CHARACTERISTICS OF EASTERN SPRUCE GALL APHID ATTACK AMONG 24 WHITE SPRUCE SEED SOURCES IN CENTRAL MAINE

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ABSTRACT.--Eastern spruce gall aphid attack on 24 range-wide white spruce seed sources growing in central Maine was investigated at the beginning of their sixteenth growing season in the field. Significant differences were found between seed sources in both number of gall aphids present and percent of trees attacked. The sources most heavily attacked were from eastern United States and southeastern Canada and those most resistant were from the Lake States and western Canada.

INTRODUCTION

The eastern spruce gall aphid (Adelges abietis L.) is an European insect introduced accidentally into the western hemisphere early in the nineteenth century (Friend 1936). It has spread extensively and is now commonly found in nurseries, Christmas tree plantations, and landscape plantings of several native and introduced spruce species in eastern United States and southeastern Canada.

Damage by the eastern spruce gall aphid is limited primarily to a reduction in the aesthetic value of the trees. Damage results in April and May when nymphs crawl to the base of expanding buds, insert their mouth parts, and begin feeding. The feeding stimulates formation of pineapple-shaped galls 125 to 190 millimeters in length (1/2 to 3/4 inch) which encase the feeding nymphs. Cells of the galls open and aphids emerge in late July or August. Galls at this time turn dark brown and are quite aesthetically objectionable. They can persist on trees for several years. Severe eastern spruce gall aphid attack can also cause stem disfiguration and result in disruption of a tree's symmetry.

Several investigators have reported that individual trees in a plantation vary widely in their susceptibility to eastern spruce gall aphid attack (Schread 1971). Some trees suffer repeated severe attacks while adjacent trees are conspicuously immune. Such an occurrence indicates that there may be genetic variability in the susceptibility of trees to attack by the insect.

Genetic differences between provenances of white spruce (Picea lauca (Moench) Voss) have been shown for a number of traits Nienstaedt and Teich 1972). However there is practically no information on white spruce provenance variation for insect susceptibility. This study describes the characteristics of eastern spruce gall aphid attack among 24 provenances of white spruce planted in central Maine (Table 1).

METHODS AND MATERIALS

Seedlings from 24 widely scattered provenances of white spruce were field-planted as 2-2 bare-root nursery stock in 1962 on the Penobscot Experimental Forest in Bradley, Maine (Latitude 44.5°N and longitude 68.4°W) by the United States Forest Service. The seedlings were hand planted in dense sod on an old-field site. No subsequent weed control or fertilization treatments were applied. The experimental design of the planting consisted of ten randomized complete blocks with four-tree square plots for each provenance. The spacing was 6- x 6-feet. Four mixed border rows of white spruce and red spruce (Picea rubens Sarg.) completely surrounded the planting. Height growth and survival data for this plantation were reported by Wilkinson 1977.

The eastern spruce gall aphid is present throughout the plantation and also on the border rows. No apparent obstacles exist within replications in the plantation to prevent random distribution of gall aphid adults.

The number of current-year galls between breast-high and waist-high branches in the four cardinal directions (eight branches) were counted on each tree in the plantation (712 trees) in June of 1977. Galls were a highly visible reddish color at that time, thus counting was quite easy. The scoring of previous year's galls was not necessary since the gall aphid attacks the same trees year after year. Heights of trees were measured to the nearest tenth meter.

Table 1.--Seed source number and location of 24 white spruce provenances planted in central Maine.[a]

Seed Source Number	State or Province	Degrees North Latitude	Degrees West Longitude	No. Trees in Sample
1628	S. Dakota	44-10	103-55	13
1630	Montana	46-48	109-31	5
1631	Manitoba	49-51	99-30	S[b]
1644	New York	44-23	74-06	10
1645	Wisconsin	45-41	89-07	10
1646	Minnesota	47-33	94-09	2
1647	Minnestoa	47-33	94-10	2
1649	New Hampshire	44-51	71-26	10
1652	Alaska	65-21	144-30	6
1653	Alaska	63-45	144-53	S
1654	Alaska	66-35	145-11	1
1655	Maine	44-50	68-38	15
1657	Labrador	52-36	56-26	S
1658	Labrador	53-46	60-05	S
1659	New Brunswick	47-50	68-21	S
1660	Quebec	46-32	76-30	S
1661[c]	Quebec	48-18	71-22	S
		48-13	71-38	
1662	Ontario	48-00	81-00	S
1663	Ontario	45-44	76-51	S
1664	Manitoba	54-39	101-36	S
1665	Saskatchewan	59-19	105-59	S
1667	Yukon	60-49	135-35	S
1669	Minnesota	47-33	94-08	6
1676	Michigan	44-30	83-45	17
1677	British Columbia	54-00	123-00	S
1678	Manitoba	56-56	92-51	S
1686	Ontario	52-15	81-40	25
1687	Ontario	48-30	89-30	S
1697	Saskatchewan	49-40	109-40	S

[a] Taken from Nienstaedt 1969.

[b] S indicates stand collection.

[c] This seed source includes samples from two areas.

