The Major Causes of Loss of Seeds Sown in 1972 at the Wind River Nursery, Carson, Washington

Latest study reveals need for evaluating seed protectants and nursery bed treatments. Data on various seed stratiafication requirements are needed.

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The Wind River Nursery, located in Carson, Washington, has been producing trees for reforestation since 1909. Eighty percent of the nursery's production is Douglas-fir. The remainder consists of ponderosa pine, western white pine, sugar pine, noble fir, Pacific silver fir, grand fir, white fir, Shasta red fir, western larch, western hemlock, Engelmann spruce, and Sitka spruce.

The soil at the nursery is a sandy clay loam that has developed on mixed basaltic and pumice alluvium of high shot content. The pH of surface soils (0-7 inches in depth) is quite low, ranging from 4.5 to 5.2.

The nursery has suffered recurrent losses of seedlings to frost and winter damage because of the restricted air drainage in the area. Damping off fungi also have contributed to these losses; however, no detailed studies of the causes, amounts of damage, and loss of seedlings are available.

A biological evaluation of seedling damage and mortality conducted by Forest Service personnel during March 1972 indicated that the major causes of losses were frost and flooding. The importance of other types of damage was unknown at that time.

To determine more accurately the causes of damage and losses of seed lings during their life span in the nursery, a series of monitoring plots was established in beds sown during April and May 1972.

Methods and Procedures

Seed treatment.

Seeds of all species were processed by nursery personnel. After storage at $^{-}18°C$, the seeds were soaked for 48 hours, drained, and mixed with vermiculite. Seeds were stratified in layers of vermiculite for 4 to 6 weeks at $2^{\circ}C$ to improve germinability. The average germination for nonchilled and chilled seeds of each species is listed in table 1.

None of the seeds sown were treated with pesticides. Seeds were sown with a tractor-mounted seed drill that planted eight rows at a time.

Plot establishment.

Monitoring plots were established (luring May 1972, in all areas of the nursery after sowing had been completed. Sample size was limited to 150 1-foot-long plots located over 27 acres. The number of plots averaged six per acre. The number of plots established in each area of the nursery was based on the percentage of total acres that each area occupied.

The location (by section, bed, and bed segment) for each sample plot was determined from a table of random digits. The location of each plot within the row was determined in the field by drawing numbered corks, with the corks being replaced after each draw.

One-foot-long sections of each sample plot row were excavated to a depth of 1 to $1^1/2$ inches and a width of 2 inches. Seeds were separated from the soil with a soil sieve with openings 1.98 mm square. The numbers of seeds excavated were recorded for each plot, replanted at original sowing depth (approximately 1/4-$1/_2$ inch) and covered with soil. All plots were marked with white plastic stakes (6 inches long) to aid in the relocation of the plots upon subsequent visits.

The plots used for seed counts were revisited at periodic intervals to determine the numbers of emerged seedlings and causes of damage and mortality. Within 1 week after seedling emergence, the numbers of live, damaged, and dead seedlings (with probable cause of damage and death) were recorded for each sample plot. The dead seedlings were removed from each plot as they were recorded to prevent duplication of mortality counts. Seedlings representative of various types of damage were used for tissue isolations to confirm the probable cause of death.

Sample plots were visited at intervals of 1 to 2 weeks until all viable seeds appeared to have germinated. Plots were revisited less frequently during the remainder of the first season, and were examined at monthly intervals during the second year.

Results

The numbers of seeds actually sown per linear foot of row for each of the major tree species at the Wind River Nursery are presented in table 2. To compensate for the poor seed viability of the true fir species, *Abies* spp., seeds are sown at a greater rate (averaging 96-104 seeds per linear foot of row) than are Douglas-fir seeds (averaging 27-30 seeds per linear foot).

Field emergence of most seed lots compared favorably with laboratory germination tests (table 1), with the exception of white fir seeds. The field emergence of this species was much poorer than the germination test indicated.

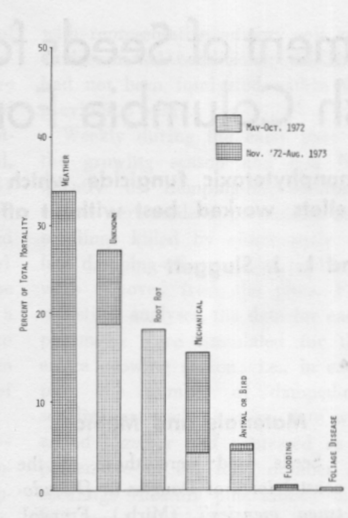

Figure 1.—Major causes of seedling mortality at the Wind River Nursery, 1972-1973.

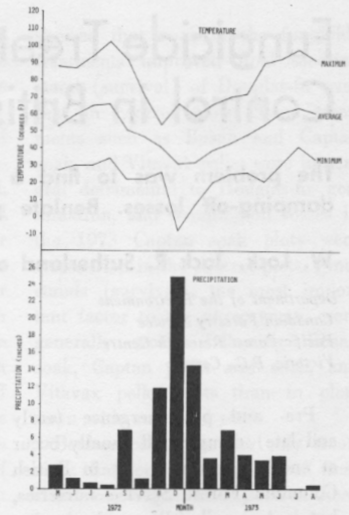

Figure 2.—Climatic data collected at the Wind River Nursery for the period May 1972 to August 1973.

