disease 66(12): 1106—1112.

KUJALA. V. 1950. Über die Kleinpilze der Koniferen in Finnland. Seloste: Havupuiden pikkusienistä Suomessa. Commun. Inst. For. Fenn. 38(4). 121 p.

KURKELA, T. 1979. *Lophodermium seditiosum* Minter et. al. sienen esiintyminen männynkaristeen yhteydessä. Abstract: Association of *Lophodermium seditiosum* Minter et. al. with a needle cast epidemic on Scots pine. Folia For. 393. 11 p.

— 1981. Versosyöpä. *(Gremmeniella abietina)* riukuasteen männiköissä. Abstract: Canker and dieback of Scots pine at precommercial stage caused by *G. abietina.* Folia For. 485. 12 p.

— & NOROKORPI, Y. 1979. Pathogenicity of *Scleroderris lagerbergii, Lachnellula pini,* and *L. flavovirens* and their cankers on Scots pine. Commun. Inst. For. Fenn. 97(1). 15 p. Seloste: *Scleroderris lagerbergii, Lachnellula pini* ja *L. Flavovirens* -sienten patogeenisuus sekä niiden aiheuttamat korot männyn taimissa.

ROLL-HANSEN, F. & ROLL-HANSEN, R. 1973a. *Scleroderris lagerbergii* in Norway. Hosts, distribution, perfect and imperfect state, and mode of attack. Medd. Nor. Skogsforsöksves. 30: 443—459.

— & ROLL-HANSEN, H. 1973b. Microconidia formed by *Scleroderris lagerbergii.* 2nd Int. Congr. Pl. Path. at University of Minnesota. Mimeograph. 2 p.

SETLIFF, E. C., SULLIVAN, J. A. & THOMPSON, J. H. 1975. *Scleroderris lagerbergii* in large Red and Scots pine trees in New York. Plant Dis. Rep. 59: 380—381.

SKILLING, D. D. 1977. The development of a more virulent strain of *Scleroderris lagerbergii* in New York State. Eur. J. of For. Pathol. 7: 297—302.

— 1981a. Scleroderris canker — The situation in 1980. J. For. 79: 95—97.

— 1981b. The development of an intermediate strain of *Gremmeniella abietina* in New York. Phytopathology 71: 225.

STEPHAN, B. R. 1978. Beobachtungen über das Vorkommen und die Variation von *Scleroderris lagerbergii* Gremmen in Norddeutschland. Zeitschrift Mykologi 45(1): 45—53.

Total of 19 references

SELOSTE

Suomalaisten *Gremmeniella abietina* -isolaattien fysiologisesta ja morfologisesta vaihtelusta.

Gremmeniella abietina -sieni aiheuttaa tuhoja kaikenikäisissä männiköissä. Sieni on eristetty myös kuuselta, kontortamännyltä, vuorimännyltä, douglaskuuselta ja lehtikuusilta. *G. abietina* -sienen kotelomaljoja (suvullinen aste) muodostuu runsaammin Pohjois-Suomen 0,5—2,0 m pituisissa taimikoissa kuin Etelä-Suomen riukuvaiheen männiköissä. Suvuttomia kuromaitiöitä muodostuu runsaammin Etelä-Suomessa kuin Pohjois-Suomessa. Laaja isäntävalikoima, tuhot eri ikäisissä metsiköissä ja erot suvullisten ja suvuttomien itiöiden muodostumisessa viittaavat rodulliseen vaihteluun *G. abietina* -sienikantojen välillä Suomessa.

Pohjoisamerikkalaisen teorian mukaan *G. abietina* -sieni jakautuu kolmeen maantieteelliseen rotuun: itä-aasialaiseen, eurooppalaiseen ja pohjoisamerikkalaiseen, joista eurooppalainen rotu on Pohjois-Amerikassa virulenttisin. Teoria vaatii vielä täsmennyksiä ollakseen luotettava. Keski-Euroopassa sienellä on havaittu morfologisia eroja siten, että Alpeilla sieni muodostaa 4—8 -soluisia kuromia ja alavilla mailla 4-soluisia. Tässä tutkimuksessa selvitettiin *G. abietina* -sienen fysiologista ja morfologista vaihtelua. Ne saattavat ilmentää patogeenista vaihtelua.

Vuoden 1981 aikana tutkittiin 10 suomalaisen isolaatin rihmaston kasvua viidessä eri lämpötilassa ja kuromien muodostumista mallasagarilla, johon oli lisätty männynneulasuutetta. Ravintoalustakoe selvitti liukoisten sokereiden ja neulasuutteen vaikutusta rihmaston kasvuun mallas- ja hagemagareilla. Vuoden 1982 aikana tutkittiin 16 isolaatin rihmaston kasvua kolmessa eri lämpötilassa. Kuromien muodostusta varten maljoja pidettiin valossa ja 15 °C:n lämpötilassa 2—4 kk. Kuromien kokoa ja solujen lukumäärää tutkittiin myös tuhonäytteistä.

Ravintoalusta ja valaistus vaikuttivat pesäkkeen ulkonäköön petrimaljalla. Liukoiset sokerit eivät vaikuttaneet sienen kasvuun, kun taas männynneulasuute oli edellytys kasvulle (taulukko 2). *G. abietina* -sieni kasvaa maljalla hitaasti: 5 viikon kasvatuksen jälkeen pesäkkeen halkaisija vaihteli välillä 24—51 mm. Isolaattien optimilämpötila oli 15—25 °C, mutta kaikki isolaatit kasvoivat myös 0 °C:ssa (taulukko 3). Isolaattien välillä oli kasvunopeudessa tilastollisesti merkittäviä eroja, joiden perusteella ne voidaan jakaa kahteen ryhmään. Joitain isolaatteja ei voitu sijoittaa kumpaankaan ryhmään.

