Fir forest in Greece. Year book Agric. For. Univ. Thessaloniki, pp. 1—89 (1956). — BOTTEMA, S.: Late-Quaternary vegetation history of northwestern Greece. Proefschrift Univ. Groningen. 190 pp. (1974). — CONOVER, W. J.: Practical nonparametric statistics. Willey, New York. 462 p. (1971). — FRANKLIN, E. C. and SNYDER, E. B.: Variation and inheritance of monoterpene composition in longleaf pine. For. Sci. 17: 178—179 (1971). — GRÜGER, E.: Pollenanalytische Untersuchung zur würmzeitlichen Vegetationsgeschichte von Kalabrien (Süditalien). Flora 166: 475—489 (1977). — HANOVER, J. W.: Environmental variation in the monoterpenes of *Pinus monticola* DOUGL. Phytochemistry 5: 713—717 (1966a). — HANOVER, J. W.: Genetics of terpenes. I. Gene control of monoterpene levels in *Pinus monticola* DOUGL. Heredity 21: 73—84 (1966b). — HANOVER, J. W.: Inheritance of 3-carene concentration in *Pinus monticola*. For. Sci. 12: 447—450 (1966c). — HANOVER, J. W.: Genetic variances and interrelationships of monoterpene concentration in *Pinus monticola* DOUGL. Heredity 27: 237—245 (1971). — HILTON, R. L.: Genetic variation and interrelationship of the cortical monoterpenes, foliar mineral elements, and growth characteristics of eastern white pine. Ph. D. Diss., Mich. State Univ., 127 pp. (1968). — HILTUNEN, R.: Variation and inheritance of some monoterpenes in *Pinus sylvestris*. Planta Medica 3: 315—323 (1975). — HOTTELING, H.: Multivariate analysis. In: Statistics and mathematics in biology. Iowa State Coll. Press, Ames. Iowa. pp. 67—80 (1954). — HUGHES, R. and LANDLEY, D.: Application of biometric methods to problems of classification in ecology. Nature 175: 806—807 (1955). — KRAL, F.: Spät- und postglaziale Waldgeschichte der Alpen auf Grund der bisherigen Pollenanalysen. Öster. Agrarverlag, Wien. 175 pp. (1979). — LEE, J. and KALTSIKES, P.: The application MAHALANOBIS's generalized distance to measure genetic devergence in durum wheat. Euphytica 22: 124—131 (1973). — LIU, TANG-SCHUI.: A monograph of the genus *Abies*. Dept. For., Coll. Agric., Nat. Taiwan Univ., Taipei, Taiwan, China. 608 p. (1971). — MARINOS, G. und SAKELARIOU-MANE, H.: Über das Alter der letzten Senkungen des Ionischen Meeres. Entdecken prähistorischer Schicht der Steinzeit in NW-Korfou. Mitteilungen der griechischen geologischen Gemeinschaft, Athen. Bd. 6: 15—24 (1964). — MATTFELD, J.: Über hybridogene Sippen der Tannen, nachgewiesen an den Formen der Balkan Halbinsel. Stuttgart. 84 pp. (1930). — MAYER, H.: Mediterran-montane Tannen-Arten und ihre Bedeutung für Anbauversuche in Mitteleuropa. In: 3. Tannen-Symposium, Wien: pp. 30—54 (1980). — MAYER, H.: Wälder Europas. Gustav Fischer Verlag, Stuttgart (1984). — MAYR, E.: Animal Species and Evolution. Belknap Press of Harvard Univ. Press, Cambridge, Mass. 797 p. (1963). — NAMKOONG, G.: Comparative analyses of introgression in two pine species North Carolina State Coll. Ph. D. thesis. 76 pp. (1963). — PANAGIOTIDIS, N. D.: Tannenplenterwälder in Griechenland. Forstwissenschaftliche Forschungen, Heft 21: 1—97 (1965). — PANETSOS, K. P.: Monograph of *Abies cephalonica* Loudon. Jugosl. Acad. Sci., Ann. For. VII: 1—22 (1975). — PANETSOS,, K.P.: Cone and Seed Characters of Greek Fir (*Abies cephalonica* LOUNDON). Dassons 73: 17—23 (1976). — PHILIPPSON, A.: Die griechischen Landschaften. Frankfurt. 2 pp. (1958). — RAO, C. R.: The utilization of multiple measurements in problems of biological classification. J. Roy. Stat. Soc., Ser. B. 10: 159—193 (1948). — RAO, C. R.: Advanced statistical methods in biometric research. Willey, N. Y. 930 pp. (1952). — ROCKWOOD, D. L.: Variation in the monoterpene composition of two oleoresin systems of loblolly pine. For. Sci. 19: 147—153 (1973). — SHAW, D. V. and ALLARD, R. W.: Methods for analysing data on the relative proportions of monoterpenes in conifers. Silva Fennica 16: 115—121 (1982). — SQUILLACE, A. E.: Geographic variation in slash pine. For. Sci. Mono. 10, 56 p. (1966). — SQUILLACE, A. E. and FISHER, G. S.: Evidences of the inheritance of turpentin composition in slash pine. In: Joint Proc. 2nd Genetic Workshop, Soc. Amer. Foresters and 7th Lake States Forest Tree Improve. Conf. 1965. North Central Forest Exp. Sta., USDA For. Serv. Res. Pap. NC-6, pp. 53—60 (1966). — SQUILLACE, A. E.: Inheritance of monoterpene composition in cortical oleoresin of slash pine. For. Sci. 17: 381—387 (1971). — SQUILLACE, A. E.: Analyses of monoterpenes of conifers by gas-lipuid chromatography. In: MIKSCHE, J. P., ed. Modern methods in forest genetics. Springer Verlag, N. Y. pp. 120—157. (1976). — STAIRS, G.: Monoterpene composition in Larix. Silvae Genet. 17: 182—186 (1986). — STEBBINS, G. L.: Variation and Evolution in Plants. Columbia Univ. Press. N. Y. 643 pp. (1950). — STEEL, R. and TORRIE, J.: Principles and procedures in statistics. A biometrical approach. McGraw-Hill, N. Y. (1980). — ZAVARIN, E.: Chemotaxonomy of genus *Abies*-II. Within tree variation of the terpenes in cortical oleoresin. Phytochemistry 7: 92—107 (1968). — ZOLLER, H.: Die wärmezeitliche Verbreitung von Haselstrauch, Eichenmischwald, Fichte und Weißtanne in den Alpenländern. Bauhinia (Z. d. Baster Bot. Ges.) 1/3: 189—207 (1960).

