The Effects of Keithia Blight on Outplanting Performance of Western Redcedar Container Seedlings at Two Reforestation Sites in British Columbia—Preliminary Results

David Trotter[1], Gwen Shrimpton[2], and Harry Kope[3]

Trotter, David; Shrimpton, Gwen; Kope, Harry; 1994. The Effects of Keithia Blight on Outplanting Performance of Western Redcedar Container Seedlings at Two Reforestation Sites in British Columbia—Preliminary Results. In Landis, T.D.; Dumroese, R.K., technical coordinators. Proceedings, Forest and Conservation Nursery Associations. 1994, July 11-14; Williamsburg, VA. Gen. Tech. Rep. RM-GTR-257. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 196-202. Available at: http://www.fcnanet.org/proceedings/1994/trotter.pdf

Abstract—The significance of various infection levels of Keithia blight on 2+0 container western redcedar seedlings after outplanting is examined. Increasing levels of Keithia infection had a negative effect on height and root collar diameter but did not impact survival. Site climate humidity appeared to contribute to the continued severity of the disease. Seedlings sprayed at the recommended nursery rate and timing with mancozeb were larger and had less disease.

INTRODUCTION

Keithia blight is a foliar disease of western redcedar, *Thuja plicata* Don, and is caused by the fungus, *Didymascella thujina* (Dur.) Maire. The fungus is an obligate parasite that is endemic to North America and is found throughout the geographical range of western redcedar (Pawsey, 1960; Sinclair et al, 1987). One of the first descriptions of significant *D. thujina* infestations of *T. plicata* was recorded in 1912 to 1915 from northern Idaho (Weir, 1916). It has also been reported on eastern white cedar, *Thuja occidentalis* L., and on *Thuja* spp in Europe due to introductions of cedar imported from North America (U.K. Forestry Commission, 1963). Individual trees vary in the degree of infestation and although all age classes are affected, seedlings and young trees are the most susceptible stages (Pawsey, 1962). Keithia blight is considered a two year disease, with infection of individual leaflets occurring in the first growing season, and disease expression and spread developing in the second. Damage is usually minimal on one year old seedlings and if present, it is confined to juvenile and mature leaves on the lower stem. In general, spread of the disease is encourage by mild temperatures and high humidity (H. Kope, pers. comm., Aug. 1994). The ascospores require free water and temperatures above 10°C for release and relative humidities above 95% and 15°C for germination. The fungus is not systemic but kills individual leaflets. After several weeks, spores form in structures called apothecia and as they mature they are forcibly ejected up to 5 cm to adjacent foliage and the infection

[1] B.C. Ministry of Forests, 14275 96th Ave, Surrey, B.C. V3V 7Z2. Tel (604) 930-3302

[2] B.C. Hydro, Vancouver, B.C.

[3] Applied Forest Science Ltd., Victoria, B.C.

cycle spreads through the plant. The ascospores are coated with a very thin and sticky film and once they affix to any surface they are difficult to remove with out damaging them. In addition, ascospores can be either wind or water-borne and are thought to be carried for great distances. Heavy infections of branches can significantly reduce seedling vigor, performance and occasionally survival. However, once seedlings are 4-5 years old they appear to overcome the effects of the disease.