Emergence for all species averaged 71.5 percent. Best emergence and survival of seedlings was recorded for Douglas-fir (Bureau of Land Management stock), 87.6 and 86.9 percent, respectively. The poorest emergence was recorded for Shasta red fir, 18.3 percent; the poorest survival for white fir, 0.0 percent. Survival for all species, expressed as a percent of numbers of seeds planted, was only 50.7 percent.

At the termination of this study, 29.1 percent of the emerged seedlings were recorded as dead or missing. The major cause of these losses was attributed to weather, 33.6 percent (figure 1).

A monthly summarization of climatic data for the period of the study was taken from nursery records (figure 2). Abnormally low temperatures experienced during December 1972 and January 1973 resulted in much damage and death of trees. Frost heave accounted for 67.0 percent of the losses incurred during the period from October 6, 1972 to February 27, 1973.

Root rot, primarily as dampingoff, caused 18.7 percent of the total loss; however, root rot was a major cause of loss of seedlings only in the first growing season (figure 1). *Pythium* and *Fusarium spp.* were isolated from damaged seedlings. Minor causes of loss were animals, birds, and foliage diseases. No damage was attributed to insects. The causes of 27.6 percent of the losses of seedlings were unknown (figure 1). Most of these losses were trees missing from plots between consecutive visits.

Discussion

The poor viability of *Abies spp. is* documented in the literature (3). Dormant embryos, injury induced during the dewinging process, insects, and the perishable nature of the Feeds_ have been cited as causes for poor viability.

Seeds exhibiting low viability under normal germination practices may show significant increases in viability after prolonged stratification; however, each seed lot may have different requirements for the length of stratification. Additional research is needed on the specific stratification requirements of each species of *Abies*. This knowledge could result in a reduction in the numbers of seeds sown per foot of nursery bed.

Delayed or prolonged germination of seeds may result in much loss to pre- and post-emergence dampingoff fungi. Seed protectant fungicides may reduce these losses.

Frost damage to tree seedlings had been investigated at the Wind River Nursery (2) prior to this study. During March 1972, it was found that 34.7 percent of nearly 7,000 seedlings examined had some terminal frost injury. The impact of frost was most noticeable on 1-0 stock origi

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nating from low elevation and southern Oregon seed sources. The greater sensitivity to frost damage exhibited by the southern Oregon seed sources when compared to more northern sources has been reported in the literature (1).

Terminal frost damage may not handicap future seedling growth, and the multiple tops resulting from frost injury may be relatively unimportant (2) ; Edgren (2) warns against heavy culling of frost damaged trees that may exhibit good juvenile growth potential.

Frost control is practiced at the nursery by watering with an overhead sprinkler system and by adding straw mulch to seedling beds; however, considerable numbers of trees are still damaged or killed each year by frost and winter injury. The use of water for frost control has at least two disadvantages. It requires close monitoring to prevent freeze damage to the seedlings. Also, the addition of water during the normally very wet winter months can result in flooding and erosion of nursery beds. This type of damage was noted at the nursery during the 1972-1973 season.

Evaluations of seed protectants and nursery bed treatments are warranted. Damping-off losses vary from year-to-year at the nursery, as the activities of this group of fungi are closely related to local weather conditions. During cool, wet springs, damage has been quite high. Sampling nursery beds for pathogenic soil fungi in the fall, prior to sowing, may be helpful to predict problem areas and make recommendations for nursery bed treatments.

TABLE 1.—Germination [1] and field emergence [2] of several tree species seeds sown at the Wind River Nursery in 1972

Tree species	No. seed lots sown	Germination % (average for all seed lots)		Field emergence (percent of seeds sown)
		None chilled	Chilled	
Douglas-fir (East Side)	14	73.1	74.2	71.7
Douglas-fir (West Side)	60	76.2	81.1	77.6
Douglas-fir (BLM stock)	5	84.2	N.T.[3]	87.6
Douglas-fir (Wind River County)	1	89.0	90.0	77.1
Noble fir	13	36.6	34.3	N.A.[4]
Pacific silver fir	2	17.0	28.0	24.9
Shasta red fir	6	17.2	17.2	18.3
White fir	1	42.0	64.0	25.0

[1] Data on seed germination was provided by Wind River Nursery personnel. Laboratory tests were conducted at the Oregon State University Seed Laboratory, Corvallis, Oregon.

[2] Data on field emergence of seeds determined from plots at the Wind River Nursery, 1972.

[3] N.T. = Seed lot not tested.

[4] N.A. = Data not available.

TABLE 2.—Numbers of seeds sown per linear foot of row for the major tree species at the Wind River Nursery 1972

Tree species	Number of one-foot-long plots excavated	Seeds sown per plot (range)	Seeds sown per plot (average)	Standard error
Douglas-fir (West Side)	115	1 to 48	28.76	0.83
Douglas-fir (East Side)	21	11 to 44	26.57	2.10
Douglas-fir (BLM stock)	8	18 to 45	30.38	3.42
Pacific silver fir	2	97 to 112	104.50	7.50
Shasta red fir	2	86 to 111	98.50	12.50

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uniform seedling densities when sowing pelleted seeds still remains.

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