Scots Pine Resistance to Pine Twist Rust-Conformity between the resistance found in an artificial environment and field trials

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(Received 7th February 1986)

Abstract

The resistance to pine twist rust *(Melampsora pinitorqua)* was tested in progenies from 4 different Scots pine seed orchards. The progenies were tested as 2-year-old seedlings with artificial inoculation in greenhouses and in forest habitats as 8-11-year-old saplings. The genetic influence on the resistance was identified in the artificial environment as well as in the forest habitat. A correlation between the two tests was found.

Key words: Scots pine, progeny test, pine twist rust, field resistance, artificial inoculation.

Zusammenfassung

Die Widerstandsfähigkeit gegen Kieferndrehrost *(Melampsora pinitorqua)* wurde in den Nachkommenschaften von 4 verschiedenen Kiefernsamenplantagen untersucht. Die Nachkommenschaften wurden als zweijährige Samenpflanzen nach künstlicher Inokulation in Gewächshäusern und in Waldbeständen als acht- bis elfjährige Pflanzen geprüft. Der genetische Einfluß auf die Widerstandsfähigkeit war sowohl in den Gewächshäusern als auch in den Waldbeständen erkennbar. Es bestand eine Übereinstimmung zwischen den beiden Prüfungen.

Introduction

The pathogenic fungi of Scandinavian forests are natural parts of their ecosystems. The natural coevolution of the trees and their pathogens has resulted in a relatively stable ecologic balance. Epidemic outbreaks of pathogens have been of a relatively small economic impact so far. Tree breeding for maximum growth may limit the genetic variation in other respects. In this situation it is important to maintain the ecologic balance already existing between the trees and their pathogens. Therefore breeding pest resistant trees should be an integrated part of the general tree breeding programme.

Breeding trees for resistance to important diseases has been performed in several countries around the world. The most well-known and progressive works were perhaps performed in the United States in breeding for resistance to blister rust (*Cronartium ribicola* FISCHER ex RABENH.), in white pines (*Pinus monticola* DOUGL. and *Pinus strobus* L.) and for resistance to fusiform rust (*Cronartium fusiforme* HEDGE & HUNT ex CUMM.) in yellow pines (*Pinus elliottii* ENGELM. and *Pinus taeda* L.) (BINGHAM *et al.* 1960, HOFF *et al.* 1973, ZOBEL 1982).

In the early 1970s a programme was initiated in Sweden for screening progenies of Scots pine (*Pinus sylvestris* L.) for resistance to important pathogens within Swedish forestry (BJÖRKMAN 1972). One of the diseases included in this programme was pine twist rust caused by *Melampsora pinitorqua* (BRAUN) ROSTR.

This work was managed as a part of the general tree breeding programme and the material tested was full-sib groups produced in Swedish pine seed orchards. The screening was performed in special research nurseries with artificial inoculation inside plastic green-houses. A large number of Scots pine progenies went through the *Melampsora*-test-nurseries in the 1970 ies (MARTINSSON 1975, 1976, 1980).

Contemporarily to these pathological tests, field trials were established with seedlings from the same seed sources for investigation of height growth and ecologic adaptation. Some of these experimental plots were later on heavily attacked by pine twist rust. The resistance to the disease of these seed sources could therefore be investigated under two different environmental conditions and at two different age classes.

The objectives of this study were:

1. To asses the field resistance to pine twist rust of Scots pine progenies attacked under natural conditions in field trials, using different scales for assessments and
2. To compare these results with those achieved from seedlings of the same seed sources attacked after artificial inoculation in green-houses.

Table 2. — Definition of degree of attack and damage index.

