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*Full Length Research*

# Control of White Root Rot Disease in Rubber Plantations in Nigeria

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**A survey of the causes, effects and control strategies of the white root disease in *Hevea* plantations was investigated. This study involves the process of disease infection through three stages: penetration, colonization and degradation. This involves the root rot path-produce a host range of enzymes which are cell wall degrading enzymes (CWDE) that may correspond to the diverse polymers in plant cell wall of the host and parasite. Symptoms of root diseases in the above ground level are somewhat similar but differ in the below ground level. Generally, the presence of above ground symptoms shows that the trees are now untreatable due to the fast and increased rate of disease infection that make death of plants imminent. The level of incidence of white root rot disease and its effect on *Hevea* latex were evaluated in Nine *Hevea* test clones comprising six local clones – NIG 800, 801, 802, 803, 804, 805, and three exotic clones – GT1, PR 107, and RRIM 700. Based on the susceptibility status, GT 1 was lowest in susceptibility status and assessed for the volume of latex and dry weight of cup lumps from effects at different infection categories of white root rot incidence. The 'O' infection category had the highest volume of latex (228.93 cm$^3$), the highest infectivity category gave the highest dry weight of cup lumps (118.88g), followed by '0' '1' and '2' categories. The paper highlights various control techniques including disease symptom detection, chemical fungicide application, isolation trenches, among others.**

**Key words:** Hevea, infection, white root diseases, symptom, pathogen, rubber.

## INTRODUCTION

Monoclonal *Hevea brasiliensis* (Willd. ex Adr. De Juss) Muell. Arg.) principally valued for its latex content, the latex or Natural Rubber (NR) is very significant in world's industrialization. This importance has been expressly emphasized in the production of elastomers, the use of which is indispensable in space, water, and ship technologies (Jacob, 2006). The dependence of world industrialization on NR production is further underscored especially now considering the diminishing reserves of petroleum with increasing environmental hazards.

The rubber tree is subject to a plethora of economically important pathological problems, mainly of fungal origin (the basidiomycetes) (Igeleke, 1998). In field plantations, root diseases pose a serious problem especially in the first few years after planting. In Nigeria, the white root rot disease of rubber is the most serious. It accounts for about 94% of incidences of all root diseases and kills up to five *Hevea* trees/ha (Otoide, 1978). Over a period of time, half of the rubber trees in a plantation are lost to the disease. The infective fungal organism of the white root rot disease is *Rigidoporus lignosus* (klotzsch) Imazeki. Aside the white root disease, other root diseases of minor importance include the brown root rot disease caused by *Phellinus noxius* Corner-Cunn., which unlike the white root rot, is most the most serious root disease in *Hevea* plantations in Liberia while *R. lignosus* and Armillaria root rots occur to a lesser extent (Nandris *et al*., 1987). Similarly, in Cote d´Ivoire, *R. lignosus* is the main cause of *Hevea* tree losses with 40-60% of the trees destroyed over a period of up to 21 years (Nandris *et al*., 1987).

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The growth and spread of infective fungal pathogens from existing population have been on the increase with great virulence and inflicting damages even to resistant genotypes. The impact of fungal pathogens results in crop losses.

