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Are Seed and Cone Pathogens Causing Significant Losses in Pacific Northwest Seed Orchards?

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Abstract

Cones systematically collected in 1983 from eight Douglas-fir seed orchards in western Washington and Oregon yielded large numbers of common molds. Fungi isolated from apparently healthy, developing cones were similar to those from necrotic cones. Necrosis in cones aborted in early stages of development was apparently not associated with pathogenic fungi or bacteria. Environmental factors appeared to account for early cone abortions, although on-site temperatures were not recorded, nor were those fungi isolated from aborted cones tested for pathogenicity. Necrotic areas in cones collected during the summer were associated with insect activity. Good crops of healthy cones were produced when fertilization and partial girdling had been used to stimulate cone production and insecticides used to control cone insects.

Keywords: Diseases (cone), diseases (seed), orchards (seed), Pacific Northwest, Douglas-fir.

Introduction

Western Oregon and Washington seed orchards now provide much of the seed required for regeneration of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) in the Pacific Northwest. Because of the high value of seed produced in orchards, cultural practices that encourage high yields of quality seed become increasingly important. Destruction of developing seed and cones by insects and disease must be minimized.

Seed and cone insects have long been known to reduce Douglas-fir seed production. Loss in productivity from fungi or other pathogens, however, has not been measured, nor is it generally accepted that significant losses from diseases occur in developing cones (Hunt 1975). Nearly all documented losses from fungi occur in stored cones and seed (Shea 1960, Bloomberg 1966). Seed viability in stored cones decreases with time, but loss can be reduced by proper handling and storage of cones and seed in controlled environments and by use of fungicides (Shea 1960, Gordon 1967, Harvey and Carpenter 1975).

In 1983, we examined cones collected periodically from Douglas-fir seed orchards to determine if diseases of seeds and cones caused significant losses in western Washington and Oregon.

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Materials and Methods

Sampling Procedure

Eight seed orchards (table 1) were sampled biweekly from onset of flowering to June, then monthly until cones were ready to be picked. Initially, six cones (two from each 120° sector) were selected from the upper crown and six from the lower crown of each of four trees representing early, late, and intermediate flowering families. Thus, 12 trees were sampled from each orchard on each date, and 12 cones were collected from each tree where cone production allowed. Because cone crops were poor in 1983, we collected only six cones from each tree as the season progressed. Aborted cones were sampled only if they appeared to have aborted since the last sampling period; such cones were not difficult to identify during those periods of rapid, early cone development.

Table 1—Seed orchards sampled for cone and seed diseases in 1983

No.	Orchard	Location	Ownership
1.	Captain Moses	Darrington, WA	USDA Forest Service
2.	Dennie Ahl	Shelton, WA	USDA Forest Service
3.	Dee Flat	Parkdale, OR	USDA Forest Service
4.	Walter H. Horning	Colton, OR	USDI Bureau of Land Management
5.	Turner	Turner, OR	Weyerhaeuser Co.
6.	Beaver Creek	Corvallis, OR	USDA Forest Service
7.	David T. Mason	Sweet Home, OR	Barringer and Associates
8.	Row River	Cottage Grove, OR	Georgia Pacific Corporation[1/]

[1/] Since acquired by Weyerhaeuser Co.

Laboratory Procedures

Procedures were modified as cones developed over the course of the growing season. Initially, female flowers were sectioned lengthwise, surface sterilized, and plated onto potato dextrose agar (PDA). As cones developed, scales were excised and similarly treated. When seed development became obvious, only the seed and that area of the ovuliferous scale cradling the seed were plated. As seeds began to approach maturity, they were carefully removed from the scales and plated onto both PDA and one of two media selective for *Fusarium* spp. (Nash and Snyder 1962, Komada 1976). The internal condition of each dissected cone was recorded. Sample tissues were surface sterilized in a stainless steel wire basket suspended for 1 minute in a beaker of 1-percent sodium hypochlorite resting in water in an ultrasonic cleaner, followed by two rinses with sterile, distilled water. Ultrasonic vibrations reduced air bubbles clinging to cones, increasing contact of tissues with the hypochlorite. These procedures were intended to sample for fungi within tissues, excluding those on the surface, even though some of the surface fungi may have become destructive before seed was extracted.