Definition of damage	Degree of attack	Damage index
Tree free from attack	0	0
Tree with isolated minor injuries though not on the leader	1	0
Tree with several minor injuries on the lateral shoots of minor damage on the leader	2	10
Tree with major damage on the lateral shoot and/or major damage on the leader	3	50

Material and Methods

Progenies from 4 different Scots pine seed orchards were investigated. These orchards were L 55 Harastorp, E 468 Tjuttorp, Y 411 Domsjöänget and AC 10—11 Öst-Teg. The progenies from 3 of the 4 seed orchards were exposed to the pathogen in field plots as 8—11 year old saplings as well as in green-houses as 2 year old seedlings. The progenies from the 4th seed orchard, AC 10—11 Öst-Teg, were investigated in one site only, as 7 year old saplings growing in a nursery. Experimental sites, size and age of experimental material and experimental design are shown in *Table 1.*

The tests of the seedlings were performed in 1973 and 1974 and some of these trials have been reported earlier on MARTINSSON 1975, 1976). The seedlings were artificially exposed to the pathogen at a sensitive stage of the annual development by spreading leaves of aspen (*Populus tremula* L.). Aspen is the alternate host of the pathogen. These leaves produced basidiospores of *Melampsora pinitorqua.*

Table 1. — Size of experimental material, experimental design and location of experimental sites.

	Progenies from seed orchard: L 55 Harastorp	E 468 Tjuttorp	Y 411 Domsjöänget	AC 10-11 Öst-Teg
Number of full-sib groups	93	85	215	145
Number of plus-trees acting as parents to the tested seedlings	28	25	50	37
Location of green-house (nursery) test and age of exp. material, years	Ådalen nursery, Stockholm 2	Ådalen nursery, Stockholm 2	Johannisfors nursery, Umeå 2	Johannisfors nursery, Umeå 7
Experimental design of green-house (nursery) test	randomized 5-seedling-plots 8 replications in green-house	randomized 1-seedling-plots 25 replications in green-house	randomized 1-seedling plots 25 replications in green-house	randomized 5-seedling plots 10 replications out of doors in nursery
Location of field experiment and age of exp. material, years	Tönnersjö, County of Halland 8	Våmhus, County of Kopparberg 11	Lagfors, County of Västernorrland 11	- -
Experimental design of field experiment	randomized 1-tree-plots 40 replications	randomized 1-tree-plots 40 replications	randomized 1-tree-plots 40 replications	-

The inoculations were done inside plastic green-houses, where the environmental conditions, i.e. temperature and humidity, were kept close to the optimal level for basidiospore release and germination. The damage of the rust attack was assessed 3 weeks after infection according to a 6 degree scale, where degree 0 corresponded to a seedling free from attack and degree 5 to an attack in which the leader of the seedling was completely destroyed by the pathogen (Martinsson 1975).

The field plots were spontaneously attacked by pine twist rust in 1980 and 1981. In these years many young Scots pine stand were attacked all over Sweden. The field plots investigated were selected as being heavily and evenly hit by the disease. The attack was assessed according to degree of attack in *Table 2.*

The progenies originating from seed orchard AC 10—11 (*Table 1*) were tested for rust resistance at age 7 years in a nursery where the seedlings were planted in a mixture with seedlings of aspen. The mixture of 1 aspen to 4 Scots pines produced a heavy source of inoculum and a strong rust attack on the Scots pines.

The mean degree of attack for full-sib and half-sib groups was calculated on the basis of the single tree scores. The data from the green-house experiments, the field plots and the nursery plots were processed in a similar way. In a separate investigation the long term impacts on the seedlings from different degrees of attack were examined (Martinsson 1985). This investigation showed that damage index, according to *Table 2,* reflected the disease influence on the future development of the attacked tree better than did the degree of attack. Therefore the degree of attack registered in one of the sub-materials, AC 10—11, was converted into damage index.

Results

Each plus-tree progeny consisted of several full-sib groups forming one half-sib group. With one exception, (*Figure 8*), the results are presented only as means of half-sib groups. In *Figures 1—4* the mean degree of attack of half-sib groups are arranged in ascending order. The half-sib groups were progenies from plus-trees which upon the controlled crossings were used as either pollen donators (i.e. fathers) or pollen receptors (i.e. mothers). The results are presented separately as progenies from either fathers or mothers. The horizontal bars in *Figures 1—4* bracket mean degree of attack of half-sib groups which in the field or nursery trials were not significantly different at the 5% level (Scheffe's test in SPSS 1980). The mean damage index and the mean degree of attack of progenies from AC 10—11 are illustrated concurrently in *Figure 4.*

The rank order correlation between the mean degree of attack found in the field trials and the green-house experiments were calculated according to Spearman (in SPSS 1980) and illustrated in *Figures 5—7.* This correlation is significant at the 1% level in the material from 2 of the 3 seed orchards where this correlation could be calculated.

A large variation was found between full-sib groups within some of the half-sib groups. Examples found in the field trial of progenies from seed orchard L 55 are illustrated in *Figure 8.*

Discussion

Ranking trees with regard to genetically dependent disease resistance is a difficult task. The value of the resistance achieved can be influenced by many factors, such as age of the host, nutrient status, water capacity, potential of inoculum, weather conditions of the season when the disease develops, latitude and other environmental conditions of the experimental sites, instructions for damage assessment, subjective bias of assessing personal.