## Disease Infection Cycles

The host-parasite interactions involve attacks by *R. lignosus* on the tap root of the *Hevea* tree. The process of disease infection is basically through three stages namely penetration, colonization and degradation. The pathogen penetrates the root system and colonizes the tissues. The mycelium of the pathogen, there after degrade the host's cell structures. The root rot pathogen of *R. lignosus* must repeatedly carry out penetration and colonization of their host cell wall. *R. lignosus* carries out its disease infection activities either by enzymatic digestion of the tissues characterized by differentiation of specialized structures (Nicole *et al*., 1985), or by mechanically penetration through colonized natural openings or wounds. Affected host tissues colonized by *R. linosus* through perforation and digestion of cell walls or by penetration through pores and pits of the vascular tissues (Nandris *et al*., 1987). Usually, fungal hyphae can be observed as intra and inter interactions of the cell wall. Such observations have revealed some distortions of the cell wall, as well as digestion of the middle lamella and of the cell walls. The implication of these distortions is that enzymatic actions are involved in degradation of cell wall polymers. The root rot path-produce a host range of enzymes which are cell wall degrading enzymes (CWDE) that may correspond to the diverse polymers in plant cell wall of the host and parasite. Infected tissues parasitized are said to contain three enzymes as CM-cellulose, pectinase and Laccase for which their involvement in the pathogenic activity may be presumed (Geiger *et al.,* 1986). Enzymatic actions in infected tissues are much higher when compared to enzyme activities in healthy tissues. In defense response, the host reacts to parasite infection with increased enzymes from the stimulation of the biosynthesis of enzymes that are present in healthy tissues (Geiger *et al.,* 1986). The enzymes involved take part in host defense responses to the parasite by degrading structural polymers in the mycelia wall. A hypothesis most frequently proposed and verified relates to excretion of parasite produced enzymes into the host tissues. The enzymes would be involved in pathogenesis by degrading the polymers in the invaded tissues.

Analysis of root tissues (Geiger *et al.,* 1986) indicated that some enzymes – (CM – cellulose, pectinase, laccase) are present only in parasite tissues. It is explained that these enzymes are biosynthesized by the parasite and not by the host. However, it is yet to be shown that the fungi are able to perform biosyntheses of those enzymes.

In wood degradation by enzymes of white root rot fungi the structural elements cellulose, hemicelluloses and lignin synthesized and deposited in the plant cell walls reinforce the mechanical strength and rigidity of the stems of higher plants.

In the host specificity of wood rotters, hard and softwood are distinguished by structural elements building the phenylpropane backbone of the lignin component. Lignin is a three dimensional, optically inactive phenyl propanoid polymer randomly synthesized from coniferyl, p-coumaryl and sinapyl alcohol precursors. Soft wood on the other hand is referred to as guaiacyl lignin, having over 95% coniferly alcohol (4-hydroxy-3-methoxy-cinnamyl alcohol) units.

## Effects and Pathogenicity of *Rigidoporus lignosus* pathogen

*Hevea* trees are usually killed by root rot pathogens infecting the plants and detection is difficult at the early stages of disease development. Symptoms of root diseases in the above ground level are somewhat similar but differ in the below ground level. Generally, the presence of above ground symptoms shows that the trees are now untreatable due to the fast and increased rate of disease infection that make death of plants imminent.

Infected trees show a general foliage discoloration, proceeded sometimes by premature flowering and fruiting. Affected tree branches die back until the whole canopy is destroyed and the tree eventually dies. In Nigeria, the foliage symptoms appear only when the tree is beyond treatment and recovery. The pathogen *R. lignosus,* forms large firm semi fleshy, often tied brackets, on the collar of infected trees in the advanced stage of the disease. Normally formations of fructification come up only and after the trees have been dead for a while. Distinctive features of fructification (basidiocarps) (Figure 1), show the upper surface of concentric zones that is brownish-orange with a bright yellow margin when fresh, while the lower surface is reddish-brown.

When roots of infected are exposed, profusely branched white rhizomorphs are readily seen. The rhizomorphs are flattened mycelia strands of 1-2 mm thick that grow firmly attached to the surface of infected roots (Figure 2).

The rhizomorphs grow rapidly and ahead of the rot and extend many meters through the soil freely hindrances from woody substrate. The internal progression of the development of the root rot pathogen is rather an ectotrophic growth characteristic. At infection point, the parasite penetrates the taproot down the soil. Following root infection, colonization within the taproot progresses towards the collar region and other parts of the root.