An analysis of variance using plot means was calculated for the number of galls per tree, percent of trees attacked (transformed to arcsin percentage), and number of galls in each cardinal direction. Duncan's new multiple range test (5 percent level) was used to test for significant differences between means. Relationships between tree height and number of galls per tree and percent of trees attacked per source (transformed to arcsin ✓percentage) were established by subjecting the plot mean data to correlation analyses.

RESULTS AND DISCUSSION

The eastern spruce gall aphid was present on 49 percent of the test trees. There was an average of 2.4 galls on the eight branches examined on each tree (Table 2). Significant differences (.01 level) were found for percent of trees attacked and number of galls per source (F values of 4.80 and 4.21 respectively). Sources with the least number of galls per tree also had the fewest trees per source attacked (r=.90). Much of the variation present in the degree of susceptibility to attack was accounted for by the differences between seed sources. Seed source variation accounted for 23 percent and 27 percent of the total variation in percent of trees attacked and number of galls per tree respectively.

The percent of trees attacked per source and average number of galls per source were both significantly correlated (.01 level) with height (r=.2007 and .3613, respectively). Although these values were significant, they explained only 4 percent and 13 percent of the variation in percent of trees attacked and number of galls per tree respectively. There was no significant difference in the number of galls present in the four cardinal directions.

The seed sources most severely attacked were those from the eastern part of the botanical range of white spruce (Table 2). Among the fast-growing commercially important sources east of 80°W longitude that were heavily attacked were: 1644 (New York); 1649 (New Hampshire); 1655 (Maine); 1659 (New Brunswick); 1660 (Quebec); and 1664 (Beachburg, Ontario). All of these sources grew as fast or faster than the local 1655 (Maine) source. Sources west of 80° W longitude that were faster growing or nearly as fast growing as the local 1655 (Maine) source and not severely attacked were: 1631 (Manitoba); 1645 (Wisconsin); 1647 (Minnesota); 1662 (Ontario); 1669 (Minnesota); 1676 (Michigan); and 1687 (Ontario).

Table 2.—Mean height and the degree of susceptibility to attack by the eastern spruce gall aphid of white spruce from 24 seed sources planted in central Maine in 1961 and examined in June 1977.[a]

Seed Source Number	State or Province	Number Trees Evaluated	Height (Meters)	Number Galls per Source[b,d]	Percent Trees Attacked[c,d]
1647	Minnesota	35	3.34	0.65a	10.0 a
1669	Minnesota	33	3.47	0.45a	16.5 ab
1630	Montana	27	1.80	0.62a	25.0 abc
1687	Ontario	32	3.33	2.86abc	27.5 abcd
1645	Wisconsin	38	3.56	0.93a	28.0 abcde
1676	Michigan	28	3.99	0.70a	32.0 abcdef
1665	Saskatchewan	21	2.02	1.03a	33.5 abcdefg
1653	Alaska	25	1.62	1.32a	34.0 abcdefgh
1631	Manitoba	29	3.32	0.97a	37.0 abcdefghi
1654	Alaska	21	1.58	0.60a	39.5 bcdefghij
1662	Ontario	29	3.24	1.61a	40.0 bcdefghijk
1677	B. Columbia	30	2.64	1.95ab	41.0 bcdefghijkl
1686	Ontario	35	3.06	1.73a	42.5 bcdefghijklm
1657	Labrador	29	2.00	1.25a	47.5 cdefghijklmn
1664	Manitoba	28	2.73	2.52abc	48.0 cdefghijklmn
1644	New York	28	3.46	6.79de	58.0 fghijklmn
1655	Maine	33	3.46	3.56abc	58.5 fghijklmn
1660	Quebec	37	3.62	5.09bcde	58.5 fghijklmn
1661	Quebec	25	3.04	5.28cde	60.0 fghijklmn
1663	Ontario	31	3.86	2.68abc	60.5 fghijklmn
1649	N. Hampshire	31	3.74	3.78abc	63.6 ijklmn
1628	S. Dakota	29	2.53	2.38abc	67.0 jklmn
1658	Labrador	28	2.60	2.41abc	67.5 jklmn
1659	N. Brunswick	30	3.63	6.81e	76.5 n
Average			3.05	2.46	44.7

[a] Sources are arranged in order of increasing percent of trees attacked.

[b] Average number of galls on the eight branches examined per tree.

[c] Data transformed to arcsin$\sqrt{\text{percent trees attacked}}$.

[d] Sources with letters in common were not significantly different at the .05 level.

DISCUSSION

Data from this study strongly indicate that genetic variability to attack by the eastern spruce gall aphid does exist in white spruce from several seed sources within the species' natural range. No previous reports of genetic differences to insect attack have been published for white spruce.

Results indicate that Christmas tree growers and other persons in Maine with an interest in the aesthetic value of white spruce trees could lessen the extent to which trees are attacked by the eastern spruce gall aphid by using seed from either the Lake States or western Canada. No sacrifice in height growth would be made by using seed from those sources since several of them are amongst the fastest growing in the plantation. The highly acclaimed 1663 (Beachburg, Ontario) is one of the sources most severely attacked in the plantation and cannot be recommended for planting where the eastern spruce gall aphid is a serious problem.

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