EFFECTS OF INSECTS ON SEED AND CONE PRODUCTION

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INTRODUCTION

My presentation on the effects of insects on seed and cone production is primarily based on conditions in the three prairie provinces, although I realize that much of the information base comes from adjacent provinces and from other outside sources. Also, because of the shortage of time, I will not deal with problems of seed storage.

Within this region of Canada, three coniferous species provide the major seed supplies for most reforestation programs, namely, white spruce, jack pine, and lodgepole pine. Seed and cone insects on spruce have been given widest attention for several reasons: (a) The insect complex on white spruce is fairly diverse and includes at least two important species that are consistently present throughout a wide geographical range extending from eastern Canada to British Columbia and Alaska. (b) Insect-caused damage to seeds and cones of spruce has been sufficiently high as to render cone collecting unprofitable. This has not usually been the case for lodgepole and jack pines. (c) Cone crops on white spruce tend to be more sporadic than those on pine, and therefore insect-caused losses, when they occur, are often more critical to seed supplies. (d) White spruce seeds are not retained in cones on the tree after the year of production and must be collected during the year they are produced and prior to release. This is not the case with lodgepole and jack pines, which retain several years of seed-bearing cones.

Although most of the information I have relates to white spruce, I will indicate potential insect problems on other important tree hosts, including balsam fir, eastern larch, black spruce, Douglas-fir, and red pine.

CONE AS A HABITAT FOR INSECTS

The female cone structure of conifers is a highly complex organ that has necessitated development of specialized adaptations by many of the insect species in order to survive. Each cone consists of a central axis around which close-fitting scales are arranged in a spiral directed toward the cone apex. Each scale may have a bract attached to its outer surface, and on its inner concave surface next to the central axis lie two seeds. A thin membranous wing is attached to each seed. In most cones the scales may be smaller at the base and apex, and most of the potentially sound seed is produced in the central portion of the cone. Much of the insect damage also tends to occur in the central portion of the cone.

In species such as spruce, fir, and tamarack in which cone development is completed in 1 year, the cone must grow from a small soft budlike structure in the spring to an elongated structure of hardened tissue by August. During this period the insect must also respond to these changes in its development and behavior. For example, moisture content in the spring may vary from 120% to 160% dry weight, but by September it will have dropped to 30-60% dry weight.

The insect species that inhabit cones of the different tree species have become highly specialized in several ways. Many are specific to a single host, while others are specific to certain structures of the cone. Specializations are apparent in both the adult and immature forms that allow, for example, exclusive feeding of larvae within seeds such as by chalcids, within scale tissue as in the case of certain midges, and by spiralling around the central cone axis to damage or destroy several seeds as in the case of the spruce seedworm.

HOST SYNCHRONY AND PHENOLOGY RELATIONSHIPS

An important aspect of insect-cone relationships is the sporadic and variable cone productivity of most tree species. White spruce, for example, may produce a good cone crop on average only every 4 years. In general, populations of insect species attacking seeds and cones tend to fluctuate with abundance of cones, but other factors also influence their numbers. Many of these factors are not well understood. During years of cone scarcity many of the insect species survive the discontinuity of food supply by adaptation to remain dormant. During such periods of food scarcity a portion of the population may remain in dormancy for 1, 2, or more years. There is a tendency for dormancy to coincide with years of low cone yield.

There is also a synchrony of insect development in relation to phenological development of the host. For example, spring emergence of the spiral cone midge on spruce in any given geographical location always coincides with the period of pollination.

KINDS OF INSECTS AND THEIR DEVELOPMENT

The complex of insect species attacking seeds and cones can be divided into two broad groups:

a. Internal feeders - Members of this group feed exclusively within the cone and include midges, certain moth larvae, beetles, and seed chalcids. They appear to be the most highly specialized for their habitat. During feeding they often leave little evidence of attack on the exterior of the cone.

b. External feeders - Members of this group mostly feed externally on the cone or burrow indiscriminantly throughout the cone. Certain species such as seedbugs feed externally by extending tubelike sucking mouthparts into the young cone tissue. Others such as the spruce budworm and spruce coneworm also feed on foliage and utilize more than one host.

