Cone production of balsam fir damaged by balsam woolly aphid

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Abstract

The effect of balsam woolly aphid, *Adelges piceae* (Ratz.), damage on cone production by balsam fir, *Abies balsamea* (L.) Mill., was studied on 49 trees classified into six aphid damage classes. Results showed that there was no appreciable effect until damage exceeded the moderate level. Cone production on trees damaged beyond this level was seriously reduced but, since advanced damage is not reached by all trees simultaneously, it was concluded that adequate seed should be available for stand replacement.

Résumé

L'auteur étudie l'effet des dommages dus au puceron lanigère du sapin (*Adelges piceae* (Ratz.)) sur la production des cônes du sapin baumier (*Abies balsamea* (L.) Mill.). Les 49 tiges retenues pour l'étude ont été classées en fonction de 6 catégories de dommages dus à l'insecte. Les résultats montrent qu'il n'y a pas d'effet appréciable jusqu'à ce que les dommages dépassent le niveau modéré. Ainsi, la production des cônes sur les arbres endommagés au-delà de ce niveau, a été réduite de façon importante, mais puisque le niveau des dommages avancés n'est pas atteint de façon simultanée chez tous les arbres en question, l'auteur conclut qu'une quantité suffisante de semences devrait être disponible pour subvenir à la formation d'un nouveau peuplement.

Introduction

The balsam woolly aphid, *Adelges piceae* (Ratzeburg), is an important pest of balsam fir, *Abies balsamea* (L.) Mill., the most abundant pulpwood species on the island of Newfoundland. Since its discovery in 1949, the aphid has spread through more than 6,000 square miles (15,500 km²). Aphid attack reduces the quality and volume of wood produced (Carroll and Bryant 1960) and may predispose trees to subsequent attack by other organisms such as hemlock looper, *Lambdina fiscellaria fiscellaria* (Guen.), (Otvos, Clark and Clarke 1971) and armillaria root rot, *Armillaria mellea* (Vahl ex Fr.) Kummer, (Hudak and Singh 1970). Periodic salvage operations have been necessary to avoid large volume losses.

This paper describes a study conducted to determine the aphid's effect on cone production.

Methods

Investigations were conducted in a stand of merchantable balsam fir where average tree age was 47 years, average height was 40 feet (12.2 m) and average diameter was 6 inches (15 cm). A good cone crop (20 or more cones per tree) has been produced in this stand every even-numbered year since 1954. Only a few cones were present in the intervening odd-numbered years. The crop was heavy, about 80 cones per tree, every fourth

year since 1956.

In Newfoundland, aphid attack usually occurs in the crowns of trees. It causes the swelling of branch nodes, the inhibition of bud and shoot development and dieback may occur. Damage often first appears 5 or 6 feet (1.5 to 1.9 m) below the crown apex of trees but subsequently spreads throughout the crowns. The stand in which the present study was conducted had been infested by the aphid for at least 10 years. Damaged trees were common and some mortality had occurred.

A total of 49 trees were randomly selected for examination. Visual symptoms of injury were used to characterize damage to these trees, according to the following classification system:

Level of Damage	Symptoms
Undamaged	— no symptoms.
Light	— swelling of nodes apparent only on close examination.
Light-to-moderate	— node swellings distinct, with some stunting and distortion of shoots.
Moderate	— node swelling and shoot distortion very distinct; no shoot dieback.
Moderate-to-severe	— pronounced nodal swelling and shoot distortion; top-most lateral branches dead or bare of needles.
Severe	— pronounced nodal swelling and shoot distortion; main stem terminal bud inhibited or dead; extensive branch dieback.

Individual standing trees were placed in the class that best described the most serious symptoms of damage then present in the crown; 10 were undamaged, nine had light damage; seven had light-to-moderate damage; seven had moderate damage; eight had moderate-to-severe damage; and eight had severe damage. This sample approximated the proportional distribution of the various levels of damage among trees in the stand.

After felling, all the cones produced during the

heavy-crop year of 1964 were counted. Cone production during the previous heavy crop in 1960 was determined by counting the spike-like cone axes that characteristically persist on trees for many years (the age of the shoot bearing the cone axis indicates the year that the cone was present). To determine if aphid damage caused a change in the distribution of cones upward or downward in the crown the counts of cones and cone axes found were tallied separately for each of the annually produced whorls of main stem nodal branches and for the branches that originated on each main stem internode between the nodal whorls. Also, one branch was randomly selected from each main stem nodal whorl and divided along its length into segments each containing one year of branch growth and the attached shoots. The number of cones of the 1964 crop were counted on each of these segments to determine the distribution along these nodal branches.

