Seed source-related eastern pineshoot borer incidence in jack pine

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Summary

Variation among 90 jack pine seed sources in incidence of eastern pineshoot borer was evaluated in 1966 (age 5) in a short-term nursery test and yearly from 1970 to 1973 (age 9—12) in a field test in northern Wisconsin. There were significant differences among sources in shoot borer incidence at all ages.

The results from this study show that eastern pineshoot borer incidence in jack pine is under strong genetic control.

Variation among sources in borer incidence was significantly correlated with variation in total height. But covariance analysis showed that variatiun in borer incidence could not be entirely attributed to differences among sources in total height.

Shoot borer incidence was also significantly correlated with time of shoot growth initiatiun and length of terminal shoot in mid-May, at about the time of shoot borer oviposition. In general, trees from intermediate-flushing seed sources had the greatest terminal shoot lengths in mid-May, the highest shoot borer incidence, and intermediate total heights. Trees from late-flushing sources had shorter terminal shoots in mid-May, the lowest shoot borer incidence, and best height growth.

Late-flushing jack pine seed sources can be selected as early as age 4 and trees from these sources should have low shoot borer incidence and rapid height growth.

Key words: Eucosma gloriola, seed source variation, phenology, selection.

Zusammenfassung

Eucosma gloriola HEINRICH (Tortricidae), ein Kieferntriebwickler, verursacht in Nordamerika an Pinus *banksiana* LAMB. und anderen Kiefernarten sowie auch an Pinus *sylvestris* L. erhebliche Schäden in Kulturen und Naturverjüngungen.

Es wurde geprüft, ob es möglich ist, diesem Befall durch den Anbau, insbesondere im Austreibeverhalten im Frühjahr unterschiedlicher Provenienzen zu begegnen. Sowohl in einem Baumschulversuch als auch in einem sich anschließenden Provenienzversuch mit 90 Herkünften stellten sich signifikante Befalls-Unterschiede heraus. Der Befall korrelierte gleichzeitig signifikant mit dem Höhenwachstum der Provenienzen.

Introduction

Eastern pineshoot borer (Eucosma gloriola HEINRICH) is commonly found in pine plantations and in extensive areas of natural pine regeneration (DEBOO et al. 1971). It prefers white pine and Scotch pine, but it also attacks red, Austrian, pitch, mugo, and jack pine (WILSON 1972). Rarely found in natural mixed stands E. gloriola is most abundant in unmanaged or abandoned Christmas tree plantations, old fields, pure blocks of pine on tree farms, and in reforestation areas (DEBOO et al. 1971).

Life History

BUTCHER and HODSON (1949), DROOZ (1960), and WILSON (1972) have described the life history of the eastern pineshoot borer. Adults emerge soon after shoot elongation begins in late April to mid-May, depending on lucality. After mating, the female usually deposits a single egg on a needle sheath on each of several new shoots. Within 2 weeks the larva emerges and bores into the shoot behind a needle fascicle, or occasionally behind a cone or bark scale along the shoot. The larva mines downward in the pith to a point 1 to 3 inches above the base uf the current year's shoot. Usually by mid-June the larva reverses direction in the shoot and begins to mine upward. Shortly after reversing direction, the larva cuts into the vascular portion of the stem. The larva then continues to feed upward in the shuat and by mid-June to eaxly July it bores an exit hole, drops to the ground, spins a cocoon in the duff ur topsoil, and pupates and remains in this condition over winter. The vascular girdling causes rapid drying of the shoot above this point and weakens the shoot, causing it to break when touched or agitated by strong winds. BUTCHER and HODSON (1949) suggested that the vascwlar girdling may prevent entrapment of the larva in pitch prior to emergence from the shoot.

Terminal shoot attack results in loss of the current year's terminal, bwt tree height is affected only during year of attack. In most instances, a lateral shoot immediately below the terminal assumes the dominant position, normal vertical growth is maintained, and the resulting slight cxooking of the main stem does not seriously affect the merchantability of the tree. Repeated terminal attack, however, usually results in forking and stunting of trees (DEBOO et *al.* 1971). Although laterals are also attacked by *E.* gloriola, their loss has little effect on tree form. However, if laterals in the top whorl as well as the leader are damaged simultaneously, forking and serious degrade may result (BUTCHER and HODSON 1949).

Genetic Resistance

Before we can efficiently breed trees resistant to the eastern pineshoot borer, we must have a better understanding of jack pine's genetic variation in susceptability to the insect. Such variation does exist and is affected by source of seed. BUTCHER and HODSON (1949) found differences in average number of attacks per tree on trees grown from eight Lake States seed sources. KING (1971), in a 10-year study of 11 jack pine plantations containing trees from 26 Lake States seed sources, found significant differences among sources in shoot borer incidence at three of the four most heavily attacked plantations.