In 1988, the first major Keithia blight infestation of western redcedar in a British Columbia container nursery was recorded and resulted in significant nursery and reforestation site losses. Since then, all coastal nurseries have recorded Keithia blight infestations, primarily in 2+0 container stock. In 1991-92, about one million seedlings were discarded due to the disease. In 1988 at Humbolt Nursery in California, over 60,000 seedlings were rejected due to moderate to heavy levels of Keithia blight (Frankel, 1990). Due to the aggressive nature of the disease, and its effects on outplanting performance, most field staff and administrators are faced with the problem of determining an acceptable level of Keithia blight on seedling stock. In recent years, studies by Natural Resources Canada - Pacific Forestry Center and the B.C. Ministry of Forests have reviewed the epidemiology of the disease, evaluated the available registered fungicides, and assessed outplanting survival. A screening of 5 registered fungicides found that bi-weekly applications of mancozeb through the growing season was effective at protecting seedlings from infection. In 1992, a preliminary outplanting study was initiated to evaluate seedling performance in relation to described levels of Keithia blight infection and site environment (D. Trotter, unpublished data, 1994, B.C. Ministry of Forests). Six sites were selected in five forest districts of coastal B.C. Each site was planted with 2+0 container seedlings having low (0-5%), medium (5-10%) and high (>10%) Keithia blight levels based on initial assessments of the foliage prior to storage and shipment. In addition, the stock was further compromised with the identification of stem lesions caused by the disease. This preliminary survey found that the degree of infection coupled with site characteristics appeared to contribute substantially to seedling survival and the aggressiveness of the disease after outplanting. Overall, seedling performance was compromised with increased site wetness and vegetation competition in conjunction with the degree of Keithia blight infection. Seedlings outplanted on the drier sites performed significantly better and eventually recovered after one year. In contrast, seedlings planted in the wetter sites, regardless of infection level, continued to be affected by the disease even after two field seasons.

In order to aid nursery personnel and field foresters, the following study was initiated to; a) evaluate the efficacy of a nursery fungicide treatment with mancozeb on outplanting, and b) develop grading criteria in relation to field performance and site characteristics.

MATERIALS AND METHODS

Seedling Source

This study was initiated at the Surrey Nursery, B.C. Ministry of Forests, which is located 35 km southeast of Vancouver, British Columbia. Western redcedar seedlings destined for outplanting assessments were selected from 2+0 415b container stock (527 seedlings per m^2) grown under operational conditions. After the first growing season, an operational spray program was initiated in which the fungicide, mancozeb was applied bi-weekly at a rate of 2.75 kg a.i./ha from June to November, 1992. Mancozeb is the recommended control for protecting western redcedar foliage from infection by Keithia blight (Barnett, 1993). Twenty-four containers of this crop were maintained as controls. The treatments were assessed bi-weekly just prior to the fungicide application. At each assessment,

10 randomly selected seedlings from each of five styrofoam containers per treatment were evaluated for the number of Keithia blight pustules or apothecia per seedling. At the end of the growing season, seedlings treated with mancozeb had no visible signs of Keithia blight. In contrast, control seedlings had infestations ranging from 0-100% of their foliage infected with the disease. In December 1992, the seedlings were categorized based on the percentage of foliage infected and treatment. The four categories were as follows: 1) 0% Keithia infection/mancozeb treatment, 2) 0% Keithia infection/control, 3) 10% Keithia infection/control and 4) 50-100% or 50+% Keithia infection/control. Seedlings were randomly selected from the two treatments, assessed for the total number of visible Keithia pustules and assigned to one of the above categories. Fifty seedlings per category were then bundled into individual wax-coated cardboard boxes, sealed and placed in a freezer storage unit at -4° C.

Study Locations

From previous preliminary outplanting studies, 2 reforestation sites were selected for outplanting of the trial stock (Figure 1).

The Holt Creek site, Duncan District (Lat. N48° 45", Long. W 124° 05"), has predominately coastal Douglas-fir *(Pseudotsuga menziesii* (Mirib.) Franco) and western hemlock *(Tsuga heterophylla* (raf.) Sarg.) in the surrounding forest. The area has warm, dry summers and moist, mild winters with an average rainfall of 1500 mm/year. The biogeoclimatic zone classification is CWHxm. The Salmon Creek site, Port Alberni District (Lat. N. 48° 59", Long. W 125° 34") has a surrounding forest species composition dominated by western hemlock *(Tsuga heterophylla*), amabilis fir *(Abies amabilis* (Dougl. *ex* Loud.) Forbes) and western redcedar *(Thuja plicata* Donn *ex* D. Don *in* Lamb). The site has moist, mild summers and winters with an average rainfall of 2800 mm/year. The biogeoclimatic zone classification for the site is CWHvh1.

