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Variation in Needle Cast Susceptibility among 29 Jack Pine Seed Sources

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Jack pine needle cast, caused by the fungus *Hypodermella* ampla DEARN., is one of a group of needle cast diseases that causes defoliation of pines. This parasite is distributed from Wisconsin to Nova Scotia (DARKER, 1932) and attacks only jack pine (Pinus banksiana LAMB.). An infected tree may lose all but the current year's needles. The effect of H. ampla on growth has not been determined, but a closely relatod fungus (H. medusa DEARN.) reduced growth of ponderosa pine (P. ponderosa LAWS.) by 40 percent on poor sites (WAGENER, 1959).

A study of the effect of jack pine needle cast on 29 jack pine seed sources began in 1961 when a severe outbreak of this disease occurred in a test plantation at Watersmeet, Michigan. This plantation is part of a jack pine geographic variation study begun in 1952 by the Lake States Forest Experiment Station and the University of Minnesota in cooperation with various university, state, and private agencies[2]).

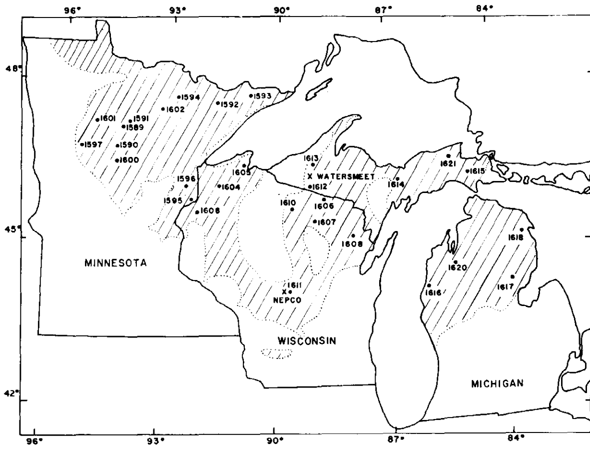

Figure 1. — Location of 29 seed source areas and 2 study plantations. The shaded area is the natural range of jack pine (from RUDOLF and SCHOENIKE, 1963).

Materials and Methods

Twenty-nine seed collections were made from several average trees of stands in Minnesota, Wisconsin, and Michigan. Seeds were sown in the Hugo Sauer Nursery at Rhinelander, Wisconsin, and the General Andrews State Nursery at Willow River, Minnesota, in 1952. Seedlings were field planted in 1954 at 17 locations within the 3 states. At each location a 4-replication, randomized, complete block design was used. Each replication consists of one square 64-tree plot of each experimental origin and one "local" seodlot. The locations of the seed sources are shown in Figure 1.

Two plantations, consisting of stock grown at Rhinelander, were used in this study[3]). The Watersmeet plantation, located 7 miles north of Watersmeet, Michigan, is in the western portion of Michigan's Upper Peninsula. Stumps indicate that the area originally supported a cover of red pine (P. resinosa AIT.) and eastern white pine (P. strobus L.). Dense natural stands of jack pine now surround the plantation.

The Nepco plantation is on the Nepco Industrial Forest, Port Edwards, Wisconsin. The Nekoosa-Edwards Paper Company owns this industrial forest and maintains the jack pine test planting. This planting is bordered on two sides by thrifty red pine plantations. Dense natural stands of jack pine also occur nearby.

The 16 center trees on each plot were scored for needle infection in 1961, and the 10 center trees on each plot in 1962. Three replications were used in 1961, and four in 1962. If a center tree was missing, the one nearest was substituted.

As previously noted, the fungus does not attack current year's growth. Therefore, the 1961 scoring applied to needles formed in 1960 or before; the 1962 scoring applied only to needles formed in 1961.

The percent of infected needles was scored as a grade. Grades eliminated the need for a subsequent transformation. The grades are as follows:

Grade	Needles Infected
	Percent
1	1—10
2	11—33
3	34—66
4	67—90
5	91—99
6	100

[1]) The authors are respectively, Associate Plant Geneticist and Principal Plant Geneticist, Institute of Forest Genetics, Lake States Forest Experiment Station, Forest Service, U. S. Dept. of Agriculture, Rhinelander, Wisconsin. Grateful acknowledgment is made to Dr. J. W. WRIGHT for review of the manuscript.

