# COMPARATIVE STUDIES OF RUBBER ROOT ROT CAUSED BY RIGIDOPORUS LIGNOSUS AND PHELLINUS NOXIUS IN THE IVORY COAST: PHYSIOLOGICAL, BIOCHEMICAL, AND CYTOLOGICAL ASPECTS OF HOST-PARASITE INTERACTIONS

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Host-parasite interactions between rubber (*Hevea brasiliensis*) and the fungi *Rigidoporus lignosus* and *Phellinus noxius* were studied in terms of the aggression against the host by these two fungi and of the host's reaction to the parasitic stress.

## Aggression against the Host by the Parasites

The course of an infection has three stages: hyphal penetration into the root system, colonization of the tissues, and breakdown of the host structures.

Two types of mechanism govern the penetration of the mycelium into the root: active mechanisms, characterized by enzymatic digestion of the tissues; and mechanical mechanisms, characterized by the use of natural openings in the root. The tissues thus penetrated are colonized either by means of perforation and digestion of cell walls (cortex and xylem) or via cell pits (phloem and xylem). Both intra- and inter-cellular fungal filaments have thus been observed.

Ultrastructural observations unambiguously show disorganization and then digestion of the fibrous structure of the cell walls, whether they consist of suberin, cellulose, pectin, or lignin. These changes suggest the involvement of enzymes that degrade plant polymers; such enzymes have indeed been demonstrated in these two fungi both in vivo and in vitro. Altogether there are esterases, phosphatases, glycosidases (α and β glucosidases, α and β galactosidases), polyosidases (cellulases, pectinases, and xylanase), peroxidase, and laccases. Most of these enzymes have been isolated from culture filtrates in order to determine their physico-chemical characteristics.

Comparing the enzymatic potentialities of each fungus reveals quantitative differences related mainly to the ratios between oxidative (laccase) and hydrolytic (osidases etc.) activities. In *R. lignosus*, laccase activity is predominant. Of the two isoenzymes secreted by this parasite, at least one depolymerizes thioglycolic lignin *in vitro*; however, the activity of its hydrolytic enzymes is much lower.

*P. noxius* has the converse ratio between oxidases and hydrolases. However, this fungus excretes a laccase that differs from those of *R. lignosus* in molecular weight and pH optimum. Unlike *R. lignosus*, *P. noxius* also excretes a peroxidase. Its highest activities, however, are in the various polyosidases, especially pectinases; there appears to be an enzymatic complex composed of a pectin methyl esterase, a polygalacturonidase, and a pectate lyase.

These differences in capacity to excrete enzymes account for the preferred sites of action of the parasites. In fact in vivo and in vitro P. lignosus preferentially degrades lignified tissues whereas P. noxius more rapidly attacks non-lignified tissues. This observation has been supported by measurements of lignin. However, in vitro the lytic action of P. noxius was greater than that of R. lignosus as determined from the weight losses of pieces of infected wood.

## Defensive Reactions of Hevea to Parasitic Stress

These reactions, which are described at the cellular and molecular level, appear at different stages of infestation.

### Early reactions

Early reactions begin at the first stages of penetration. The most characteristic are cellular hyperplasia and hypertrophy in the cork, generally accompanied by stimulation of the phenolic pool, which can be visualized cytochemically.

### Post-initial reactions

These reactions take place when the cortical tissues begin to be invaded. Histologically the activity of the subero-phellodermal cambium leads to the establishment of supernumerary cell layers under the points of penetration. At the cellular level, some cell walls thicken, as a result of suberification or lignification of their constituents. The lignification is attributable to a substantial increase in an isoperoxidase activity of the host that, at least in vitro, can polymerize coumaryl and coniferyl alcohols into the corresponding dihydroxyphenols.

### Differentiated reactions during the colonization of tissues

In the cork the morphology of the cell walls is profoundly altered by the formation of zones of wall apposition. In the central cylinder, the libero-ligneous cambium becomes heterogeneous in function, producing islets of lignified cells distributed around the periphery of the phloem.

### Late reactions

Very rarely the anatomical organization of the root is radically altered by mechanisms of tissue neogenesis. These are characterized both by the development of foci of meristematic cells and by the establishment of new secondary tissues. This complex of tissues, probably originating from scar calluses, constitutes an anatomical barrier resistant to fungal attack. On adult trees these calluses contain a major isoperoxidase, the same as that mentioned above, which is probably involved in the process of lignification of these reaction tissues.

Of the reactions described here, some (such as the formation of supernumerary cortical cell layers) certainly limit the spread of the parasite, but only tissue neogenesis is really effective. On the other hand, all of them are completely non-specific, since they occur also with other host-parasite pairs. A dynamic analysis of these reactions as a function of the parasite's development in host tissues shows that the CODIT (Compartmentalization Of Decay In Tree) model is applicable to the pair Hevea brasiliensis/root rot fungus.