Most of the progenies were tested for resistance both in one artificial environment and in one natural environment. The artificial environments were green-houses in which the experimental material was placed from the time of the basidiospore release to the early development of the acial stage. The environmental factors in the green-houses were controlled but only to a limited extent. The environment of the field trials were natural forest habitats without any artificial control.

Testing genetically dependent disease resistance under completely controlled conditions is associated with certain problems. The environmental and genetical conditions have to be defined in such a way that adequate results are achieved. The host's physiological state and predisposition for infection will influence the results. Environmental fac-

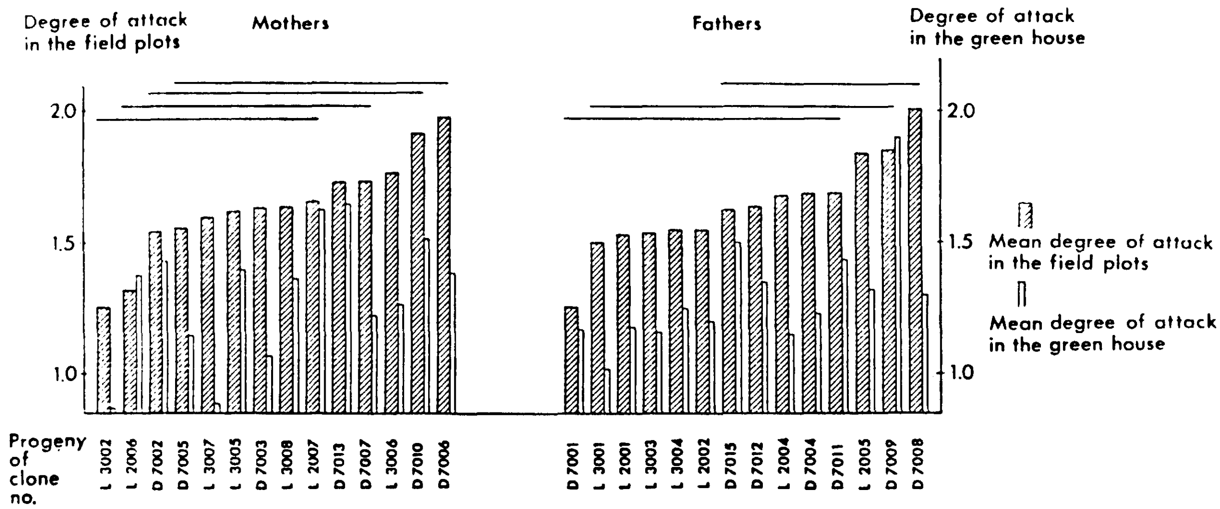

Figure 1. — Resistance of progenies from 28 plus-trees of seed orchard L 55 Harastorp tested in a green-house of Adalen nursery as 2 year old seedlings and in a field trial at Tönnersjö as 8 year old saplings. Horizontal bars bracket those progenies which were not significantly different from each other at the 5% level in the field trial.

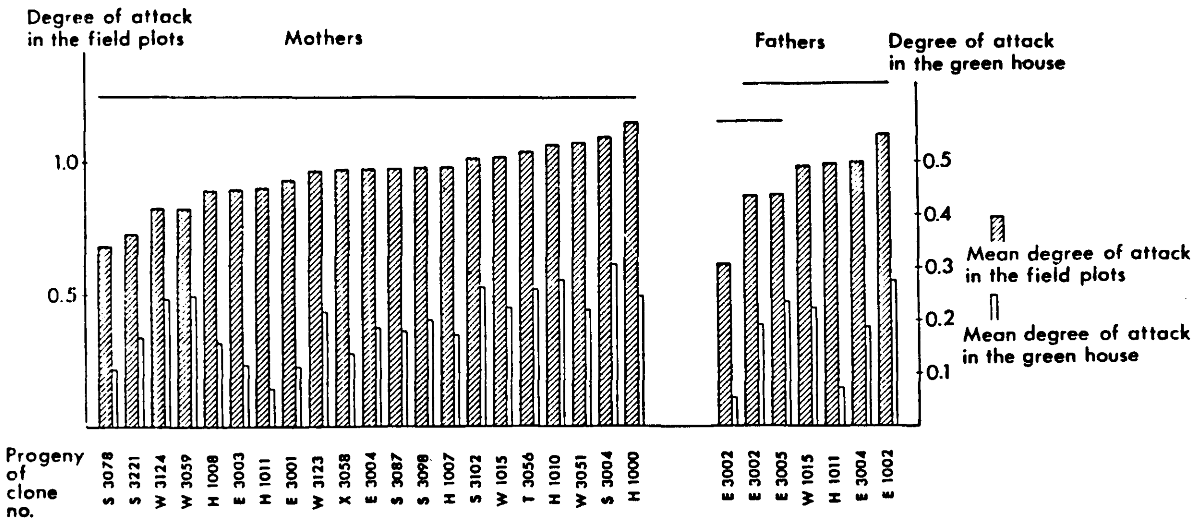

Figure 2. — Resistance of progenies from 25 plus-trees of seed orchard E 468 Tjuttorp tested in a green-house of Ådalen nursery as 2 year old seedlings and in a field trial at Våmhus as 11 year old saplings. Horizontal bars bracket those progenies which were not significantly different from each other at the 5% level in the field trial.

tors like light, temperature and humidity should also be considered (Gäumann 1951, Van der Plank 1963). Futhermore, the genetical mechanisms of the host's resistance to the disease and the pathogen's virulence as well as the concept of breeding for vertical vs horizontal resistance may come into consideration (Kinloch 1982).