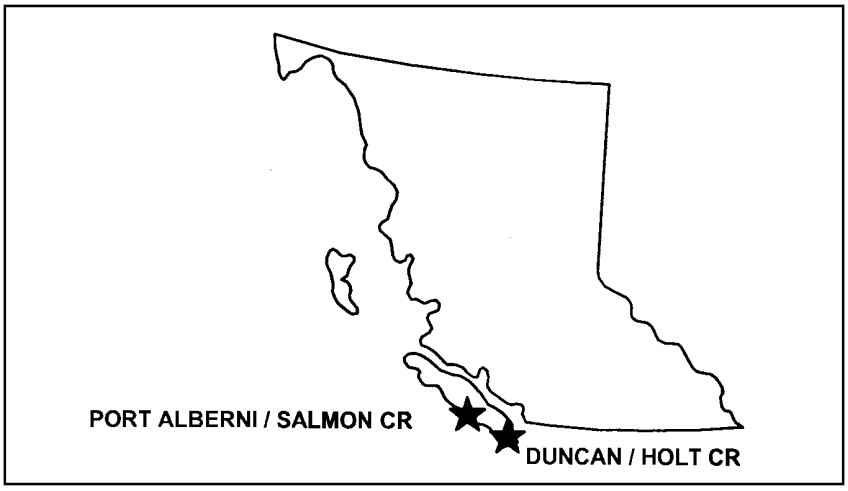

Figure 1. Location of trial outplanting sites in British Columbia.

Experimental Design

The trial seedlings were transported and outplanted at both reforestation sites on April 7-9, 1993. The seedlings were planted in a randomized complete block design with 5 seedlings and replicates respectively per Keithia infection category. The seedlings were positioned in rows with a 1 m spacing and a 3 m spacing between treatments. Each seedling was then covered with a 0.75 cm high plastic mesh tube for protection against animal damage. Seedlings at both sites were examined on October 19 & 20, 1993 (Fall, 93) and June 1 & 6, 1994 (Spring, 94). Stem heights and root collar diameters were measured at each site. Survival was scored into three categories; dead, unacceptable and acceptable. Seedlings were rated as unacceptable if they were found to be chlorotic and Keithia infections were recorded on both new and old foliage. The degree of Keithia infection was assessed by counting the number of pustules on the four top and bottom branches of each seedling.

Analysis

Differences among Keithia infection categories for mean height, root collar diameter and number of pustules were evaluated by analysis of variance and SNK multiple range test at the alpha level of 0.05.

RESULTS AND DISCUSSION

The degree of seedling survival for the 4 Keithia infection categories differed depending on initial Keithia infection and trial site. At the Holt Creek site, the Fall 93 assessment found overall only 13% of the 50+% category seedlings to be unacceptable (Fig. 2). By the Spring 94 assessment, the unacceptable 50+%/control treatment seedlings had died with additional mortality noted in the 0%/control treatment.

In contrast, the number of acceptable seedlings at the Salmon Creek site decreased significantly with increasing initial Keithia infection (Fig. 3). In addition, dead seedlings were found in all but the 0%/mancozeb treatment category. By the Spring 94 survey, the unacceptable seedlings had improved and were all rated as acceptable. The reduction in the percentage of dead seedlings in the 10%/control treatment was due to the appearance of new branchlets emerging from the base of some dead stems.

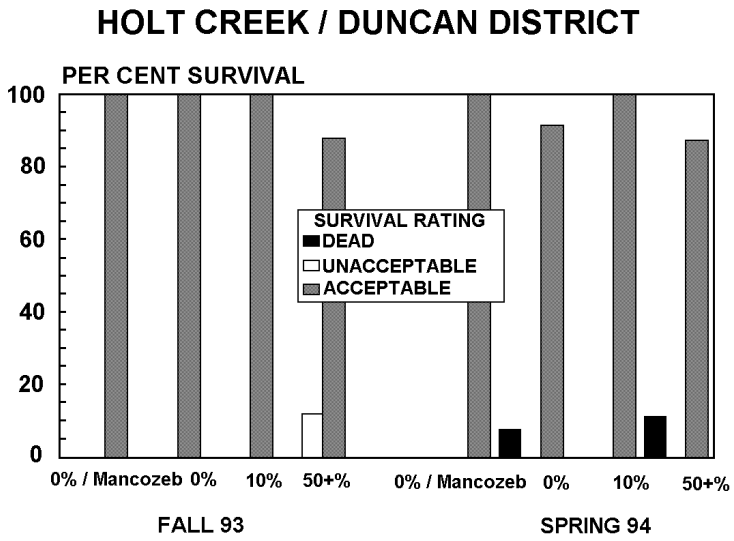

Figure 2. Per cent survival and rating of outplanted seedlings at the Holt Creek site.