WONG et al. (1966) reported that E. gloriola prefers to attack trees in the interrnediate height class. Although KING (1971) found a significant negative correlation between shoot borer incidence and 10-year height in plantations with significant seed source differences, a linear covariance analysis showed that variation arnong sources in shoot borer incidence could not be entirely attributed to differences in height growth variation. These results suggest that variables other than total height may play an important role in insect resistance.

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STEINER (1974) studied incidence of eastern pineshoot borer among 112 provenances of Scotch pine planted at three locations in Lower Michigan and found that short varieties were the most resistant, varieties of intermediate height were least resistant, and tall varieties were intermediate in resistance. Resistance also varied with latitude of seed origin: northern varieties were most resistant and southern varieties were least resistant. He speculated that the time at which shoot growth begins in the spring could be the source of variation in resistance if adult insects prefer shoots and young needles of a certain length for oviposition.

Our results from nursery and field studies involving 90 jack pine seed sources indicate that eastern pineshoot borer incidence is associated with time of shoot growth initiation and length of the shoot at the time of oviposition.

Methods

Nursery Study

Jack pine seed from 90 sources collected throughout the species range and supplied by the Petawawa Forest Experiment Station, Canadian Forestry Service, Chalk River, Ontario (YEATMAN 1974) was sown in the Hugo Sauer State Nursery at Rhinelander, Wisconsin, in the spring of 1962. A randomized complete block design with 10-tree plots and five replications was used in the nursery. Trees were grown in the nursery for 5 years at 1 × 1 foot spacing. Terminal shoot elongation was measured periodically from May 14 to July 15 during the fourth growing season. Total height was measured in the fall of 1965 (age 4), and borer incidence on terminal shoots was evaluated in 1966.

Because shoot elongation measurements were not begun until May 14, procedures utilized by TEICH and HOLST (1970) were used to determine the date on which 5 percent of total elongation was achieved. The procedure involves conversion of periodic shoot measurements to probits which show a linear relation with time; the date on which a specific percentage of total elongation was achieved can then be determined from the linear regression. The date on which 5 percent of elongation was achieved is used in this study as an indicator of relative time of growth initiation.

Field Study

A permanent field planting was established 17 miles north of the nursery with 2—1 stock from the 90 seed sources in the spring of 1965. A randomized complete block design with four-tree linear plots and 12 replications was used. Trees were planted at 6 × 8 foot spacing. Total height of trees was measured in the fall of 1965 (age 4), 1969 (age 8) and 1972 (age 11). Borer incidence on terminal shoots was determined yearly from 1970 to 1973.

Results and Discussion

Incidence of borer damage on terminal shoots averaged 22 percent in the nursery and increased in the field from 29 percent in 1970 to 44 percent in 1971 before declining to 12 and 15 percent in 1972 and 1973, respectively *(Table 1)*. The rapid decline in shoot borer incidence from 1971 to 1972 occurred at about the same time when crown closure began to take place. This observation and a study in Ontario by DEBOO *et al.* (1971), in which incidence of shoot borer decreased with crown closure, indicate that decline in shoot borer population intensity is related to stand closure and not to total height as suggested by SCHANTZ-HANSEN and JENSEN (1954).

Table 1. — Eastern pineshoot borer incidence in jack pine from 90 seed sources

	Nursery	Field			
	1966	1970	1971	1972	1973
			Percent		
All sources	22	29	44	12	15
Seed source range					
Minimum	0	8	17	0	2
Maximum	42	57	70	28	29

Table 2. — Correlation coefficients (r) between years in shoot borer incidence

Year	1970	1971	1972	1973
1966	0.439**	0.417**	0.312**	0.500**
1970		.719**	.247*	.444**
1971			.182	.520**
1972				.365**

Significance levels: * = 5 percent, ** = 1 percent.

In our study, seed sources varied considerably in shoot borer incidence in the nursery and the field. Analysis of variance showed that differences among seed sources were statistically significant for all years. And except for 1972, when shoot borer incidence averaged only 12 percent, correlations between years were significant *(Table 2)*, indicating little genotype-year interaction. These results also show that susceptibility of jack pine to eastern pineshoot borer is under strong genetic control.

We found that shoot borer incidence was significantly correlated with climatic variables at seed origin that were also significantly correlated with tree growth, such as temperature during the growing season, length of growing season, and number of growing degree days above 42° F *(Table 3)*. In general, trees from the coldest climates had the highest shoot borer incidence, while those from the warmest climates had the lowest incidence.

