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The Brown Bast Syndrome of Hevea
Part I. Morphological Observations

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From a study of several cases of long rested brown bast trees by visual examination, scoring using a sharp instrument, looking at sectional views and by histological examination of the tissues, it is found that excessive meristematic activity is a predominant feature which leads to formation of tumorous tissue. Both the vascular cambial activity and the activity of adventitious meristems surrounding previous 'nuclei' of necrotic activity resulting in the formation of nodules which finally form the so-called occluded xylem in the bark are responsible for the eventual manifestation of tumours. In some cases however, the nodule formation is not evident and the affected bark dries, cracks up and sloughs off. In such cases, smooth renewal of bark results from the activity of the vascular cambium alone. The implications of these findings are discussed.

Brown bast is a well known physiological disease of *Hevea*[1]. It was known in Malaya in 1912 and in Java since 1912 although it was confused with other tapping panel diseases. According to Sharples[1], Gallaher had commented on such a disease as early as 1909. Reports by Petch[2,3] indicate that there is some confusion between brown bast and abnormalities of trees exhibiting nodules and burrs. The disease reached alarming proportions in Malaya[1] in the period 1917–23. Investigations carried out at that time resulted in the characterisation of this disease as of physiological origin and planters were advised to use reduced intensity of tapping to curb the percentage of incidence.

Researchers on exploitation of *Hevea* by modern methods of excision tapping have repeatedly confirmed the relation between intensity of exploitation and the incidence of dry trees. They have also observed clonal differences in susceptibility. A notable case from historical records is the plight of RRIM 500, which, when tested in small-scale clone trials exhibited high incidence of dryness[4]. Seedling trees in Java on daily tapping had 50%–85% incidence of brown bast[5] (perhaps cumulative). In more recent times, researchers have connected the relationship between agroclimatological regions and the degree of incidence of dryness[6]. Furthermore, recently De Fay[7] recognised the need to distinguish between reversible and irreversible forms of dryness.

Burr formation as reported by Petch[2,3] and description of cases of woody nodules embedded in the bark of *Hevea* can be associated with brown bast. Tapping wounds caused by the pricker used for extraction of latex in earlier days before the advent of excision tapping were probably the causative factors for burr formation in those trees although later researchers, particularly Rhodes[8] pointed out that nodules formed in early stages of brown bast trees that he examined. Gomez[9], in reviewing the anatomy of diseased brown bast cases remarked on the frequency of meristematic activity and the formation of occluded xylem in long rested brown bast trees.

Perusal of old pictures of trees mutilated by 'machadinho' tapping indicates very clearly that the wound reaction in *Hevea* is of a severe nature and even today burred trees can be associated with poor standards of excision tapping.

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In the present and a subsequent paper[10], an attempt will be made to distinguish between the major types of morphological variants of brown bast reaction in trees continuously tapped despite the incidence of partial dryness and trees rested from tapping for various periods of time from the onset of dryness.

MATERIALS AND METHODS

In a research station such as the RRIM Experiment Station at Sungei Buloh, there are many trees in various fields, which are resting due to brown bast. The authors made a survey of such trees to secure samples for histological examination; some of the results are reported in this paper as far as the morphological types are concerned. Although many photographic records were obtained, this paper gives only a brief summary. The trees examined were of various clones, ages, tapping history and other agri-horticultural differences and hence no attempt was made to describe morphological variations arising from these sources of variation. Visual observations, often aided by a scoring instrument such as a tapping knife were all that was required for characterisation in the field for testing whether the affected bark was yielding latex or was dry; and, if there was yield, which part of the bark yielded latex and so on.

Histological observations, when required were made on samples fixed in formalin acetic alcohol[11] for several days before sectioning using a hand microtome or sledge microtome or by paraffin wax embedding techniques[11].

Whole trees were examined by sectional view in a number of instances to observe gross histology.

RESULTS AND DISCUSSION

Figure 1 shows a long rested brown bast tree showing many protuberances characteristic of malformed brown 'bast' or bark. Many of the burrs contain woody tissue embedded in the phloem and often these are connected to the main xylem. *Figure 2* shows a cross-sectional view of another brown bast tree with xylem nodules embedded in the phloem. *Figure 3* shows spiral burr formation in a long rested brown bast tree showing a trunk which is not readily amenable for further exploitation. *Figure 4* shows a longitudinal section of such a stem showing that the occluded xylem has in fact fused with the main xylem although traces of phloem can still be seen by the expert eye. Some of this phloem is occluded in the adventitious xylem. Occasionally, dry rubber is present in such cell debris (indicated by arrows).

Figure 5 shows a section through the bark revealing the characteristic brownish streaks visible to the naked eye on the surface of the cut in selected trees affected by early stages of brown bast. The name of the disease originates from this phenomenon. In the example shown, two latex vessel rows are affected. *Figure 6* shows a higher magnification of such an affected zone showing evidence of necrosis, gummosis and unusual cell division. *Figure 7* shows the zone of necrosis in finer detail. Eventually, a nodule which is embedded in the phloem is formed as seen in *Figures 8* and *9*. *Figure 10* shows evidence of gummosis in sieve tubes and the intercellular spaces surrounding the medullary rays.