[2]) P. O. RUDOLF of the Lake States Forest Experiment Station and T. SCHANTZ-HANSEN of the University of Minnesota planned and initiated the overall study. P. O. RUDOLF has also issued several mimeographed reports. The 1958 height data used in the analyses were available in the Lake States Forest Experiment Station files.

[3]) A plantation on the Argonne Experimental Forest, Three Lakes, Wisconsin, was also examined in 1961. However, 1961 frost damage and the needle cast measurements were confounded to such an extent that this plantation was eliminated from the analysis.

Results

Strong differences among origins in susceptibility to the needle cast fungus existed for all examinations of the plantations (*Tables 1, 2, and 3*). Although there is a weak negative relation between five-year height and disease infection (*Table 4*), susceptibility differences exist independently of height differences (*Table 5*). By the end of the 1962 growing season the least susceptible origin had about 25 percent of the foliage infected, while the most susceptible origin had about 95 percent infection.

Seed origins from northeastern Minnesota showed the lowest resistance, and origins from Lower Michigan the highest. However, resistance was not completely related to geographic location of the origins. For example, origins 1612 and 1613, from the western portion of Michigan's Upper Peninsula, differ in north-south distance by only 30 miles, yet 1612 was a consistently resistant origin, and 1613 a consistently susceptible one. Origin 1597, from Becker County, Minn., was more susceptible than its neighboring sources to the north and east.

Table 1. — Summary of analyses of variance of needle cast fungus scorings.

Place and date of examinations	Source of variation: Replication	Seed origin	Error
	Degrees of freedom		
	2	29	58
	Mean square		
Watersmeet, July 3, 1961	2.10	.504***	.0736
Watersmeet, August 22, 1961	2.55	.358***	.0888
	Degrees of freedom		
	3	28[1])	84
	Mean square		
Watersmeet, June 25, 1962	1.897	1.899***	.189
Watersmeet, August 16, 1962	.280	1.627***	.149
Nepco, June 27, 1962	.570	1.588***	.177
Nepco, August 21, 1962	.307	1.493***	.163

*** Significant at the 0.1 percent level.
[1]) Only seed origins common to both plantations are included in 1962 analyses.

There is a strong relationship between the performance of origins at the two plantations in 1962 (*Table 4*). However, there are a few real exceptions to this relationship (*Table 6*, note significant origin × plantation interaction). Most notable is origin 1618 from Lower Michigan. At Watersmeet this origin had about 14 percent foliage infection while at Nepco 25 percent of its foliage was infected. This is the largest difference any origin showed between plantations. Origin 1589 also showed a decreased resistance at Nepco, while origins 1605 from northern Wisconsin and 1614 from Michigan's Upper Peninsula, showed greater resistance at Nepco than at Watersmeet. However, with the exception of 1618, these changes are small enough to be attributed to experimental error. In general, the results gathered at one plantation would apply to the other or to similar environments in Wisconsin and the western portion of Michigan's Upper Peninsula.

The strong relationship between the Watersmeet 1961 and Watersmeet 1962 examinations (*Table 4*) indicates that the among-origin differences remain constant from year to year.

This constancy of infection differences from environment to environment and from year to year demonstrates that infection differences are largely determined by seed source. Since selection of a highly susceptible source would result in a loss of up to 95 percent of the tree's foliage from needle cast infection, resistance to this disease should re-

Table 2. — Average 1961 needle cast fungus infection at Watersmeet, Michigan.

July 3: Source number	Mean grade	Significance at the 1-percent level[1])	August 22: Source number	Mean grade	Significance at the 1-percent level[1])
1594	4.10		1594	4.27	
1602	3.58		1593	3.83	
1593	3.37		1597	3.77	
1592	3.27		1602	3.73	
1613	3.23		1592	3.63	
1597	3.10		1613	3.60	
1609	3.04		1601	3.53	
1614	3.04		1609	3.47	
1610	3.02		1606	3.43	
1608	2.83		1611	3.43	
1611	2.81		1615	3.37	
1615	2.79		1600	3.33	
1600	2.77		1591	3.27	
1621	2.77		1614	3.27	
1590	2.71		1607	3.23	
1601	2.71		1605	3.23	
1605	2.71		1590	3.23	
1620	2.70		1621	3.17	
1606	2.69		1610	3.17	
1607	2.64		1589	3.13	
1595	2.63		1596	3.10	
1591	2.60		1595	3.07	
1596	2.58		1608	3.03	
1589	2.54		1620	3.00	
1604	2.46		1616	2.93	
1618	2.44		1604	2.90	
1616	2.39		1618	2.80	
1612	2.18		1612	2.73	
1617	2.08		1617	2.63	

[1]) Bars connect sources which are not significantly different from each other at the 1-percent level.

