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OBSERVATIONS ON THE FORMATION OF ZONE LINES IN WOOD BY *PORIA WEIRII*

by

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ABSTRACT

The formation of zone lines, based on 8 years' observations in the course of related Poria weirii *(Murr.) Murr. studies, depends upon conditions prior to burial, time, temperature, soil microflora, soil moisture, and stage of decay. Conditions favorable to growth of* P. weirii *are not generally favorable to zone line formation.*

Keywords: *Poria weirii*, root damage, fungi-wood deterioration.

INTRODUCTION

Zone lines are structures formed in wood by several of the higher fungi. Though appearing as lines in cross sections, these structures actually envelop the active fungal colony and allow the fungus forming them to exclude elements of a hostile environment, primarily drought and antagonistic micro-organisms (fig. 1). Many important root pathogens employ this mechanism: *Poria weirii* (Murr.) Murr., *Fomitopsis annosa* (Fr.) Karst. (*Fomes annosus*), and *Armillariella mellea* (Vahl. ex Fr.) Karst. (*Armillaria mellea*).[1/] A thorough

[1/] S. D. Garrett. Pathogenic root-infecting fungi. London, Cambridge University Press, 294 p., 1970.

understanding of the formation of zone lines and conditions conducive to their destruction could be important in the biological control of root disease fungi.

In studies of *P. weirii* survival over the past 8 years, there has been considerable opportunity to observe conditions leading to formation of zone lines. Most of these observations, though related to survival of *P. weirii*, have not been reported. In this paper, an attempt is made to assemble this information as a reference for future work on zone line formation.

OBSERVATIONS

Most observations discussed here originated with studies employing wood cubes cut from trees naturally infected by *P. weirii*. Some of the cubes were buried in soil in the field, but more often in containers held under laboratory conditions. Successful formation of zone lines under study conditions depended upon conditions prior to burial, temperature, time, soil microflora, soil moisture, and extent of decay.

Conditions Prior to Burial

In general, the longer (up to 40 days) colonized wood is stored under conditions favorable for *P. weirii* survival and development ($<5^{\circ}$ C) and humidity (90 percent), the better the chance for zone line formation after burial. This is at least in part because zone line "initials" may be formed in the colonized wood in storage.

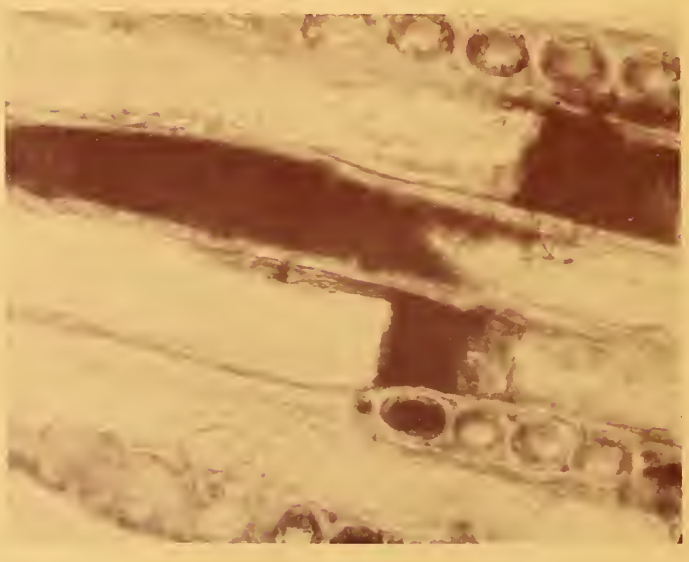

Figure 1.--Microscopic section showing composition of *P. weirii* zone line. Cell spaces are filled with dark pigmented, thick-walled hyphae. Adjacent cell walls also appear darker.

Temperature

When buried, colonized wood was incubated at temperatures from +2° to +15° C; zone lines formed more often at these than at higher temperatures presumably because *P. weirii* was better able to compete with the soil microflora. When higher (20° C) temperatures were used, zone lines formed faster when competition with antagonistic soil micro-organisms was reduced; e.g., when sterile soils were inoculated with micro-organisms which did not exhibit highly antagonistic reactions with *P. weirii* in paired culture on malt agar.

