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Comparison of microbial populations between red alder and conifer soils[1]

K. C. Lu, C. S. Chen, and W. B. Bollen
Forestry Sciences Laboratory, Pacific Northwest Forest and Range Experiment Station, Corvallis, Oregon;
Hazelton Laboratories, Falls Church, Virginia;
and
Oregon State University, Department of Microbiology, Corvallis, Oregon

Abstract

Seasonal populations of molds and bacteria in the F layer and A11 soil horizon from stands of pure conifers, pure red alder, and conifer-alder mixtures near the Oregon coast were compared by dilution plating techniques. All organisms were generally more numerous in the F layer than in the A11 horizon. On this very moist site, populations of molds were lowest in spring, when the soil was extremely wet. In the F layer, Streptomyces *species, of particular interest due to their possible antagonism against root pathogens, consistently comprised a higher proportion of the total bacterial population of the mixed stand than of either pure alder or pure conifer stands.*

Introduction

The F layers and A11 horizons of forest soils harbor high populations of microorganisms active in carrying out a series of biochemical transformations essential to nutrition of trees and other plants. Evaluation of these transformations is important for comparing rates of nutrient release in different soils or under different environmental conditions. Moreover, the upper profile often appears crucial to establishment of seedlings.

Kivinen (1938) and Pearsall (1938) reported the relatively high acidity of soil under *Alnus* spp., and Hesselman (1917) found that nitrification occurred in acid woodland soil under alder stands. No information prior to this symposium has been reported about effects of red alder (*Alnus rubra* Bong.) on populations and activities of soil microbes in relation to soil fertility in either pure alder or mixed alder-conifer stands.

We have been studying the effects of red alder on forest soil near the Oregon coast on plots whose primary variable is tree species: pure red alder, pure conifer (*Pseudotsuga menziesii* (Mirb.) Franco, *Tsuga heterophylla* (Raf.) Sarg., and *Picea sitchensis* (Bong.) Carr.), and alder mixed with conifers. The stands are now about 40 years old and have developed characteristic understories. Climate and soil parent material are similar for all plots.

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Investigations have revealed pronounced differences in soil properties between three distinct plant associations, differences attributable almost entirely to influence of alder. Some of these, as presented in other papers in this symposium, are lower pH values, higher total nitrogen, and higher accumulation of ammonium and nitrate forms of nitrogen under red alder and red alder-conifer mixtures than under pure conifers. In this paper, we compare three types of stands in terms of seasonal populations of soil microbes.

Materials and Methods

Four sampling periods were scheduled from April 1962 to March 1963 to coincide with phenology of alder:

April 1962 – leaves appeared and flowers opened
July 1962 – flowers fell
September 1962 – seeds ripened and leaf fall started
March 1963 – leaf buds burst and understory vegetation began rapid growth

For each period, a sample was composited from three subsamples of the F layer and A11 soil horizon of each plot and immediately screened through a sterilized ¼-inch sieve. Each subsample contained all material of each horizon from a 1-square-foot area demarcated by an iron sampling frame. Microbial analyses were made from triplicate plates of appropriate dilutions of the sieved fresh soils poured with peptone-glucose agar, acidified to pH 4.0 for molds, and with sodium-albuminate agar, pH 7.2, for bacteria and *Streptomyces*. Incubation was at 28 C. Counts were made after 3 days for molds and after 15 days for bacteria and *Streptomyces*.

Results

MOLDS

F layers. – Fluctuation of molds is shown in Fig. 1. Under pure alder, counts ranged from about 100 thousand per gram of soil in April to 380 thousand in July. Numbers under pure conifers changed from 100 to 700 thousand, with the lowest count in April and the highest in March. Trends under the pure alder and pure conifers were roughly parallel, the numbers decreasing from March to April, increasing in July, and finally decreasing in September. Numbers of molds in the F layer of the mixed stand changed little, increasing only slightly from March to September.

All horizons. – Molds fluctuated in the upper mineral soil in the same pattern under all three stands (Fig. 2). Highest numbers occurred in July and lowest in September. The counts varied from 55 to 180 thousand under pure alder, 135 to 300 thousand under pure conifers, and 82 to 215 thousand in the mixed stand.