Table 3. — Average 1962 needle cast fungus infection at two plantations, Watersmeet, Michigan, and Nepco Industrial Forest, Wisconsin.

June 25—27			August 21—22		
Source number	Mean grade	Significance at the 1-percent level[1]	Source number	Mean grade	Significance at the 1-percent level[1]
1594	5.04		1594	5.33	
1602	3.55		1613	3.99	
1613	3.48		1602	3.89	
1593	3.38		1593	3.81	
1592	3.33		1614	3.53	
1597	3.15		1597	3.45	
1621	3.13		1621	3.41	
1614	3.04		1611	3.39	
1615	2.96		1600	3.34	
1601	2.93		1615	3.29	
1611	2.93		1590	3.18	
1600	2.89		1592	3.18	
1590	2.75		1601	3.15	
1591	2.71		1591	3.08	
1607	2.69		1606	3.05	
1606	2.60		1607	3.03	
1609	2.45		1609	3.00	
1610	2.44		1595	2.94	
1595	2.44		1589	2.84	
1589	2.41		1596	2.81	
1596	2.40		1608	2.79	
1605	2.24		1610	2.75	
1620	2.18		1618	2.74	
1608	2.11		1605	2.61	
1616	2.10		1620	2.61	
1618	2.10		1604	2.55	
1604	2.08		1616	2.54	
1617	2.00		1617	2.54	
1612	1.93		1612	2.31	

[1]) Bars connect sources which are not significantly different from each other at the 1-percent level.

Table 4. — Correlation coefficients (r) between needle cast fungus infections, height, and latitude of seed source.

Item	Infection						Height		Seed Source
	Watersmeet 1961		Watersmeet 1962		Nepco 1962		Waters-meet	Nepco	Latitude
	7/3	8/22	6/25	8/16	6/27	8/21	1958	1958	
Infection: Watersmeet									
7/3/61	1.00								
8/22/61	.91***	1.00							
6/25/62	.90***	.91***	1.00						
8/16/62	.88***	.90***	.98***	1.00					
Nepco									
6/27/62	.81***	.81***	.86***	.86***	1.00				
8/21/62	.85***	.82***	.89***	.88***	.91***	1.00			
Height: Watersmeet, '58	—	-.39*	-.44*	-.43*	-.38*	—	1.00		
Nepco, '58	-.44*	-.47**	-.55**	-.54**	-.44*	—	.48**	1.00	
Seed Source: Latitude	.56**	.67***	.66***	.61***	.49**	.54**	—	-.56**	1.00

— (r) = less than .37.
* (r) = 0.37 or larger, significant at the 5-percent level.
** (r) = 0.47 or larger, significant at the 1-percent level.
*** (r) = 0.58 or larger, significant at the 0.1-percent level.

ceive serious consideration in any jack pine improvement program. Fortunately, the correlation between five-year height and resistance suggests that selection of seed sources on the basis of height growth alone will also result in increased resistance and vice versa.

There is no real change in ranking of the origins between dates within either plantation (*Table 6*, note non-significant origin × plantation × date interaction). This does not preclude the possibility that some origins may make significantly greater changes between examinations than other origins. That is, there may be among-origin differences in the rate of symptom development. Such differences could not be detected from an analysis based on total damage because of the high correlation between infection at successive dates.

To estimate the rate of symptom development, the difference in infection between examinations was computed for each plot. Since these differences could be directly affected by the amount of initial infection — a heavily infected tree does not offer the same chance for change that a lightly infected tree does — an adjustment was made for initial infection by using covariance analysis. After making

Table 5. — Summary of analyses of covariance results. Significant F-value indicates differences exist in dependent variable not attributable to variation in independent variable[1]).