Time

At most temperatures (+2° to 20° C), *P. weirii* was able to form noticeable zone lines within a month. Lines formed at higher temperatures were noticeably thicker and appeared darker when colonized substrates were split open.

Soil Microflora

The soil microflora greatly affect formation of zone lines by *P. weirii*. To begin with, antagonistic elements of the microflora under suitable soil conditions can invade the colonized wood and replace *P. weirii* before zone line defenses can be produced. Once zone line formation begins, chances of survival and further development of the barriers are both substantially increased. The ability of *P. weirii* to form lines in the presence of antagonistic soil microflora is strongly influenced by conditions prior to burial and temperature-moisture relationships in the soil. Temperature and moisture strongly influence activity of the soil microflora as well as *P. weirii*.

When *P. weirii* is not in competition with soil microflora (in sterile soil), zone lines rarely form. Often the soil is colonized by *P. weirii* mycelium moving out from the colonized wood. The same has been shown with colonized alder chips in glass tubes. When unsterile soil is added to the tube, zone lines form at the soil-chip interface. If sterile soil is added, it is colonized by *P. weirii* growing from the alder chips. Addition of unsterile soil results in formation of zone lines in the previously sterile soil or at the soil-chip interface. When specific fungi (stain fungi) were added to sterile soil used to bury *Poria*-colonized cubes of wood, zone line formation was stimulated and culminated in a thick dark line. Similar introduction of highly antagonistic fungi (i.e., *Trichoderma viride* Pers. ex S.F. Gray aggr.) overwhelmed *P. weirii* before zone lines could be formed. If a stimulus were present, time did not permit erection of a zone line barrier to exclude the fungus from entry and replacement of *P. weirii*.

Soil Moisture

Stimulation of zone line formation by certain moisture and temperature relationships has been reported elsewhere in the literature for other fungi.[2/] Apparently

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[2/] H. Hopp. The formation of colored zones by wood destroying fungi in culture. Phytopathology 28: 601-620, 1938.

soil moisture as well as aeration and antagonistic fungi may promote zone line formation in colonized buried wood by *P. weirii*. In our studies, soil moisture contents ranged from 29 to 47 percent of dry weight and all were conducive to zone line formation.

Extent of Decay

Nelson[3/] states that although *P. weirii* forms zone lines more consistently in wood in advanced stages of decay, the effectiveness of these lines in excluding antagonistic microflora was no greater than those lines in lesser decayed wood. Numerous later observations have shown that zone lines are much more likely to form in wood in advanced stages of decay.

DISCUSSION AND CONCLUSIONS

The several observations reported here have led to the following conclusions:

1. Visible zone lines can be formed by *P. weirii* in wood in 30 or fewer days at temperatures normally occurring in forest soils over most of the year.

2. At temperatures above 15° C, competition from soil fungi is so great that *P. weirii* is not able to form protective barriers; but, when defensive barriers have already begun, the fungus is able to resist invasion at this or higher temperatures.

3. Where microbial competition is absent (as in sterilized soil) and other factors are favorable for *P. weirii* growth, it does not form zone lines. If fungi with comparatively low competitive abilities (certain "stain" fungi) are introduced, zone lines are formed. If highly antagonistic fungi (such as *Trichoderma viride*) are introduced, zone lines may not be formed in time to resist invasion whether or not the antagonistic fungus provides a stimulus.

In general, it appears that conditions favorable for growth of *P. weirii* are not conducive to formation of zone lines. When factors such as soil moisture or microbial competition reach triggering levels, *P. weirii* is stimulated to form zone lines. Whether zone lines are barriers to outward movement of *P. weirii* as well as to invasion by soil fungi is unknown.

The practical interest in zone lines, their formation, and their effectiveness as barriers to competing microflora stems from possibilities of biological control of root diseases. Since zone lines promote the survival of *P. weirii* in wood in soil, site treatments which break up colonized wood and encourage highly antagonistic fungi could be potential control measures for this disease.

[3/] Earl E. Nelson. Factors affecting survival of *Poria weirii* in small buried cubes of Douglas-fir heartwood. Forest Science 13: 78-84, illus., 1967.