Mold counts under the three stands were higher in the F layer than in the A11 horizon except under conifers, where molds were about 50 percent lower in the F layer than in the A11 horizon at the April and July samplings. A higher microbial population in the upper fermentative layer than in the

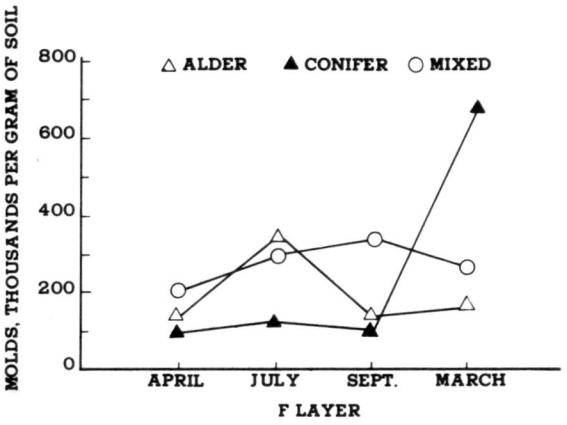

Figure 1. Seasonal changes in mold numbers.

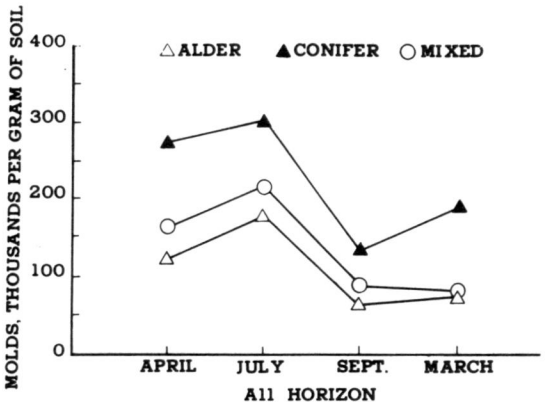

Figure 2. Seasonal changes in mold numbers.

lower mineral layer was reported by Powers and Bollen (1935). These authors attributed the vertical difference in microbial populations to differences in nutrient values and physical conditions of the horizons.

Penicillium species predominated in all samples except the F layer under pure alder, where *Trichoderma* was more abundant (Table 1). In the March samples, *Trichoderma* was found only under alder. *Mucor* species were present in all samples except the alder F layer. *Aspergilli* appeared only in mixed-stand soil and the A11 horizon under pure conifers.

Studies on the relation of mold numbers and soil moisture content have shown that increase in soil moisture from the air-dry condition to near water-holding capacity will correspondingly increase the numbers (Jensen,

TABLE 1. Molds in F layers and All horizons (March 1963 samples) under alder, conifer, and mixed stands

Stand	Horizon	Water	pH	Molds					
				Total	Mucors	Aspergilli	Penicillia	Trichoderma	Others
		Percent		*Thousands per g soil*	*Percent*				
Alder	F	193	3.6	225	0	0	33	67	0
	All	98	3.9	73	13	0	40	37	10
Conifer	F	135	5.1	709	27	0	41	0	32
	All	105	5.3	195	19	8	39	0	34
Mixed	F	135	3.9	291	20	3	54	0	23
	All	90	4.3	79	23	5	49	0	23

1934). Because the area of our study has high annual rainfall and is effectively mulched by well-developed litter and F layers, the water supply could not often be a critical factor. On the contrary, reduction of mold counts in spring seemed more related to excess water, which could reduce aeration; generally, numbers of molds were inversely related to soil moisture.

BACTERIA

F layers. – Counts of bacteria (including *Streptomyces*) in pure alder fluctuated from 5.0 to 34.3 million per gram, being high in March and September and low in April and July (Fig. 3). Under pure conifers, the variation was similar, changing from 9.9 million in April to 37 million in September. Numbers in the mixed stand varied from 3.7 million in September to 16.7 million in July. Although the fluctuation in the mixed stand was much less than under pure stands of alder and conifers, the trend was opposite.

All horizons. – The trend in numbers of bacteria was similar in pure alder and pure conifers (Fig. 4), although the maximum for alder was in March and for conifers in July. Numbers ranged from 3.2 to 5.9 million under alder and from 3.1 to 11.3 million under pure conifers. In the mixed stand, on the other hand, numbers were lower and decreased to 1.7 million in September.

These numbers of bacteria are low, compared with numbers typical of field soils; such low numbers are generally characteristic of woodland soils (Salisbury, 1922). The data show that the bacterial population was always larger in the F layer than in the A11 horizon.