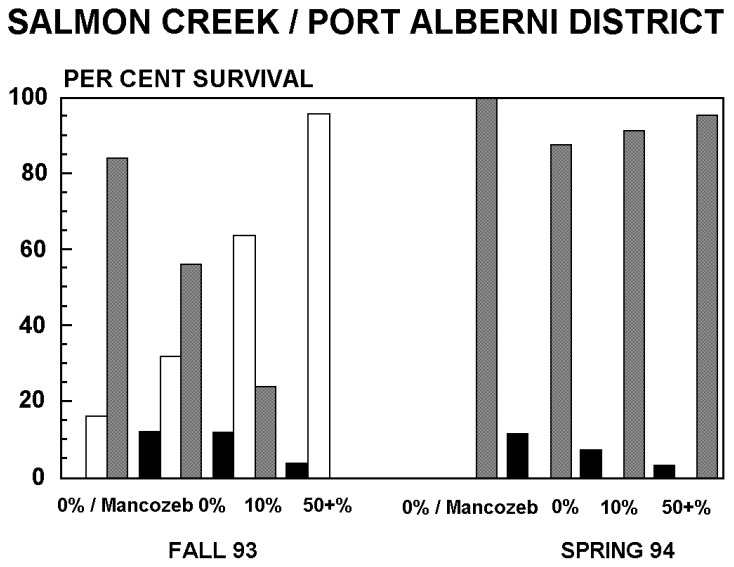

Figure 3. Per cent survival and rating of outplanted seedlings at the Salmon Creek site.

Both stem height and root collar diameter were significantly impacted by the level of disease. At Holt Creek, stem heights were found to decrease with higher Keithia infection levels while at Salmon Creek there was little difference in seedling heights (Figure 4).

For root collar diameter, the decrease was significant at both sites (Figure 5). In comparison, seedlings from Holt Creek, regardless of infection level, were larger after 14 months than those outplanted at Salmon Creek. At both sites, the seedlings treated with mancozeb were taller and thicker with the largest seedlings located at Holt Creek.

The degree of disease incidence on the foliage of the seedlings was closely correlated to the initial level of Keithia infection and the outplanting site. At Holt Creek, the number of pustules or apothecia found in the Fall 93 assessment was higher on the bottom than top four branches regardless of initial infection level (Figure 6).

Overall, the number of new infections was greater with correspondingly higher initial disease levels. By the Spring 94 survey, the number of infections had decreased in the top foliage and remained constant in the lower branches. Similarly, the seedlings at Salmon Creek were found to have less Keithia infection in the top foliage compared to the bottom branches, and that the number of pustules had increased from the initial infection level (Figure 7).

At Salmon Creek, the amount of Keithia infection in the top branches was found to decrease over time but the reverse was observed for the lower branches. Between the two sites and regardless of treatment, the degree of Keithia infection was significantly greater at the Salmon Creek location. In all cases, the 0%/mancozeb treatment seedlings had significantly less disease than the other treatments.

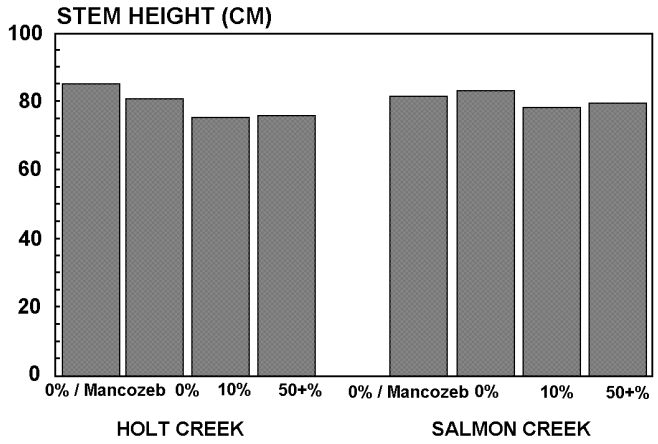

Figure 4. Mean stem height for outplanted seedlings for Spring 94 at both trial sites.