Kuromaitiöiden solujen lukumäärässä havaittiin eroja isolaattien välillä. Pohjois-Suomessa kuromat ovat yleensä 4—8 -soluisia, kun ne Etelä-Suomessa ovat useimmiten 4-soluisia. Etelä-Suomessa esiintyy melko yleisesti myös 4—8 -solun tyyppiä, kun taas Pohjois-Suomesta 4 solun tyyppiä löydettiin vain kahdesti (kuva 3). Kuromien pituus vaihteli välillä 14—56 μm. Kuromien pituuden vaihtelu johtui lähinnä solujen lukumäärästä. Noin kymmeneltä isolaatilta löydettiin mikrokonidioita. Kuromien solujen lukumäärä on ilmeisesti geneettisesti määräytynyttä, koska 4—8 -soluiset isolaatit muodostavat myös laboratoriossa 4—8 -soluisia kuromia (taulukko 4).

Rihmaston kasvun ja kuromien solujen lukumäärän perusteella *G. abietina* -sieni jakaantuu kahteen morfologiseen tai fysiologiseen rotuun (A ja B). Rotujen välillä ei kuitenkaan ole selvää rajaa ja muitakin rotuja kuin A ja B saattaa olla. Rotu A:n kuromat ovat 4-soluisia ja sen rihmasto kasvaa nopeammin kuin rotu B:n, jonka kuromat ovat 4—8 -soluisia (kuvat 1 ja 2). Patogeenisuuseroja ei tutkittu.

Kanadalaisten ja amerikkalaisten tutkimusten mukainen eurooppalainen rotu USA:ssa kasvaa nopeasti ravintoalustalla muodostaa 4—8 -soluisia kuromia, kun taas kanadalainen rotu kasvaa hitaammin ja muodostaa 4-soluisia kuromia. Tämän tutkimuksen tulokset eivät siis ole identtisiä sen teorian kanssa, missä *G. abietina* -sieni jaetaan kolmeen maantieteelliseen rotuun.

Kotelomaljojen esiintymisestä sekä rotujen A ja B patogeenisuudesta tarvitaan lisätietoja. Mikrokonidioiden merkitys *G. abietina* -sienen elämänkierrossa on myös selvittämättä.

UOTILA, A. 1983. Physiological and morphological variation among Finnish *Gremmeniella abietina* isolates. Seloste: Suomalaisten *Gremmeniella abietina* -isolaattien fysiologisesta ja morfologisesta vaihtelusta. Commun. Inst. for. Fenn. 119:1—12.

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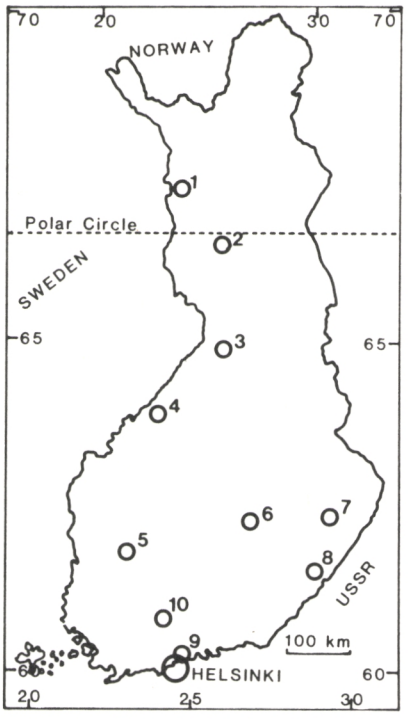

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FACTS ABOUT FINLAND

Total land area: 304 642 km^2 of which 60—70 per cent is forest land.

Mean temperature, °C:	Helsinki	Joensuu	Rovaniemi
January	-6,8	-10,2	-11,0
July	17,1	17,1	15,3
annual	4,4	2,9	0,8
Thermal winter (mean temp. < 0°C):	20.11.—4.4.	5.11.—10.4.	18.10.—21.4.

Most common tree species: Pinus sylvestris, Picea abies, Betula pendula, Betula pubescens

Communicationes Instituti Forestalis Fenniae

115 Annila, E., Heliövaara, K., Puukko, K. & Rousi, M. Pests on lodgepole pine (*Pinus contorta)* in Finland. Seloste: Kontortamännyn tuhot Suomessa.

116 Kolari, K.K. (Ed.) Growth disturbances of forest trees. Proceedings of international workshop and excursion held in Jyväskylä and Kivisuo, Finland, 10.—13. October, 1982. Seloste: Metsäpuiden kasvuhäiriöt. Jyväskylässä ja Kivisuolla 10.—13. lokakuuta, 1982, pidetyn kansainvälisen symposiumin esitelmäraportit.

117 Sievänen, R. Growth model for mini-rotation plantations. Seloste: Lyhytkiertoviljelmän kasvumalli.

118 Saarenmaa, H. Modeling the spatial pattern and intraspecific competition in *Tomicus piniperda* (Coleoptera, Scolytidae). Seloste: Pystynävertäjän tilajärjestystä ja lajinsisäistä kilpailua kuvaavia malleja.

119 Uotila, A. Physiological and morphological variation among Finnish *Gremmeniella abietina* isolates. Seloste: Suomalaisten *Gremmeniella abietina* -isolaattien fysiologisesta ja morfologisesta vaihtelusta.

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