Results and Discussion

Over the season, 4,564 cones were examined. From these, 7,293 fungi were isolated, but only a few of the fungi were identified. Most of the isolates appeared to be common molds normally classified as saprophytes or facultative parasites. Many of these isolates, especially from earliest samples, may include fungi that escaped surface sterilization in spite of attempts to eliminate air bubbles on the cone surface. Shea (1960) and Gordon (1967) also found molds dominating their isolations.

PDA supports the growth of many but not all fungi; thus, fungi other than those isolated may have been present. No attempt was made to isolate potential pathogens other than fungi.

We recovered one isolate of *Fusarium* sp. from *Fusarium*-selective media, but no tests were made to determine if it was pathogenic. We consider recovery of only a single isolate notable, however, because we sampled a broad range of families on a broad range of sites over an entire growing season. Finding only one isolate does not mean that spores of the fungus could not have been on tissue surfaces. If *Fusarium* spp. gain access to nursery beds through infested seed, our results would suggest that invasion of seed tissues occurs after cone harvest and not while cones are developing on the tree.

Cones aborted in large numbers at early stages of development in most orchards. Although a pathogenic cause for at least some of these abortions cannot be ruled out, they appeared more likely to be caused directly by unfavorable environment because: the abortions seemed to occur simultaneously; they were concentrated in certain families or locations within an orchard; they occurred generally in one orchard experiencing low temperatures; and they did not seem to be associated with any one fungus or small group of fungi.

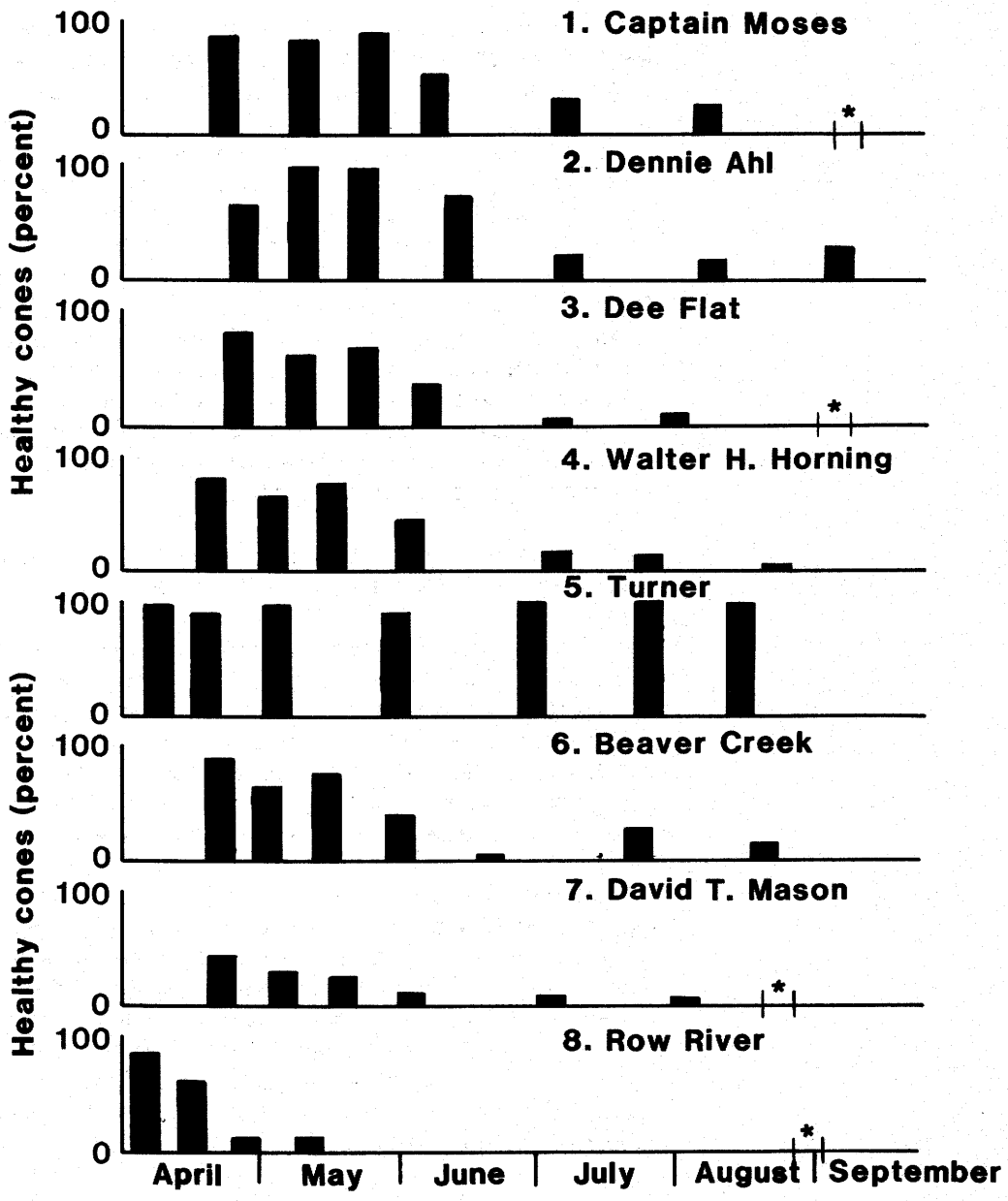
As the season progressed beyond the first 4 weeks, necrotic cones or necrotic areas in cones were associated with insect mining.[1/]