LIFE HISTORY

Most seed and cone insects have a 1-year life history, although a variable proportion of the population of many species may remain in dormancy for 1 or more years. For most species, adult emergence occurs in the spring, and eggs are laid about the time female cones are open for pollination. Larval feeding (the damage stage in most species) commences shortly after eggs are laid and is completed during late June to early August, depending upon the species. Specialization of feeding and development allow one or several species to co-exist within the same cone.

INSECT SPECIES COMPLEX AND THEIR DAMAGE

Slides were shown to illustrate several insect species and the damage caused by internal and external feeders.

STAND CHARACTERISTICS, CONE PRODUCTION, AND INSECT ABUNDANCE

Information is relatively rare on fluctuations of seed and cone insect populations from year to year. In one study followed for 6 years in British Columbia, four insect species in Douglas-fir cones were monitored. Their abundance generally followed the same trend as cone abundance. Small differences in species abundance were attributed to the elevation at the plot locations. It has been widely observed that cone and seed damage is often greatest during years when cone productivity is low, probably because the ratio of insects to cones is much higher then than when cone productivity is high. During years of low cone production the percentage of damaged cones of white spruce and Douglas-fir can reach 100%, but it may only reach 25% when cones are abundant. This suggests that additional collecting of cones should be done during years of cone abundance.

Within crowns there appears to be little variation in insect species diversity. On Siberian larch in the USSR, however, three main damaging species are usually present, but their population densities may fluctuate from area to area, tree to tree, and even within crowns of individual trees.

The incidence of damaged cones and seed may also vary greatly from location to location within the same year. In 1967, a year of fairly good cone production in Alberta, white spruce cone collections were made at 17 locations throughout the province. The incidence of damaged cones at these locations varied from 4% to 97%. In 1978 two white spruce cone collections from the Lac la Biche area had estimated seed losses due to insect damage of 31% and 42%, but the average number of potentially viable seeds per cone was relatively low (average 42 and 31 per cone). The fact that the number of potentially viable seeds per cone varies with cone production may help account for the higher insect losses in different locations and years.

In 1979 two locations near Grande Prairie were sampled, and the incidence of damaged cones was 21% and 10%, even though good cone crops were produced at both locations. This amounted to only 5-6% seed loss due to insects alone.

In Ontario a recent study of insects attacking white spruce cones in three different habitats indicated that the abundance of certain insect species varied greatly with stand conditions. This could have implications where stands are thinned and maintained for permanent seed collecting areas. In special areas where higher cone productivity is promoted there is the possibility these areas will sustain higher losses due to insects than will the surrounding forested areas. Hence, some form of control may have to be instituted on an annual basis.

There is evidence that fertilization of stands to promote tree growth may also affect insects in an unfavorable way. For example, in shelterwood stands of Norway spruce in northern Europe, fertilization with nitrogen and phosphorus caused increases in both larval numbers and weights of larvae of *Laspeyresia strobilella*, a cone-feeding insect. This occurred 1 year after application of fertilizer.

INSECT-CAUSED LOSSES PER CONE

Seed losses per cone are dictated by the insect species involved, the incidence of cones damaged, and the number of insects per cone. The following examples of white spruce cones containing one larva of *Laspeyresia youngana* or *Hylemya anthracina* illustrate the potential damage.

L. youngana: (British Columbia estimate) One larva destroys 23-40% of seeds.

H. anthracina: (British Columbia estimate) One larva may destroy 30-90% of seeds per cone.
(Alberta estimate) One larva may destroy an average of 40% of seeds per cone.

CONTROL STUDIES OF SEED AND CONE INSECTS

Several attempts have been made since the 1960s in both Europe and North America to control insects of seeds and cones by use of chemical insecticides, especially those with systemic properties. Dimethoate and metasystox-R applied as a 0.5-1.0% solution in water have generally provided good control on white spruce and Douglas-fir in British Columbia and the northwestern United States. Application to spruce seed orchards in Finland has also given good control. However, timing of application is important and should be made shortly after pollination or about the time when cones have started to turn down. Concentrations of insecticide greater than 1% have produced phytotoxic effects, especially when applied during pollen germination. Application by helicopter has helped ensure good coverage of the upper crown and cone-bearing twigs.