Dependent variable	Independent variable	F value
	Watersmeet Plantation	
Infection, July 3, 1961	Height, 1958	6.66***
Infection, August 22, 1961	Height, 1958	3.97***
Difference between 1961 examinations	Heigth, 1958	3.79***
Difference between 1961 examinations	Infection: July 3, 1961	2.54**
Difference between 1962 examinations	Infection, June 25, 1962	.83
	Nepco Plantation	
Difference between 1962 examinations	Infection, June 27, 1962	1.64*

* Significant at the 5-percent level.
** Significant at the 1-percent level.
*** Significant at the 0.1-percent level.
[1]) All analyses are based on plot means. There were 29 and 57 degrees of freedom for origin and error respectively for the 1961 analyses; and 28 and 83 respectively for the 1962 analyses.

Table 6. — Combined analysis of variance of 1962 needle cast fungus infection for all dates and plantations.

Source of variation	Degrees of freedom	Mean square
Plantation	1	.8028[1])
Dates	1	20.4876**[2])
Dates × plantation	1	2.9028
Error (a)	6	.7509
Origin	28	6.2385***[3])
Origin × plantation	28	.2824*[3])
Origin × date	28	.0437
Origin × plantation × date	28	.0421
Error (b)	336	.1697

* Significant at the 5-percent level.
** Significant at the 1-percent level.
*** Significant at the 0.1-percent level.
[1]) Non-significance determined by t-test.
[2]) Based upon replications-within-planting × dates (Error a) as error term.
[3]) Based upon origin × dates × replications-within-planting (Error b) as error term.

this adjustment, differences in rate of symptom development were found at Watersmeet in 1961 and at Nepco in 1962 *(Table 5)*. These differences were independent of height growth. However, the correlation between the Watersmeet 1961 changes and Nepco 1962 changes was negative (r = —.50).

Because among-origin differences in symptom development differ with year and location, selection directly for this character seems of little use. These differences are probably the result of among-origin differences in foliage condition at time of infection.

Finally, a word about the fungus itself. There was no real difference in the level of infection between plantations *(Table 6)*. Furthermore, the change in infection between dates did not differ between plantations. This seems to indicate that outbreaks of this disease are determined more by macroclimatic than microclimatic factors.

Summary

A 10-year-old jack pine test plantation near Watersmeet, Michigan, was scored for jack pine needle cast fungus infection in 1961 and 1962. The plantation, including 29 seed source origins, was part of a geographic variation study begun in 1952. In 1962 an identical planting near Port Edwards, Wisconsin, was examined.

These examinations show that the seed sources differ in susceptibility to the fungus. Since these differences remain constant from year to year and from environment to environment, they are considered to have a direct genetic basis.

The rate of symptom development may also differ among origins. These differences are not under direct genetic control, but vary with year and location.

On jack pine sites in Wisconsin and the western Upper Peninsula of Michigan, seed sources from lower Michigan exhibit the highest resistance to needle cast fungus, and seed sources from northeastern Minnesota the lowest.

Résumé

Titre de l'article: *Variation dans la sensibilité à la chute des aiguilles entre 29 provenances de Pinus banksiana.*

Une plantation comparative de 10 ans de *Pinus banksiana* située près de Watersmeet, Michigan, a fait l'object d'observations concernant une attaque cryptogamique causant la chute des aiguilles en 1961 et 1962. Cette plantation comprenant 29 provenances faisait partie d'une étude sur la variation géographique de l'espèce commencée en 1952. En 1962, on a examiné une plantation identique située près de Port Edwards, Wisconsin.

Ces observations montrent que les provenances manifestent une sensibilité différente aux attaques de champignons. Ces différences restant constantes d'année en année, et pour diverses stations, on en conclut qu'elles ont une base génétique directe.

La vitesse de développement des attaques peut également varier suivant les origines, mais ces différences ne sont pas sous contrôle génétique direct, elles varient suivant l'année et la station.

Sur les plantations de *Pinus banksiana,* dans le Wisconsin et dans la Péninsule occidentale du Michigan, les provenances du Michigan inférieur manifestent la résistance la plus forte et les provenances du nord-est du Minnesota la plus faible.

Zusammenfassung

Titel der Arbeit: *Variation in der Anfälligkeit für Nadelschütte bei 29 Herkünften von Pinus banksiana.*

Eine 10 Jahre alte Pflanzung von *Pinus banksiana* bei Watersmeet, Michigan, wurde auf die Infektion mit dem Nadelschüttepilz hin 1961 und 1962 untersucht. Sie enthielt 29 Herkünfte dieser Kiefer und war ein Teilstück einer Untersuchung der geographischen Variation seit 1952. 1962 wurde dann eine identische Pflanzung bei Port Edwards, Wisconsin, bonitiert.