In 1970 and 1971, when shoot borer incidence exceeded 28 percent, incidence was significantly and negatively correlated with total height in the nursery in 1965 and in the field in 1965 and 1969 *(Table 4)*. However, linear convariance analysis showed that variation among sources in shoot borer incidence could not be entirely attributed to variation among sources in total height.

Table 3. — Correlation coefficients (r) between eastern pineshoot borer incidence and seed origin variables

Shoot borer incidence	Latitude	Longitude	Annual precipitation	Annual temperature	January temperature	May temperature	July temperature	Length growing season	Growing degree days
1966	-0.049	-0.196	0.068	-0.155	-0.143	-0.147	-0.226*	-0.218*	-0.098
1970	.313**	-.020	-.031	-.428**	-.351**	-.472**	-.523**	-.487**	-.431**
1971	.409**	-.070	-.039	-.578**	-.502**	-.583**	-.638**	-.618**	-.604**
1972	-.158	-.107	.119	.051	.007	.128	.008	-.008	.101
1973	.109	-.113	-.045	-.298**	-.289**	-.266**	-.347**	-.341**	-.241*

Significance levels: * = 5 percent, ** = 1 percent.

Table 4. — Correlation coefficients (r) between eastern pineshoot borer incidence and growth

Shoot borer incidence	Date of 5% growth completion 1965	Terminal shoot length 5-14-65	Total height nursery 1965	Total height field 1965	Total height field 1969
1966	-0.038	0.594**	0.028		
1970	-.445**	.284**	-.482**	-0.523**	-0.357**
1971	-.606**	.545**	-.577**	-.590**	-.420**
1972	.050	.304**	.156	.090	.157
1973	-.204	.418**	-.176	-.210*	-.083

Significance levels: * = 5 percent, ** = 1 percent.

Table 5. — Terminal shoot length and eastern pineshoot borer incidence

	Nursery test			Field test		
Number of sources	Terminal shoot length	Total height	Borer incidence	Total height		Shoot borer incidence
	May 14, 1965	1965	1966	1965	1969	1970–1973
	cm	cm	percent	cm		percent
19	<7.0	91	14	37	134	18
14	7.0–7.9	90	18	37	136	24
29	8.0–8.9	82	25	34	135	27
20	9.0–9.9	82	26	32	135	28
8	>9.9	76	30	30	126	29
90	Mean 8.1	85	22	34	134	25

Borer incidence in 1970 and 1971 was also significantly and negatively correlated with date when 5 percent of shoot elongation was completed *(Table 4)*. In both years, above-average incidence was exhibited by the earliest flushing sources; the highest incidence occurred in sources with slightly later flushing dates; and the lowest incidence occurred in late-flushing sources.

Only terminal shoot length on May 14, 1965 was significantly correlated with shoot borer incidence in all years. Terminal shoot lengths during May and early June, 1965 were significantly correlated with shoot borer incidence in the nursery in 1966. In 1966, shoot borer incidence was significantly correlated with terminal shoot length on May 14, 1965 (r = 0.59), May 21 (r = 0.63), May 28 (r = 0.44), June 7 (r = 0.31), and June 14 (r = 0.24), but not with terminal shoot length after this date. Shoot incidence in 1970 through 1973, however, was not significantly correlated with terminal shoot length measured after May 14, 1965. Because shoot borer oviposition occurs a few weeks after terminal shoot elongation begins (Wilson 1972), the data suggest that current year terminal shoot length in mid-May (about the time of oviposition) is the most important variable associated with terminal shoot borer incidence. In general, trees having short terminal shoots on May 14, 1965 had the lowest shoot borer incidence, while those with the longest terminal shoots had the highest incidence *(Table 5)*.

Table 6. — Growth and eastern pineshoot borer incidence

Number of sources	Total height 1972	Date of 5% growth completion 1965	Shoot length May 14, 1965	Terminal borer incidence Nursery 1966	Terminal borer incidence Field 1970–1973
	cm	day[1]	cm	percent	
11	<200	115	7.2	11	24
8	200–224	119	8.9	28	27
9	225–249	121	7.8	20	30
14	250–274	122	8.8	28	29
14	275–299	122	8.7	28	29
24	300–324	125	7.7	22	22
10	>324	126	7.8	16	17
90	Mean 268	122	8.1	22	25

[1]Days from January 1.

Data on growth, including terminal shoot growth initiation, shoot length on May 14, 1965, total height at age 11, and shoot borer incidence are summarized for all sources in *Table 6*. The data show that the earliest-flushing seed sources had below average terminal shoot lengths on May 14, 1965, and average or below shoot borer incidence. Trees from these sources were the slowest growing in the test. Sources with average flushing dates had above-average shoot lengths on May 14, 1965 and the highest shoot borer incidence. Trees from these sources were of intermediate height at age 11. The fact that trees of intermediate height in a plantation have the highest shoot borer incidence has also been reported by Wong *et al.* (1966).