In pine seed orchards of the southern United States, carbofuran has been applied to the soil to effectively control two species of seedbug. Percentages and yields of filled seeds per cone were greatly increased with application of 45 g of 10% carbofuran per cm of tree diameter of loblolly, slash, shortleaf, and Virginia pines.

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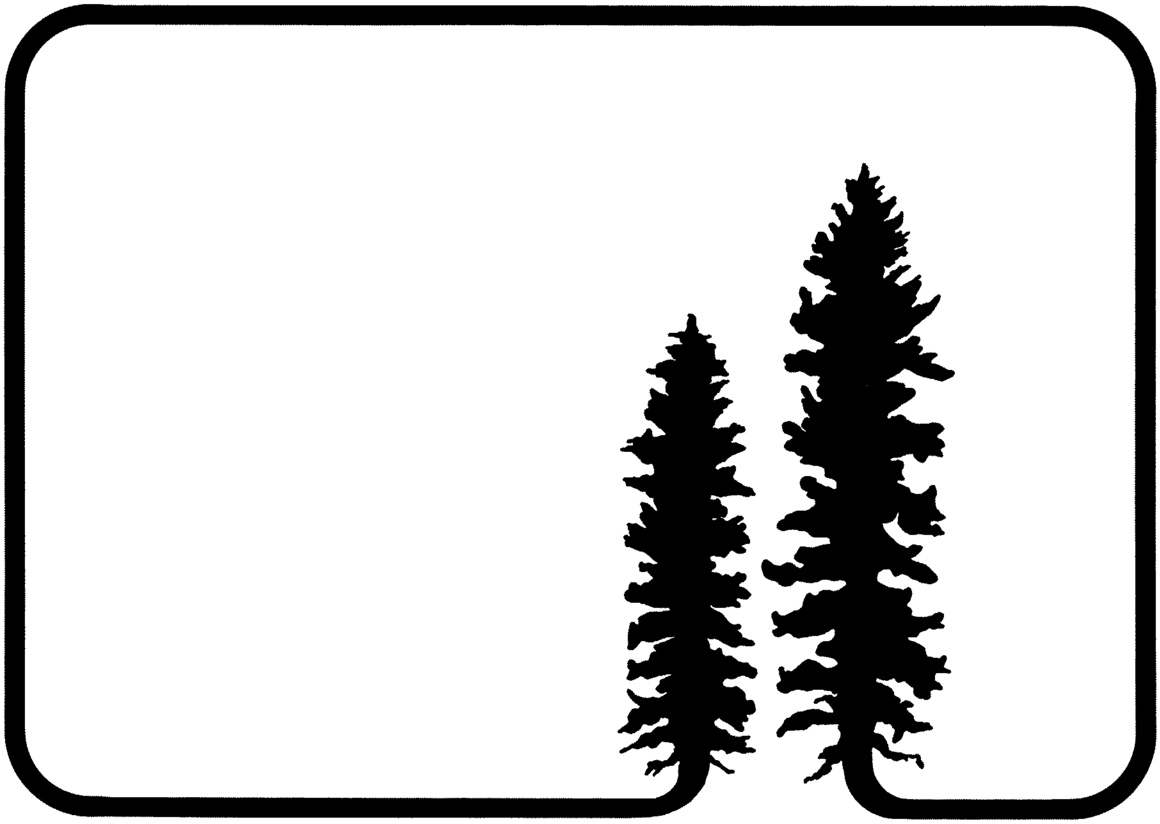
High-quality collection and production of conifer seed

Proceedings of a workshop held

November 14, 1979, in Edmonton, Alberta



Compiled by R. F. Huber

Northern Forest Research Centre • Edmonton, Alberta • Information Report NOR-X-235