STREPTOMYCES

F layers. – The population of these higher bacteria, expressed as percent of total bacteria, in the F horizon under pure alder ranged from a low of 10 percent in March to a high of 52 percent in July, dropping to 35 percent in September (Fig. 5). A similar trend occurred in the mixed stand, where the highest value, 63 percent, was recorded in July. The lowest proportion of

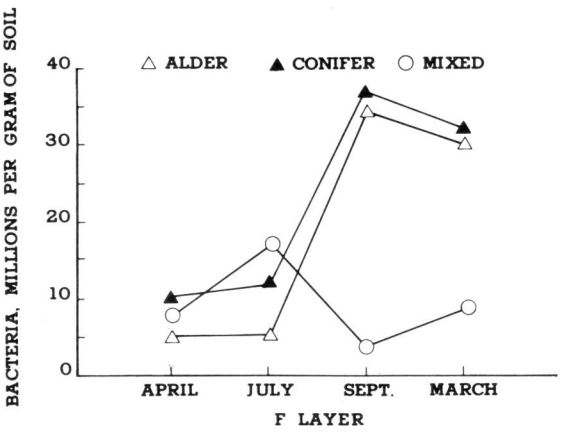

Figure 3. Seasonal changes in bacterial numbers, including *Streptomyces*.

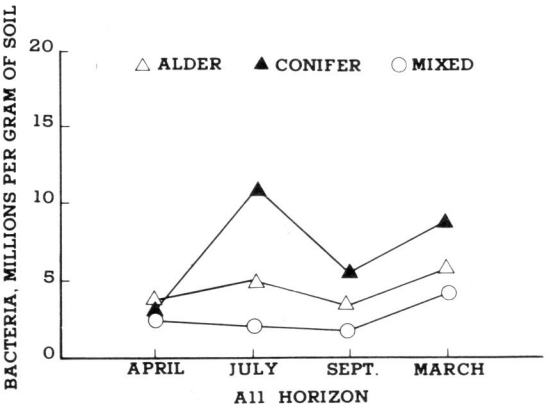

Figure 4. Seasonal changes in bacterial numbers, including *Streptomyces*.

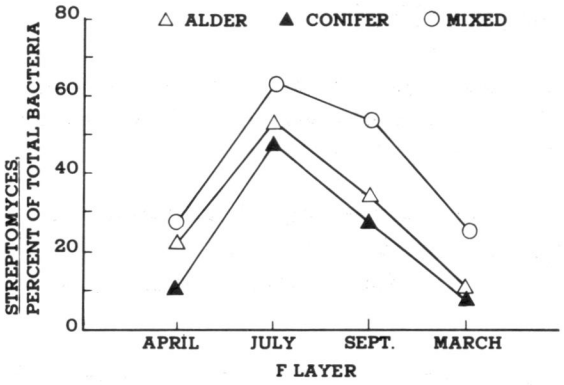

Figure 5. Seasonal changes in percentage of *Streptomyces*.

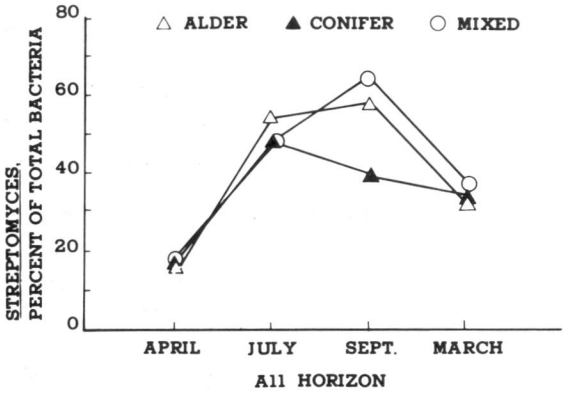

Figure 6. Seasonal changes in percentage of *Streptomyces*.

Streptomyces, 10 percent, was found in April under pure conifers; it increased slightly thereafter but remained consistently lower than in the alder or mixed stands.

All horizons. – Similar trends of change in *Streptomyces* percentage (Fig. 6) occurred under pure alder and pure conifers. In the mixed stand, there was an increase from 25 percent in March to 65 percent in September. The highest value recorded under pure alder was 56 percent in September, when the maximum of 65 percent for the mixed stand was found. The lowest value, 20 percent, occurred under pure alder and pure conifers in April.

The data showed that the F layer of the mixed stand contained the highest proportion of *Streptomyces* at all seasons. Because many *Streptomyces* produce antibiotics, their preponderance in the alder-conifer association may be important in inhibiting fungal pathogens of conifer roots.

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