TABLE 2

Radiation sterilization of adult male spruce budworm.

Treatment (kR/♂)	Sample size	% mating failure	% egg hatch from ♀ that mated with irradiated ♂
0	17	35	76
10	16	31	59
30	20	20	0
40	20	50	0

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PATHOLOGY

Infection of Engelmann Spruce by Hemlock Dwarf Mistletoe.—Evidence from nature and from artificial inoculations indicate that hemlock dwarf mistletoe [*Arceuthobium campylopodum* Engelm. f. *tsugehsis* (Rosend.) Gill] will infect about 20 conifer species and varieties included in the genera *Tsuga, Abies, Pinus, Larix* and *Picea*. Extensive damage is generally restricted to the principal hosts, western hemlock [*Tsuga heterophylla* (Raf.) Sarg.] and mountain hemlock [*T. mertensiana* (Bong.) Carr.], though pure stands of shore pine [*Pinus contorta* Dougl.] are occasionally severely attacked.

Species of spruce [*Picea*] are rarely attacked, and only when closely associated with infected western or mountain hemlock. Reports of natural infection exist for Brewer spruce [*P. breweriana* S. Wats.] in California (Hawksworth and Graham, Nthwst. Sci. 37:31-38, 1963) and Sitka spruce [*P. sitchensis* (Bong.) Carr.] in Alaska (Laurent, Plant Dis. Reptr. 50:921, 1966) and British Columbia [Molnar *et al.*, Can. Dep. For., 1967 Ann. Rpt. For. Insect Dis. Surv., 1968). Inoculation of white spruce [*P. glauca* (Moench) Voss] and Norway spruce [*P. abies* (L.) Karst.] showed these species were also susceptible to hemlock mistletoe (Smith, Can. Dep. For., Bi-m. Progr. Rpt. 21(6):3-4, 1965). In September 1969, F. G. Hawksworth (Rocky Mtn. For. and Range Exp. Sta., Ft. Collins, Colorado, Pers. comm. 1969), found a suppressed Engelmann spruce [*P. engelmannii* Parry] with several mistletoe-caused brooms near Santiam Pass, Oregon. No aerial shoots were visible but basal cups were present. Because the spruce occurred among western hemlock trees heavily infected by hemlock dwarf mistletoe, the mistletoe on it was assumed to be the same. This note presents information on the susceptibility of Engelmann spruce to hemlock dwarf mistletoe gained from artificial inoculations.

Inoculations were carried out near Victoria on plantation-grown Engelmann spruce from two provenances, Montana and southeastern British Columbia. The test trees were thrifty, growing almost 12 inches per year during the past 5 years. Seeds were collected and stored and inoculations effected, but only at the axils of needles, as previously described (Smith, Bi-Mon. Res. Notes, 2:—, 1970). Each year from 1963-1966, 10 mistletoe seeds from each original host were planted on each of four trees of the two provenances. A total of 640 seeds were used during the 4-year period.

Sixty-three infections were obtained; 28 swellings appeared within 1.5 years of inoculation, while a few were not apparent until after 3 years. Swellings were more globose (length: width = 2.7:1) than those resulting from normal parasitism of western hemlock trees (5.7:1) growing in the same plantation. Aerial shoots appeared irregularly, as early as 1.5 years after inoculation in a few infections, but more commonly not for 2 years or more. By August 1969 (3-6 years after inoculation) more than half of the infections still lacked shoots, contrasting with infections on western hemlock in which all swellings produced aerial shoots within 3 years of inoculation. After emergence, aerial shoots on Engelmann spruce developed normally; the longest measured was 79 mm. Flowers developed on 13 of the infections and anthesis proceeded regularly. A few female flowers were observed in 1968 but failed to develop into fruit in 1969. More female flowers appeared in 1969 and they seemed to be developing normally at the last examination.

Because of the earlier success with white and Norway spruce, infection of Engelmann spruce was not entirely unexpected. However, the high rate of infection was surprising. In particular, 44 infections developed from 160 seeds planted in 1965, an infection rate of 28%. This included 16 infections on southeastern British Columbia Engelmann spruce from 40 seeds collected from shore pine. Other than the latter particularly successful combination, there were no overall differences in the susceptibility of Montana and British Columbia spruce, or in the infectiveness of hemlock mistletoe from hemlock and shore pine.

Considering the relatively high frequency of infection produced in this study, natural infection of Engelmann spruce can be expected to occur wherever it is exposed to hemlock mistletoe. The Santiam Pass report noted earlier is the first observation of this in nature. In this case, the absence of living shoots prevented verification of the mistletoe species, but the presence of only hemlock mistletoe in the area and the demonstrated susceptibility of Engelmann spruce indicate that hemlock mistletoe was likely the casual agent. As range maps suggests that Engelmann spruce and hemlock mistletoe are probably sympatric in other areas of the Cascade Mountains in Oregon, Washington and British Columbia, other instances of this host-parasite combination undoubtedly exist. Hemlock mistletoe on Engelmann spruce may not be extensive or particularly damaging, but forest managers concerned with mistletoe control should be aware of this potential source of dwarf mistletoe inoculum.—R. B. Smith, Forest Research Laboratory, Victoria, B.C.

Development of Corky Root Disease in Douglas-fir Transplants.—Corky root, a stunting disease of Douglas-fir seedlings (Bloomberg, Can. Dep. For., Bi-Mon. Res. Notes 24:8, 1968), was probably introduced into the Duncan, B.C., forest nursery in fill-soil containing large populations of the nematode *Xiphinema bakeri* Williams 1961 (Sutherland and Dunn, Plant Dis. Reptr. In press). Consequently, the disease is present in well-defined areas.

In 1967, 1-0 Douglas-fir of a single seedlot from an uninfected nursery were transplanted into the area containing the nematode-infested soil and also into an area containing the original nursery soil. Two years later, the transplants in small patches of the imported soil area were severely stunted but elsewhere stunting was absent. For sampling purposes, the area was divided into "stunted" and "unstunted" plots. Five transplants were removed from each plot by carefully digging out as much of the root system as possible, together with surrounding soil. The plants and soil were placed immediately in polyethylene bags. For comparison, six transplants plus surrounding soil, in an adjoining area containing the original nursery soil, were dug from eight points about 20 feet apart.

Shoot and root growth of each seedling were measured. Lateral roots, and new root tips were counted. Disease severity in roots was rated by degree of swelling, lack of root hairs and clubbing of root tips.

The number of *X. bakeri* on seedling roots were determined by carefully removing the roots, with adhering rhizosphere soil, and quickly submerging them in a bucket half-filled with water. The roots were then washed with a stream of water, and the nematodes extracted by a modified (final screen of 325 mesh) Christie and Perry method (Proc. Helminthol. Soc. Wash. 18:106-108, 1951). To determine the populations of *X. bakeri* in the soil, each sample was thoroughly mixed and the nematodes extracted, by the same procedure from a 500 g (wet wt) aliquot. Nematode counts were expressed on an oven-dry weight of soil basis.