Es zeigte sich, daß sich die Herkünfte in ihrer Anfälligkeit für den Pilz unterschieden. Da aber diese Unterschiede Jahr für Jahr und in verschiedener Umwelt konstant blieben, wird für sie eine direkte genetische Basis in Betracht gezogen.

Im Entwicklungsausmaß der Symptome unterschieden sich die Herkünfte auch. Solche Unterschiede sind aber nicht direkt genetisch kontrolliert, sondern sie variieren je Jahr und Örtlichkeit.

Auf Kiefernstandorten in Wisconsin und im westlichen Upper Peninsula, Michigan, zeigen Herkünfte vom unteren Michigan die höchste Resistenz gegen die Nadelschütte und

die Herkünfte aus dem NO von Minnesota die geringste Resistenz.

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Berichte

Weltkonsultation in Forstgenetik und Forstpflanzenzüchtung vom 23.—30. August 1963 in Stockholm

Die Ergebnisse dieser im Jahrgang 1963 der *Silvae Genetica* angekündigten Konsultation der FAO, auf Einladung der schwedischen Regierung in Stockholm, veranstaltet mit Unterstützung der IUFRO, liegen jetzt in drei Publikationen vor. Heft 73/74 der *Unasylva,* Band 18, 1964 bringt die Berichte der Senior-Rapporteure der 10 Sektionen:

I. GUSTAFSSON, Å.: Forstgenetik und Zytologie.
II a. STERN, K.: Populationsgenetik, Heritabilität, Kombinationseignung und Nachkommenschaftsprüfung.
II b. WRIGHT, J. W.: Hybridisierung zwischen Arten und Rassen.
III. CALLAHAM, R. Z.: Provenienzforschung.
IV. MORANDINI, R.: Einführung exotischer Baumarten.
V. WAREING, P. F.: Genetik und Baumphysiologie.
VI a. BJÖRKMAN, E.: Züchtung auf Krankheitsresistenz.
VI b. SJØEGAARD, B.: Züchtung auf Resistenz gegen Insekten.
VII. ZOBEL, B. J.: Züchtung auf Holzeigenschaften.
VIII. MATTHEWS, J. W.: Samenproduktion und Zertifizierung.

Diese Berichte entsprechen etwa den während der Konsultation verteilten Texten, berücksichtigen aber auch die Ergebnisse der Diskussionen in den einzelnen Sektionen. Da sie selbst zusammenfassende Referate darstellen, kann ihr Inhalt hier nicht referiert werden; es wird auf die Originalarbeiten verwiesen. Außerdem enthält das Heft zwei weitere Beiträge von I. DÖRMLING über „einige Pfropfmethoden" und W. PLYM-FORSHELL über „Genetik und Forstwirtschaft in Schweden", in denen praktische Erfahrungen mitgeteilt werden, sowie eine Anweisung über die Bewertung von Plusbäumen.

Im Eigenverlag der FAO wurden als *„Proceedings of the World Consultation on Forest Genetics and Tree Improvement"* mineographiert die Beiträge zu den einzelnen Sektionen herausgegeben. Band 1 enthält die Beiträge zu Sektionen I—IV, Band 2 die zu Sektionen V—VIII. Im ersten Band findet man außerdem die Teilnehmerliste, eine Liste der Autoren, das Inhaltsverzeichnis für beide Bände und organisatorische Bemerkungen. Jedem der abgedruckten Referate sind Zusammenfassungen in englischer, französischer und spanischer Sprache beigegeben.

MERGEN, F.: Evaluation of spontaneous, chemical, and radiation-induced mutations in *Pinaceae.* Nr. 1/1, VIII, 15 S.

Eine Übersicht über die bisher bekannten Tatsachen auf diesem Gebiet, ergänzt durch eigene, unveröffentlichte Versuchsergebnisse des Verfassers vor allem über die Effekte chronischer Strahlenbelastung von Koniferen.

KOSHOO, T. N.: Cytogenetical evolution in conifers. Nr. 1/2, II, 5 S.