The large proportion of common molds and, more importantly, the isolation of similar kinds and numbers of fungi from necrotic and apparently healthy cone tissues leads us to believe that many of these fungi may have been merely "resting" in cones and not colonizing living tissues as primary pathogens. All isolates were classified into broad taxonomic groups, but only a few were identified to species; none were tested for pathogenicity. Thus, we have analyzed only those data on appearance of cones at the time they were dissected.

Considerable variation in numbers of healthy-appearing cones occurred among the eight orchards sampled. Cone production in 1983 was generally poor, and insect populations built up from the heavy 1982 cone crop contributed substantially to even poorer yields in orchards where insecticides were not used. In some orchards (especially 7 and 8), the poor cone crop, early abortions, and insect damage combined to limit collections to fewer cones than planned or to no cones on some dates. A combination of partial girdling and fertilizing in the previous year, and applying insecticide at orchard 5 apparently resulted in comparatively large numbers of healthy cones throughout the sampling period.

Even though previously aborted cones were not included in successive samples, percentage of healthy cones dwindled progressively with time (fig. 1). The most significant drop occurred at the end of May with the appearance of cone insects. Losses from insects in June, July, and August were heavy in all but orchard 5 where insecticides were used. Losses from aborted cones in April were considerable in some orchards (especially 7) and in some families (especially early flowering families) in several orchards. Even though we cannot rule out bacteria or fungi in these early abortions, environmental factors were more likely responsible. Gordon (1967) found immature Douglas-fir cones heavily contaminated with fungi and bacteria. We saw no obvious qualitative or quantitative differences between fungi from immature aborted cones and apparently healthy ones.

[1/] Insects and samples of insect-infested cones were sent to Timothy D. Schowalter, Department of Entomology, Oregon State University, to supplement his study of damage caused by cone insects.



* Indicates no healthy cones were found

Figure 1.—Percentage of healthy cones in samples collected from eight seed orchards, April-September 1983.

We consistently found darkened (water-soaked in appearance) areas of fleshy cone tissues associated with cone-mining insects. By the end of August or early September, nearly all insect-infested cones had nearly 100 percent of the tissues in some stage of decay. Although we did not test these cones, viable seed produced by them would likely be lacking in quantity and perhaps quality as well. Cones not mined by insects appeared normal.

Losses in seed production from cone abortion during early stages of development are sometimes considerable. We believe that seed and cone pathogens do not cause significant losses in Pacific Northwest seed orchards, but additional study of the pathology of cones in early stages of development is needed. Our study was conducted over only one season; conditions—hence diseases—in other years could differ greatly from those in 1983.

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