The disease resistance which could be observed and assessed in a natural forest environment on saplings or young

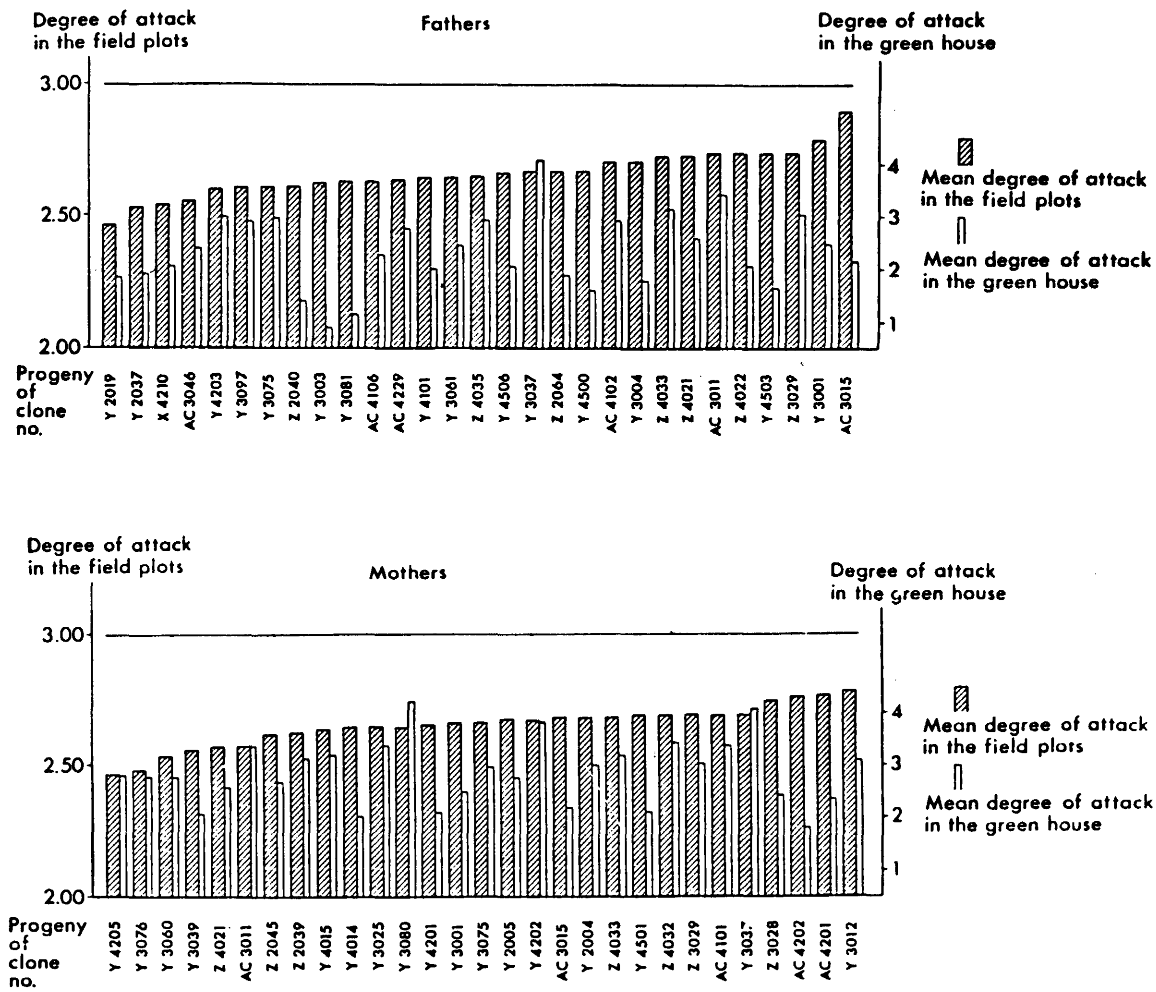

Figure 3. — Resistance of progenies from 50 plus-trees of seed orchard Y 411 Domsjöänget II tested in a green-house of Johannisfors nursery as 2 year old seedlings and in a field trial at Lagfors as 11 year old saplings. The horizontal bar indicate that there were no significant differences between the progenies in the field test.