The results of this study indicate that late-flushing jack pine seed sources can be selected as early as age 4 in short-term nursery tests and trees from these sources will not only have the lowest incidence of eastern pineshoot borer but also the best growth .

Variables not evaluated in this study, such as shoot diameter, needle length, needle fascicle position, temperature at oviposition site, and chemical composition may also be important. Further study will be necessary to verify which of these variables, or others, are the most important in the oviposition site selection process.

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Short Notes

Performance of White spruce [Picea glauca (Moench) Voss] Progenies after Selfing

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Summary

Self-, and open-pollinated white spruce (*Picea glauca*) progenies were compared in three field tests. These tests were first evaluated in 1976 at ages 18, 14 and 7 years respectively. The average heights of the selfed trees were 33, 18 and 25 percent shorter than the open-pollinated trees in these tests; the degree of depression was not related to the age of the tests. Survival of selfed progenies was 11, 20, and 1 percent less respectively. There was considerable tree-to-tree variation in tolerance of selfing. The importance of avoiding inbreeding for the maintenance of plant quality is discussed.

Key words: Inbreeding effect, cross breeding effect, growth vigour, performance.

Résumé

Des descendances d'Epinette blanche (*Picea glauca*) obtenues par autopollinisation ont été comparées dans trois essais sur le terrain avec des descendances maternelles résultant de pollinisations libres. La première évaluation de ces essais a eu lieu en 1976 aux âges 18, 14 et 7 années, respectivement. Les hauteurs moyennes des arbres autopollinisés étaient de 33%, 18% et 25% inférieures à celles des arbres obtenus par pollinisation libre dans ces essais; le degré de perte en hauteur n'était pas relié à l'âge des essais. La survie des descendances par autopollinisation était de 11, 20 et 1 pour-cent moins respectivement. Il y avait une variation considérable d'un arbre à l'autre quant à tolérance de l'autopollinisation. L'importance d'éviter la consanguinité pour conserver la qualité des arbres est discutée.

Zusammenfassung

Titel der Arbeit: Leistung von Nachkommenschaften der *Picea glauca* nach Selbstung.

Nachkommenschaften der *Picea glauca*, die aus Selbstung und von freiabgeblühten Bäumen stammen, wurden in 3 Feldversuchen im Alter von 18, 14 und 7 Jahren geprüft. Die mittlere Höhe der Bäume aus Selbstung war um 33, 18 und 25% geringer als die Höhe der vergleichbaren aus freier Bestäubung hervorgegangenen Gruppen, doch war die geringere Leistung unabhängig vom Testalter. Es überlebten 11, 20 und 1% weniger als bei den frei abgeblühten Nachkommenschaften. Die Selbstung hatte eine von Baum zu Baum sehr unterschiedliche Wirkung. Die Notwendigkeit der Inzuchtkontrolle wird allgemein diskutiert.

Introduction

With the probable exception of red pine (*Pinus resinosa* AIT.) (FOWLER 1965), inbreeding depression commonly results from self-pollination in pine and spruce (FRANKLIN 1970). In comparison with out-crossed progenies, selfing results in low seed set, poor survival, reduced growth and vigor and an increase in frequency of dwarfs and seedlings with pigment and morphological aberrations.

Among spruce species, the oldest existing experiment investigating the effect of self-pollination involved 5 parent trees of Norway spruce (*Picea abies* [L.] KARST) planted in 1916 by Sylven. At age 61, average height and DBH of the selfed progenies were respectively about 28 and 25% less than for wind-pollinated progenies (ERIKSSON *et al.* 1973). The same experiment was carried into the second generation by further selfing and variously constructed crosses to create a range of inbreeding coefficients from 0 to 0.75. The initial results indicated that increased inbreeding was accompanied by decreased height growth (ANDERSSON *et al.* 1974).

Studies of inbreeding depression of white spruce have mostly concentrated on seedlings in greenhouses and nurseries. Information about field performance of inbred progenies is still scanty. MERGEN *et al.* (1965). reported no difference in the first year height growth between self- and wind-pollinated progenies. YEATMAN and VENKATESH (1974) found no apparent effect of selfing on time of flushing of 2-year-old white spruce seedlings, although typically the selfed progenies were smalller than the out-crossed seedlings. A recent study by COLES and FOWLER (1976) indicated that selfing reduced both seed set and seedling growth. Similar results were also reported by KING *et al.* (1970).

This note compares the performance of selfed white spruce progenies with wind-pollinated ones in three different trials at Petawawa Forest Experiment Station (PFES), Chalk River, Ontario.