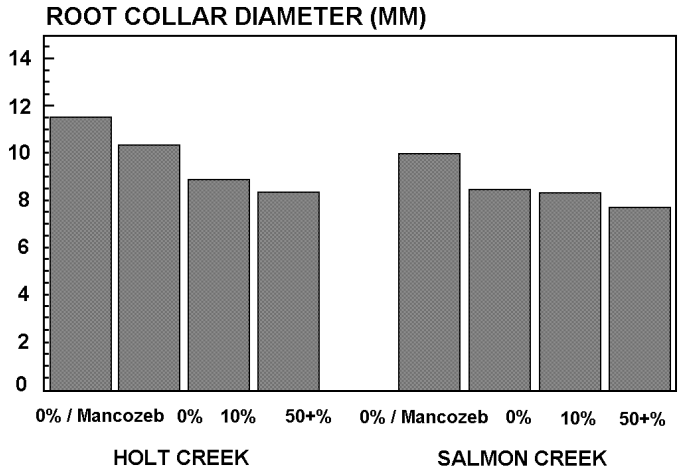

Figure 5. Mean root collar diameter for outplanted seedlings for Spring 94 at both trial sites.

The initial degree of Keithia infection coupled with environmental site differences appears to significantly impact on western redcedar seedling growth especially in the first year of outplanting. At both sites, seedling survival was not severily affected but initial seedling ratings were poor at Salmon Creek. Similar observations were reported from an outplanting of moderately infected western redcedar seedlings from Humbolt Nursery in California (Frankel, 1990). Furthermore, both the degree of infection and reduction in seedling growth were greater at the Salmon Creek site. At Holt Creek, the incidence of disease appears to be in decline across the 4 treatments but its early effects on seedling growth are still evident. The Salmon Creek site has a comparatively wetter climate and thus provides biological conditions conducive to Keithia blight. This is similar to findings by Porter (1957) who found that site microclimate was the chief factor responsible for differences in Keithia infection. Though a spray program with mancozeb can substantially reduce the effects of Keithia blight in the field, wet sites like Salmon Creek still afford an environment better suited for continued Keithia infection. Yet for nursery growers and field foresters, a mancozeb spray program presents a viable avenue to protect

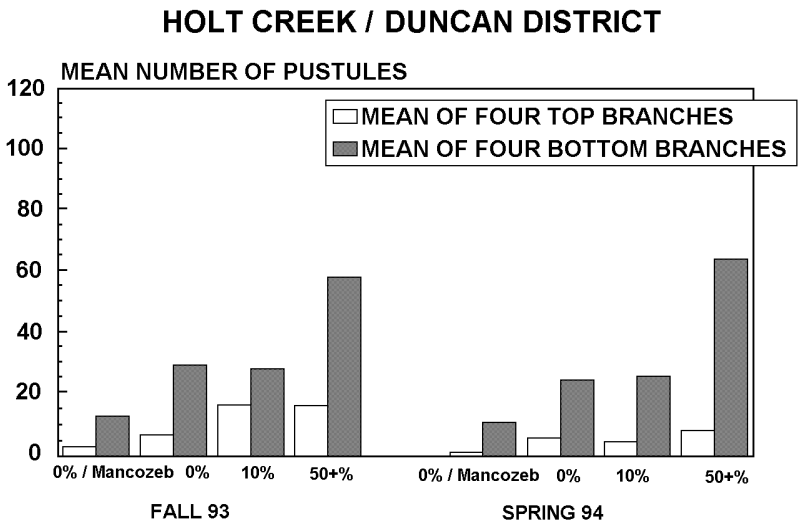

Figure 6. Total mean number of Keithia blight pustules on the four top and bottom branches of outplanted seedlings at the Holt Creek site.