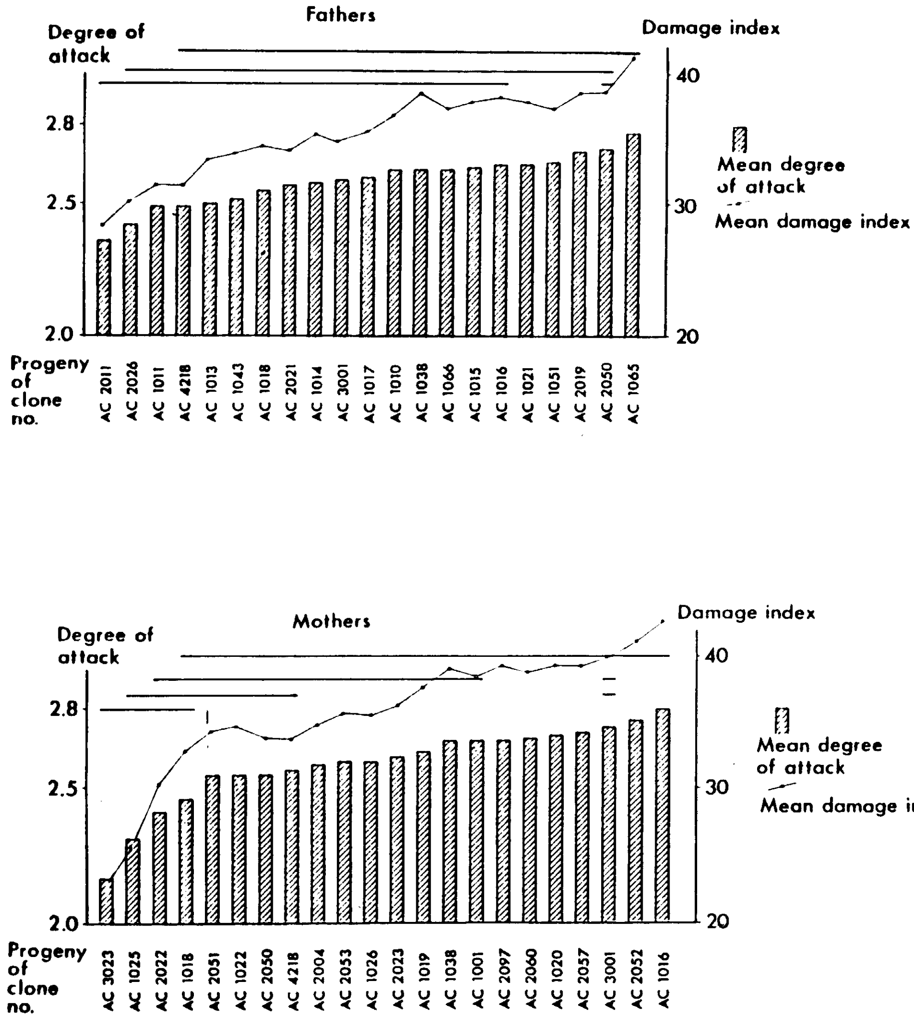

Figure 4. — Resistance of progenies from 37 plus trees of seed orchard AC 10—11 Öst Teg tested in Johannisfors nursery. The horizontal bars bracket those progenies not significantly different from each other at the 5% level.

trees should therefore be more reliable, at least for that region where the research plot is located, than a test in an artificial environment. If these sorts of experiments are to be performed in a controlled or semi-controlled environment, the possibilities for success would be greater the shorter the period of time used for the experiment, provided that the environmental control is relevant for the results.

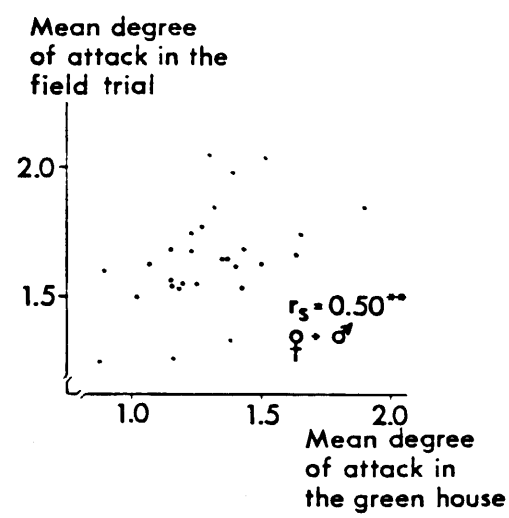

Figure 5. — Rank order correlation between the test in green-house (Ådalen) and field trial (Tönnersjö) of progenies from seed orchard L 55 Harastorp.

The resistance of the progenies from 3 of the seed orchards were tested in an artificial environment as well as in a natural forest habitat. The correlation between the rank order of the progenies in the green-house tests and the field trials was in 2 of the 3 cases 0.50 and 0.56 respectively and significant at the 1% level, i.e. the material of seed orchards L55 and E 468 (*Figures 5* and *6*). The poor correlation between the resistance found in the field trial and the green-house test of progenies from seed orchard Y 411 was probably caused by the high average degree of attack in the field plot in Lagfors, which hid the mean contrasts between the progenies (*Figure 7*),

In the green-house tests the variation among progenies from mothers was larger than that from the fathers. This was probably an effect of the young seedlings used in the green-house test. Young seedlings may be more influenced by the mother than by the father due to the mothers influence on the seed weight (Martinsson 1980, Rohmeder 1972).