Genmutation, Hybridisierung und Änderungen des Karyotyps sind die Hauptursachen der Evolution bei den Koniferen. Polyploidy und Apomixis haben kaum eine Rolle gespielt. Dies gibt Hinweise auf die Zweckmäßigkeit bestimmter Züchtungsmethoden.

HYUN, S.-K., und KIM, C. S.: Some characteristics of autotetraploids of tree species induced by colchicine treatment. Nr. 1/3, V, 16 S.

Morphologische und physiologische Merkmale colchicininduzierter Tetraploider von mehreren Laubbaumarten werden beschrieben.

SEKAWIN, M.: Etude d'un peuplier tétraploide obtenu artificiellement et de sa descendance. Nr. 1/4, III, 6 S.

Der tetraploide Klon wurde durch Knospenbehandlung aus dem bekannten Klon 'I 154' entwickelt. Seine Wuchseigenschaften sind schlechter als die des diploiden Klons, ebenso seine Vermehrbarkeit durch Stecklinge. Demgegenüber ist seine Fertilität besser. Die Nachkommenschaften sind intermediär zwischen tetraploidem Vater und diploider Mutter. Sie sind sämtlich triploid.

HASEGAWA, M., und SHIRATO, T.: Genetics of flavonoids in *Prunus* wood. Nr. 1/5, II, 4 S.

Die Flavonoide im Holz von *P. subhirtella* und *P. speciosa,* sowie des Hybriden zwischen beiden werden verglichen. Der Hybrid hatte das in der mütterlichen Art vorhandene Vermögen zur Synthese von Isoflavonen verloren, statt Chrysin wurde Genkwasin gefunden. Demgegenüber wurde im Holz des Hybriden mehr Sakuranin als Prunin gefunden, das für die andere Elternart charakteristisch ist.

YIM, K. B.: Sensitivity of pine seed to neutron, gamma- and X-ray irradiation. Nr. 1/6, IV, 9 S.

Samen von *Pinus densiflora, P. rigida* und *P. banksiana* zeigten artspezifische Unterschiede in der Strahlenempfindlichkeit. Unter den keimfähigen Samen nach Bestrahlung fand sich ein höherer Prozentsatz, der abnorme Sämlinge hervorbrachte.

FUKUHARA, N.: Inheritance of needle discoloration of sugi (*Crytomeria japonica* D. DON.) Nr. 1/7, IV, 6 S.

Kreuzungsversuche mit grünbleibenden und rotverfärbenden Bäumen bestätigten Ergebnisse eines früheren Versuchs, demzufolge „Grün" durch einen dominanten Faktor bedingt ist.

RUGGERI, C.: Observations on the bisexual behaviour of a population of *Populus tremula* L. Nr. 1/8, II, 2 S.

Das Verhalten der hermaphroditen Population in Süditalien, die näher untersucht wurde, ist sicherlich genetisch bedingt. Daneben zeigen die wechselnden Anteile der verschiedenen Blütentypen von Jahr zu Jahr, daß es eine erhebliche Interaktion zur Umwelt gibt.

JOHNSSON, H.: Arrangement and design of field experiments in progeny testing. Nr. 2a/1, III, 8 S.

Die Probleme von Feldversuchen zur Forstpflanzenzüchtung, insbesondere Minimisierung der Bodenheterogenität und von Nachbarschaftseffekten, werden im Zusammenhang mit Sortenzahl, Wiederholungszahl, Parzellengröße u. a. diskutiert. Eine kurze Beschreibung schwedischer Standardverfahren sowie eine Diskussion der Schwierigkeiten bei der Ausdeutung von Versuchsergebnissen ist angeschlossen.

TODA, R.: Mass selection and heritability studies in forest tree breeding. Nr. 2a/2, IV, 7 S.

Es wird versucht, den durch natürliche Mortalität oder Durchforstung eintretenden Selektionseffekt bei der Berechnung der Heritabilität zu berücksichtigen. Die Schwierigkeit der Interpretation der Heritabilität unter derartigen Bedingungen wird hervorgehoben.

HATTEMER, H. H.: Estimates of heritability published in forest tree breeding research. Nr. 2a/3, I, 14 S.

Die Arbeit enthält eine Liste der bis 1963 veröffentlichten Heritabilitätsschätzungen bei Forstpflanzen, sowie Angaben über Me-