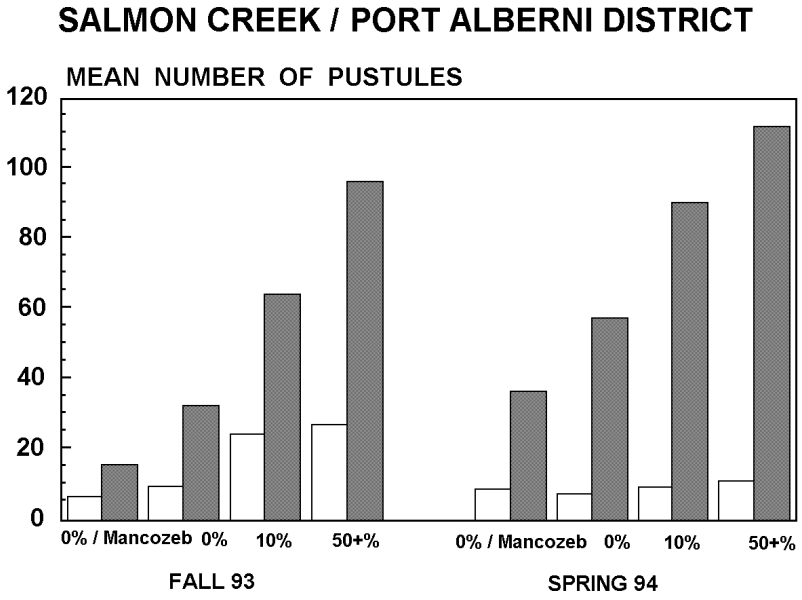

Figure 7. Total mean number of Keithia blight pustules on the four top and bottom branches of outplanted seedlings at the Salmon Creek site.

and enhance western redcedar seedlings in the nursery and field environments. Also, prior knowledge of the amount of Keithia blight on nursery stock may provide field foresters with some options as to the degree of infection that may be accepted depending on the desired destination. For example, the Holt Creek site presents less of a risk to outplanting performance if a decision is made to accept western redcedar seedlings with small amounts of visible Keithia blight. This would not be the case for a location similar to the Salmon Creek site. Further studies are needed to help develop a greater understanding of the outplanting effects of Keithia blight on container seedlings.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the contributions made to this study by the following people: S. Clary, J. Dennis, J. Fliczuk, D. Hall, G. Jaggs, K. Kahle, T. Peterson, J. Sutherland, B. Wilson, C. Wilson and the staff of Surrey Nursery.

BIBLIOGRAPHY

Barnett, C. (editor) 1993. Nursery crop production guide for commercial growers. 1993-1994 edition. British Columbia Ministry of Agriculture, Fisheries and Food, Victoria, B.C. 116pp.

Frankel, S. 1990. Evaluation of fungicides to control cedar leaf blight on western redcedar at Humbolt Nursery. Forest Pest Management Report No. 90-01, USDA Forest Service, Pacific Southwest Region. 4pp.

Pawsey, G. 1960. An investigation into *Keithia* disease of *Thuja plicat*a. Forestry 33: 174-187.

Pawsey, G. 1962. Rotation sowing of *Thuja* in selected nurseries to avoid infection by *Keithia thujina.* Quarterly Journal of Forestry 56: 206-210.

Porter, W.A. 1957. Biological studies on western redcedar blight caused by *Keithia thujina* Durand. Interim Report. Forest Biology Laboratory. Victoria, B.C. Forest Biology Division. Science Service. Department of Agriculture. Ottawa. Canada.

Sinclair, W.A., H.H. Lyon and W.T. Johnson. (editors). 1987. *Didymascella* leaf blight. in Diseases of Trees and Shrubs. Cornell University Press. Ithaca and London.

U.K. Forestry Commission. 1963. Keithia disease of *Thuja plicat*a. Leaflet No. 43 Her Majesty's Stationary Office, London, England. 7pp.

Weir, J.R. 1916. *Keithia thujin*a, the cause of serious leaf disease of western redcedar. Phytopathology 6: 361-363.