The disease resistance which could be observed and assessed in a natural environment is certainly more time consuming to determine and the application of the results are limited to the special circumstances under which the determination was done. However, the information received from a field trial is probably more reliable. Also the age of the field trial material is more adequate with reference to the age of commercial plantations when pine twist rust attacks are most common. The two main problems of testing young material under artificial conditions are: 1) The correlation between the resistance of seedlings to that of young trees. 2) The problems associated to the control of the artificial environment.

The degree of attack used in this investigation produced data of a non-parametric character. This sort of data is not well suited for certain statistical analysis, for instance calculation of aritmetric mean values (Conover 1971). The transformation of degree of attack into damage index was a measure to transform non-parametric data into parametric. This transformation was based on the real impact of the disease on the growth of the tree found in a separate experiment. The practical influence from this transformation on the ranking of progenies was minor *(Figure 4)*. However, the damage index is a more realistic measure of the economic impact from the disease than is the degree of attack.

Conclusions

The genetic influence on the resistance to pine twist rust in Scots pine can be identified in 2-near old seedlings in green-house experiment as well as in 8—11 year old trees in natural forest habitats. It is therefore possible to make a genetic selection among progenies of Scots pine for improving the general combining ability of pine twist rust resistance. This selection can be based either on green-house tests of 2-year old seedlings or field trials at a later stage. Because of the big problems associated with artificial control of green-house tests the filed trials are to be preferred even though this procedure is more time consuming and the application of the results are limited.

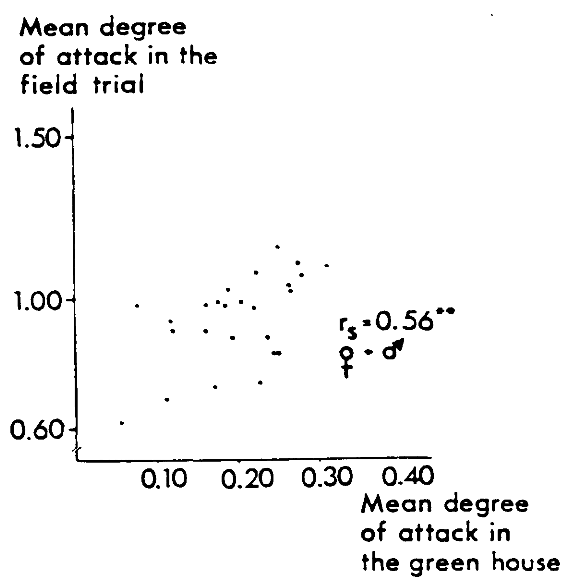

Figure 6. — Rank order correlation between the test in greenhouse (Ådalen) and field trial (Våmhus) of progenies from seed orchard E 468 Tjuttorp.

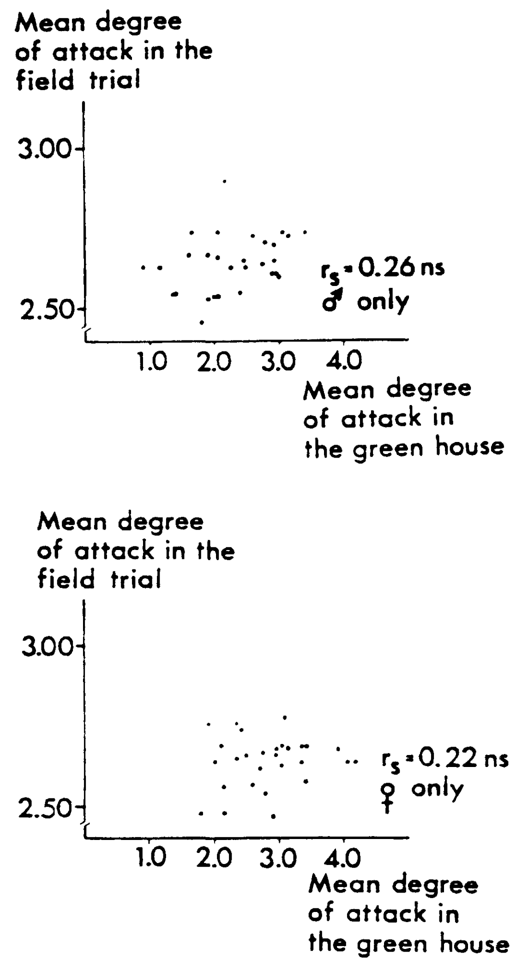

Figure 7. — Rank order correlation between the test in greenhouse (Johannisfors) and field trial (Lagfors) of progenies from seed orchard Y 411 (Domsjöänget II).

In the practical application of ranking resistance of half-sib groups there is no significant difference between the two methods of damage assessment described. However, the damage index is based on parametric data and is therefore more suitable for statistical analysis than is the degree of attack.

Acknowledgements

This investigation was financially supported by the Swedish Research Council for Forestry and Agriculture. Many people have been involved in the field work, the processing of data and the reviewing of manuscripts. I would like to express my sincere thanks to Mr. Assar Ernstsson, Mr. Jim Hunt, Dr. Margareta Karlman, Dr. Bo Kindbom, Mr. Jan-Erik Lundh, Mr. Stefan Löfmark and Miss Ann-Kathrin Persson.