**Figure 1.** Basidiocarps of *R.lignosus* on dead *Hevea* tree.


**Figure 2.** Rhizomorph(whitish) strands on the collars of root of *Hevea* tree.

Newly killed wood is brownish thereafter turns cream and soft. This shows fading of coloration along a gradient from the progression front of the parasite toward the tissues that were colonized before now. The effect of *R. lignosus* causing white root rot extracellular enzymes

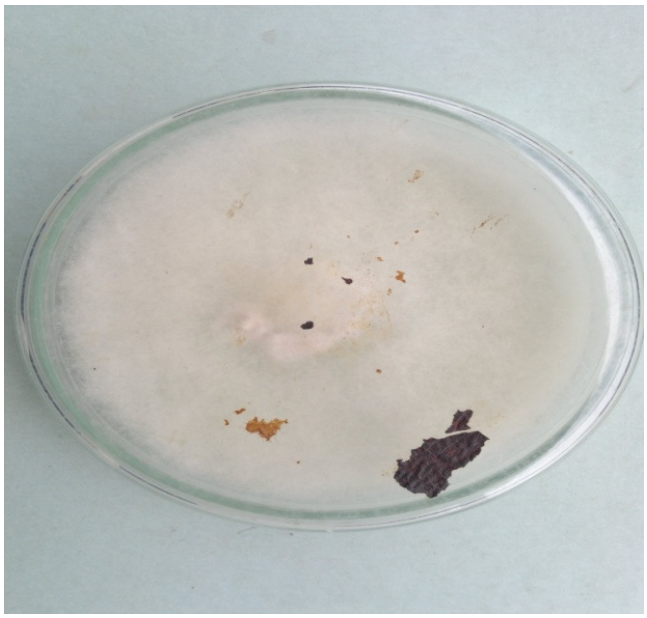

**Figure 3.** Fluffy growth of *R. lignosus*.

degradation of lignin in the cell walls of the root system. The basidiocarps seen at the collar region of the tree produce a large number of basidiospores especially during rainy season, but appear less functional in the dissemination of the disease. In newly established *Hevea* plantation after clearing of a forest, mycelia of *R. lignosus* do cause infection to take place. However, in the second planting, spores can become inoculum source for infecting the stump surfaces of old rubber trees that are existing between the planting rows. In plate cultures, *R. lignosus* growth on potato dextrose agar (PDA) or malt agar (MA) forms a superficial, extensive white fluffy myceilia (Figure 3).

## Assessment of Effect of White Root Rot Disease on Quantity and Quality of Rubber Production

The level of incidence of white root rot disease and its effect on *Hevea* latex were evaluated at the Rubber Research Institute of Nigeria, main station, Iyanomo (Omorusi, 2013). The plantation experimental site was previously cropped with cassava, yam, and plantain. The plantation consists of 36 sub plots of one hectare each with nine clones planted out in a completely randomized block designed. Nine *Hevea* test clones comprising six local clones – NIG 800, 801, 802, 803, 804, 805, and three exotic clones – GT1, PR 107, and RRIM 700 were assessed for the study. Assessment of the severity of the white root rot disease was based on disease index method by Parry (1990) on a scales of 0 = no infection, 1 = light infection, 2 = moderate infection, and 3 = severe

**Table 1.** Disease indices of incidence of white root rot of six *Hevea* test clones.

| Rep. | Hevea clones | | | | | |
|---|---|---|---|---|---|---|
| | NIG 800 | NIG 800 | NIG 800 | GT 1 | PR 107 | RRIM 707 |
| 1 | 25.10 | 23.18 | 28.00 | 9.34 | 25.30 | 22.83 |
| 2 | 31.72 | 21.10 | 20.13 | 10.75 | 27.47 | 26.48 |
| 3 | 28.13 | 29.19 | 29.90 | 10.61 | 33.61 | 37.11 |
| 4 | 26.53 | 34.00 | 32.00 | 28.14 | 35.80 | 22.00 |
| Mean | 27.87 | 26.87 | 27.51 | 14.71 | 30.55 | 26.86 |

**Table 2.** Volume of latex and dry weight of cup lumps under infection categories in GT 1

| Infection category | Volume of latex ($cm^3$) | Dry weight of cup lumps (g) |
|---|---|---|
| 0 | 228.93 | 114.00 |
| 1 | 192.44 | 103.71 |
| 2 | 191.17 | 94.00 |
| 3 | 224.18 | 118.88 |
| Cv (%) | 26.91 | 28.24 |

infection. Infection was then calculated using the following formula, thus:

$$\text{Disease index (D I)} = \frac{(0 \times a) + (1 \times b) + (2 \times c) + (3 \times d)}{a + b + c + d} \times \frac{100}{x}$$

where,
0, 1, 2, and 3 are infection categories
a, b, c, and d are plants that fall into the infection categories
x is the maximum disease category which is 4

The result of the white root rot incidence in six clones are shown in Table 1.