Results and discussion

Average total cone production during 1964 was 87 cones on undamaged trees; 56 of these were found on main stem nodal branches and the remainder were on the main stem internodal branches (Table 1). Cone production averaged 70 or more on trees in each of the light, light-to-moderate and moderate damage classes, and about 55% of these cones were found on the main stem nodal branches. Trees in the moderate-to-severe damage class averaged only 19 cones and only about four cones were produced on each severely damaged tree. Average total cone production in the previous heavy crop year for all trees except those in the severe class was 57 or more. About 69% of these occurred on main stem nodal branches. Trees in the severe class averaged only 37 cones for the previous heavy year of different ages. The percentage that were located

crop and their low production was probably caused by aphid damage to the trees before the occurrence of the 1960 cone crop.

When expressed as a percentage of the previous heavy crop, total cone production in 1964 increased to 128% on undamaged trees and to 158% on trees in the light damage class; it decreased to 88% on trees in the light-to-moderate class; was nearly equal on trees in the moderate damage class; decreased to 23% for trees in the moderate-to-severe damage class; and to 10% for severely damaged trees. These data show a marked decrease in total cone production between 1960 and 1964 crops on trees as damage increases beyond the light class. Production on main stem nodal branches, like total production decreased for the 1964 crop in each succeeding level of damage beyond the light damage class. However, cone production for the 1964 crop on main stem internodal branches was not appreciably decreased until damage exceeded the moderate class. The increase in total cone production between crop years by trees in the light damage class over that of undamaged trees occurred largely on main stem nodal branches. It is postulated that this increase may have occurred in response to the initiation of aphid damage.

The occurrence of cone axes from a number of previous cone crops on all sample trees indicated that they were all cone bearing trees and should have produced cones in the more recent crop year. However, data show that 25% of the trees in the moderate-to-severe damage class and 62% in the severe class did not produce cones in the more recent crop year presumably because aphid damage had increased since the previous crop was produced.

The counts of cones from the 1964 crop indicated that aphid damage caused changes in the distribution of cones among the main stem branches

TABLE 1. Means and standard deviations of total cone production and cone production on main stem nodal branches for 1964 and previous cone crop (1960) on trees in six balsam woolly aphid damage classes^a

Damage class in 1964	No. trees examined	Total production		Nodal branch production	
		1964	1960	1964	1960
Undamaged.....	10	87 ± 34	68 ± 48	56 ± 27	53 ± 34
Light.....	9	90 ± 67	57 ± 40	53 ± 48	39 ± 28
Light-to-moderate.....	7	70 ± 36	79 ± 51	37 ± 25	46 ± 31
Moderate.....	7	75 ± 39	77 ± 58	41 ± 26	60 ± 52
Moderate-to-severe.....	8	19 ± 22	82 ± 40	13 ± 16	52 ± 41
Severe.....	8	4 ± 5	37 ± 32	2 ± 3	18 ± 17

^aAverage cone production on main stem internodal branches is the difference between total production and nodal branch production.

TABLE 2. Percentage distributions of cones produced by main stem nodal and internodal branches of different ages in 1964 by trees in six balsam woolly aphid damage classes.

Damage class	No. cones found	Nodal branches								No. cones found	Internodal branches					
		% cones by branch age (years)									% cones by branch age (years)					
		2	3	4	5	6	7	8	9		2	3	4	5	6	
Undamaged	55	1	18	46	25	8	2			309	21	46	28	5		
Light	478	3	20	32	21	21	2		1	332	24	58	17		1	
Light-to-moderate	257	3	18	33	24	17	5			231	20	38	26	14	2	
Moderate	290	3	18	27	27	13	10	1	1	238	21	29	33	13	4	
Moderate-to-severe	103	6	15	27	16	10	25	1		46	9	48	19	2	22	
Severe	20	5	55	20	20					8	37	25	13

Figure 1. Distribution of cones produced in 1964 on primary whorl branches of trees in six aphid damage classes.

on 4-year-old or younger nodal and internodal branches decreased as the level of damage increased from the light class up to the moderate-to-severe class (Table 2). On trees in the severe damage class most cones were found on 3-year-old nodal and on 2-year-old internodal branches: no cones were produced on branches that were more than 5 years old.

The distribution of cones of the 1964 crop along branches from the one branch sample of each whorl of primary nodal branches is shown in Figure 1. Cones were most frequently present and were also most numerous on the 2 to 4-year-old segments of the branches regardless of damage, but cones were distributed differently and were less numerous on trees in the moderate-to-severe and severe damage classes. In particular, the overall decrease in cone production resulting from increasing aphid damage is very apparent in this figure.

Management implications

This study has shown that the balsam woolly aphid had no appreciable effect on cone production until damage exceeded the moderate level. Beyond the moderate level aphid damage seriously reduced cone production. However, as advanced damage is not reached by all trees simultaneously it can be concluded that aphid infested stands will probably produce adequate seed for stand replacement, providing, of course, that aphid injury to trees is not detrimental to seed quality.

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