References

Bingham, R. T., A. E. Squillace and J. W. Wright: Breeding blister rust resistant western white pine II. First results of progeny tests including preliminary estimates of heritability and rate of improvement. - Silvae Genetica 9, 33—41 (1960). —— Björkman, E.: Die Prüfung forstlicher Baumarten auf Resistenz gegen parasitäre Pilze. - Eur. J. For. Path. 2, 229—237 (1972). —— Conover, W. J.: Practical non-parametric statistics. - Wiley, New York, 1 ed., 462 p, (1971). —— Gäumann, E.: Pflanzliche Infektionslehre. - Verlag Birkhäuser, Basel, 2. Aufl., 681 p, (1951). —— Hoff, R. J., G. J. McDonald and R. T. Bingham: Resistance to *Cronartium ribicola* in *Pinus monticola:* Structure and gain of resistance in the second generation. - USDA Forest Service, Research Note INT-178. Intermountain Forest and Range Experiment Station, Ogden, Utah. 8 p,

♀ \ ♂	D 7001	D 7008	D 7009	D 7011	D 7012	D 7015	D 7004	L 2001	L 2002	L 2004	L 2005	L 3001	L 3003	L 3004	Rank among mothers
D 7002	1.4		1.6		1.3				1.7		1.8		1.5		3
D 7003	1.1			2.1			1.8	1.6	1.4				1.9		7
D 7005	1.3			1.9	1.8				1.6			1.7		1.2	4
D 7006		1.9	2.2				1.9	1.7		2.1	2.0				14
D 7007		1.9		1.5		1.7				1.8		1.5		2.1	10
D 7010		2.3				1.7	1.7	1.9			2.0			1.8	13
D 7013			1.6		1.6	1.7				2.0		2.0	1.8		11
L 2006	1.1		1.7			1.4		1.3		1.3		1.1			2
L 2007	1.8		2.0			1.8			1.5	1.6			1.3		9
L 3002	1.0			1.3		1.4		1.2			1.5		1.2		1
L 3005				1.5	1.7				1.6			1.7	1.7		6
L 3006		2.0			1.7		1.6	1.7			2.1			1.7	12
L 3007		2.3	2.0				1.5		1.4			1.3		1.3	5
L 3008		1.9		1.8	1.8					1.3	1.8			1.4	8
Rank among fathers	1	14	13	11	8	7	10	4	3	9	12	2	5	6	

Figure 8. — Crossing chart and mean degree of attack of full-sib groups originating from seed orchard L 55 Harastorp, growing in the field trial in Tönnersjö. Highly significant differences between full-sib groups within half- sib groups appeared. Crossings within mother D 7003 and mother L 3007 are such examples. Within other half-sib groups only minor differences between full-sib groups were registered, e.g. mother L 3005.

(1973). —— KINLOCH, B. B.: Mechanisms and inheritance of rust resistance in conifers. - In HEYBROEK, H. M., STEPHAN, B. R. and WEISSENBERG, K. (eds): Resistance to diseases and pests in forest trees - Proc. 3rd Int. Workshop on Genetics and Host-parasite interactions in Forestry, Wageningen, The Netherlands, 14—21 Sept. 1980, IUFRO, 119—129 (1982). —— MARTINSSON, O.: Test of resistance against parasitic fungi on forest trees. - Sveriges Skogsvårdsförbunds Tidskr. (73) 31—46 (1975). —— MARTINSSON, O.: Resistens mot två olika parasitsvampar på samma plusträdsavkommor. - Institutet för skogsförbättring, Föreningen skogsträdsförädling, Årsbok 1975, Uppsala, 145—151, (1976). —— MARTINSSON, O.: Testing Scots pine for resistance to pine twist rust. - Folia Forestalia (422) 25—31 (1980). —— MARTINSSON, O.: The influence of pine twist rust *(Melampsora pinitorqua)* on growth and development of Scots pine *(Pinus sylvestris)*. - Eur. J. For. Path. (15) 103—110 (1985). —— ROHMEDER, R.: Das Saatgut in der Forstwirtschaft. - Paul Parey, Hamburg und Berlin, 273 p, (1972). —— SPSS: Statistical package for the social sciences, 2nd ed. - McGraw-Hill Book company, New York, 675 p, (1980). —— VAN DER PLANK, J. E.: Plant diseases . Epidemics and control. - Academic Press, New York, San Francisco, London, 349 p, (1963). —— ZOBEL, B.: Developing fusiform resistant trees in the southeastern United States. - In "Resistance to diseases and pests in forest trees" Proc. 3rd Int. Workshop on the Genetics of Host-parasite interactions in Forestry, Wageningen the Netherlands, 14—21 Sept. 1980, 417—426 (1982).

Establishing a Picea glauca (Moench) Voss Base Breeding Population for the Lake States Region of the United States

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(Received 24th February 1986)

Annotation

Discusses problems and solutions in selecting founders (parents) and in establishing and maintaining base breeding populations, using *Picea glauca* in Minnesota, Wisconsin, Michigan as an example. Selection from existing breeding collections leads to genetic imbalance followed by loss of genetic diversity in future generations. Equalization of the population is discussed.

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