Disease indices recorded showed highest susceptibility score in PR 107 (30.55) and lowest score in GT 1 (14.71). Intermediate scores among other clones were equally high compared with PR 107. The lowest susceptibility in GT 1 indicated that GT 1 showed a significant level of resistance to the white root rot disease.

Based on the susceptibility status recorded, the GT 1 lowest susceptibility status was assessed for the volume of latex and dry weight of cup lumps from effects at different infection categories of white root rot incidence (Table 2). The 'O' infection category had the highest volume of latex (228.93 $cm^3$), however, showed no significant difference with the rest clones. The highest infectivity category gave the highest dry weight of cup lumps (118.88g), followed by '0' '1' and '2' categories but no significant difference among the clones was obtained. This may be attributed to increase in DRC in response to effect of the white root rot disease.

## Root Diseases Prevention

Treating trees infected by root diseases is very difficult and expensive. Therefore, it is important to prevent them. Before an old rubber area is cleared for replanting all root diseases sources must be removed and burnt. The sources can be located from vacant patches or vacant planting point resulting from dead trees. Clearing method such as uprooting and poisoning of old trees have been found to reduce root disease incidence in replanting. Even if the trees are manually felled by cutting, the stumps must be poisoned and cut surface painted with creosole. All these will deprive the root disease fungi of food sources. Establishing and maintaining pure legume cover crops can also reduce root diseases as they cause roots and stumps to rot faster.

During transplanting of rubber, 226g of powdered sulphur should be incorporated into the planting hole. Sulphur is known to promote the growth of fungi which are antagonistic to the root diseases fungi (Rajaakshmy and Jayarathnam, 2000). Paintings of collar protectant chemical to the collar of the plant can also prevent root disease infection for two years (Rajaakshmy and Jayarathnam, 2000). As the trees grow there are bound to be damages caused to the tissues from time to time. Such open wounds on any part of the tree should not be left untreated. Suitable fungicidal wound dressing should be applied immediately. This is because root spores can enter tree through such wounds.

## Disease Symptom Detection

Foliage of infected trees shows general discoloration, often preceded by premature flowering and fruiting.

Branches of infected tree die back until the whole canopy is destroyed and the tree eventually dies. In Nigeria, usually the foliage symptoms appear only when the tree is no longer treatable. The stick-trapping method is also a useful tool in detecting the growth of *R. lignosus*. The sticks of *Hevea* wood are poked down the soil around the collar of the tree. The developments of mycelium on the stick are checked after three weeks of insertion into the soil. Another technique is the use of mulch around the collar for three weeks to provide a damp microclimate for the superficial mycelium growth on the collars of the trees. After three weeks the mulch is removed, mycelia growth of *R. lignosus* can be seen.

## White Root Disease Detection

The infected tree must first be located and identified. This can be done by foliage inspection of three-monthly intervals, beginning from six-month old plants. Tree with unhealthy and deformed leaves should be suspected as root-diseased. This is confirmed by collar inspection. The collar region of the infected plant is exposed by digging a cavity around the base of the plant, the depth of opening should be about 5cm for a year old to about 20cm for a four –year old plant.

A sharp flat-ended hardwood is used for this purpose to avoid causing injuries to the roots .When a diseased tree is found, the neighboring tree in the row must be collar-inspected, although they may have been passed during foliage inspection. They may have been infected but have not shown symptoms on the leaves. This procedure is continued along the row until a disease-free tree is found.

## Treatment of White Root Disease

Determination of fungicidal effects of treatment is related to the severity of infection at time of fungicide application, as well as rate and type fungicides applied and method and frequency of disease inspection.

The level of disease severity at the collar site of the tree is paramount to the success of treatment. However, if the disease has reached an advance stage showing obvious yellowish foliage symptoms presentation, fungicides application is rather of no use. Trees detected to be Infected can still be saved if infection had not gone beyond the threshold by application of fungicides at various rates.

Collar inspection presentation is a more useful means than foliar inspection as infected trees could be detected at a much earlier stage. Many infected trees detected by foliar inspected are usually beyond protection. Re infection of trees could appear six to ten months after treatment on a small percentage of previously infected trees. Prophylactic treatment approaches on non-infected

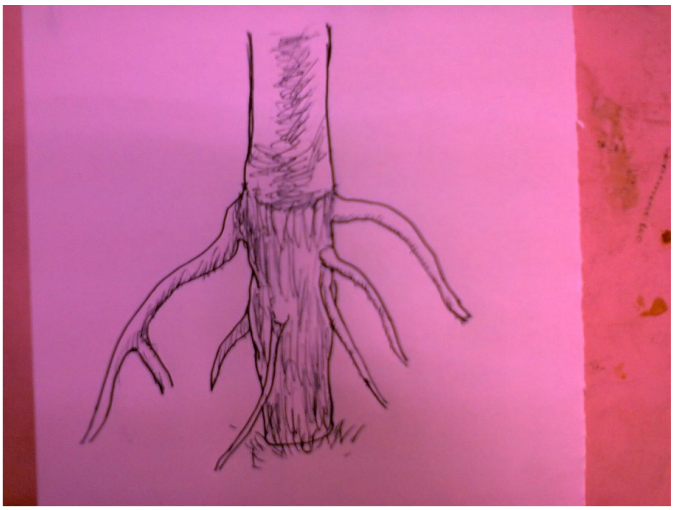

**Figure 4.** Diagrammatic representation of exposed tap and lateral roots for dressing with PCNB fungicide.

border trees may not be necessary if infected trees have been treated with fungicide. Growth rate of treated trees which had recovered returned to normal about nine months later. Treatment of rots involves excavating soil around the roots of infected trees and removal of surface rhizomorphs and root sections penetrated by the pathogen. A long lasting collar protectant dressing such as pentachloronitrobenzene (PCNB) is then painted around the collar, tap root and basal portion of the main laterals of the tree, before replacing the soil (Figure 4). The same treatment is given to immediate tree neighbours, especially those along the same row. A less laborious method is to escavate soil around tree base to form a s light furrow, then drench with 2 litres of 0.5% calixin (i.e. Tridemorph). Infected trees with those of two direct neighbours are treated with fungicides every six months.

## Control of Root Diseases in Mature Rubber Plantation

The purpose of controlling root diseases described earlier is to remove their sources when the trees are still young, in other to prevent other trees from being infected with the disease at maturity. The principle of root disease control in mature rubber is the same as for immature rubber. It is expected that tappers should know the locations of the diseased trees in the plantation as this simplifies work of locating them. Treatment of diseased tree is aimed at preventing the spread of the disease. However, with age, the cost of treatment also increases and the time will come when the infected trees are left of their fate and isolated by trenches, so that the diseases do not spread to other trees.

**Isolation Trench**

A trench of 30 cm wide and 60 cm deep is dug all round the infected tree at half the distances of the neighbouring healthy trees. All roots found crossing the trench are cut off and the debris collected and burnt. The trench is then refilled with loose soil to two –thirds its depth. The trench is reopened yearly and any roots found crossing the trench are pruned off and the debris collected and burnt. This procedure is repeated several times until the fungus on the infected trees becomes inactive, thus depleting food source to the root disease fungus. This will only take place when the infected trees rot. Proper sitting of the isolation trench is very important, as it is necessary to ensure that no disease trees are outside the isolated area. This will involve inspection of the collars of the trees around the infected one until a healthy tree is found to site the trench between the healthy and the diseased trees. During the process of constructing an isolation trench, all exposed roots must be carefully inspected. Any diseased roots are isolated, there is therefore the need locate the trench further more.

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