Figure 11 shows a case of brown bast of a distinctly different variety. In this case, the meristematic activity is smooth, so much so that the renewed bark is without major protuberances causing a visible bulge. The affected external phloem has however, cracked and is in the process of sloughing off.

The usual current procedure in plantations is to rest dry trees once they are found to be nearly dry and not worth while to tap. Such trees, when examined after a period of time reveal drying of the panel, cracking of the bark and sloughing off of the bark which has been affected by the condition of dryness. However, in many cases, there is a kind of tumour formation at the site of original disease or in a spiral fashion extending downwards or upwards, following the usual alignment of bark tissues and conducting xylem tissues, thus clearly indicating that agents causing meristematic activity were actively transported

Figure 1. A long rested tree suffering from brown bast. Several nodules are visible.

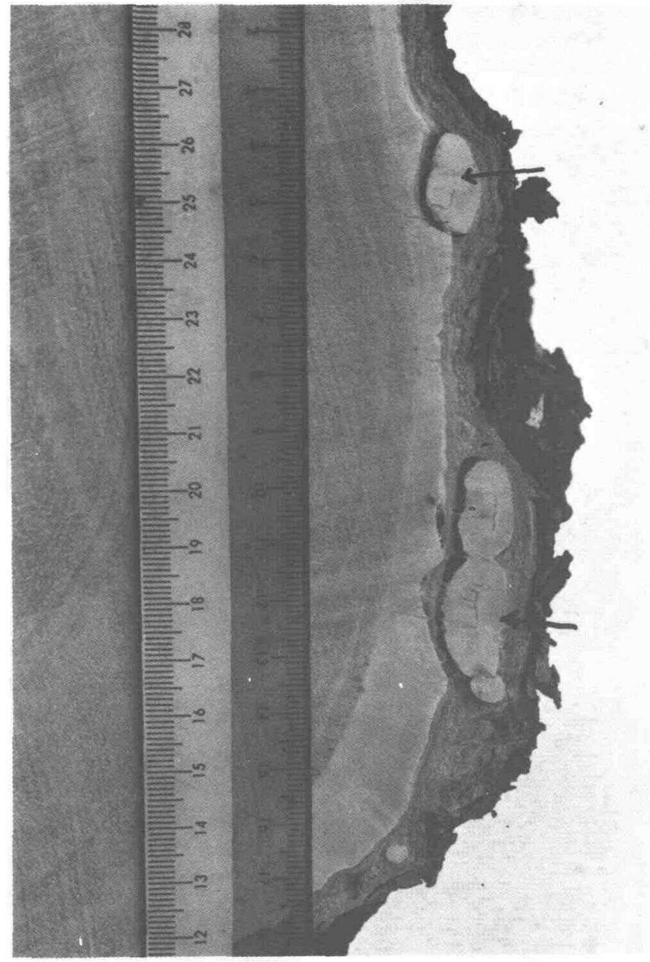

Figure 2. Cross section through stem of brown bast affected tree showing embedded nodules in the bark, i.e. occluded xylem (arrows). Section was painted with phloroglucinol.

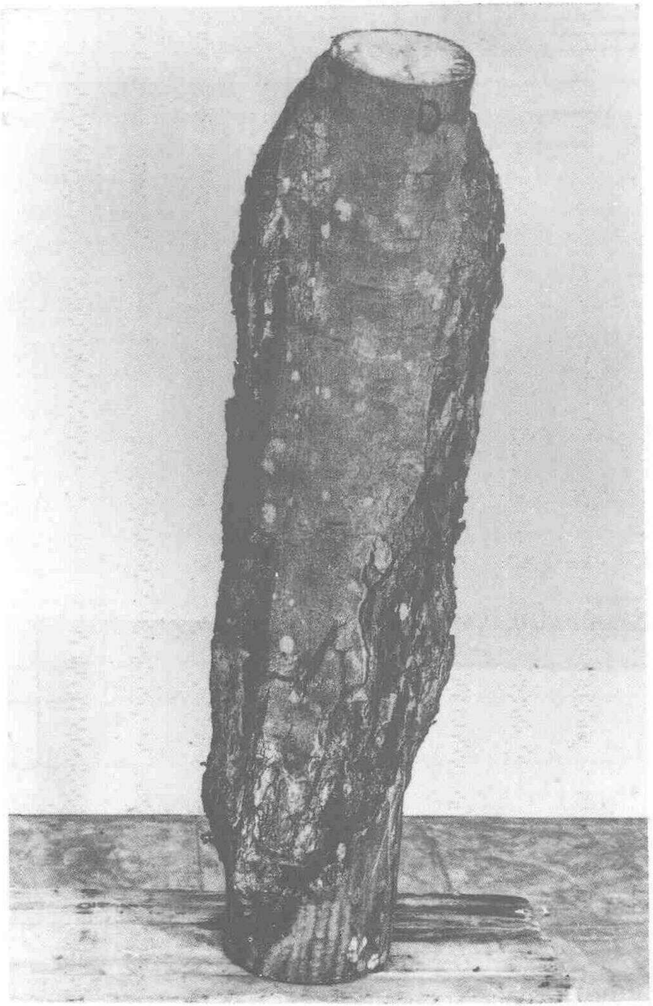

Figure 3. Spiral burr formation in long rested brown bast tree.

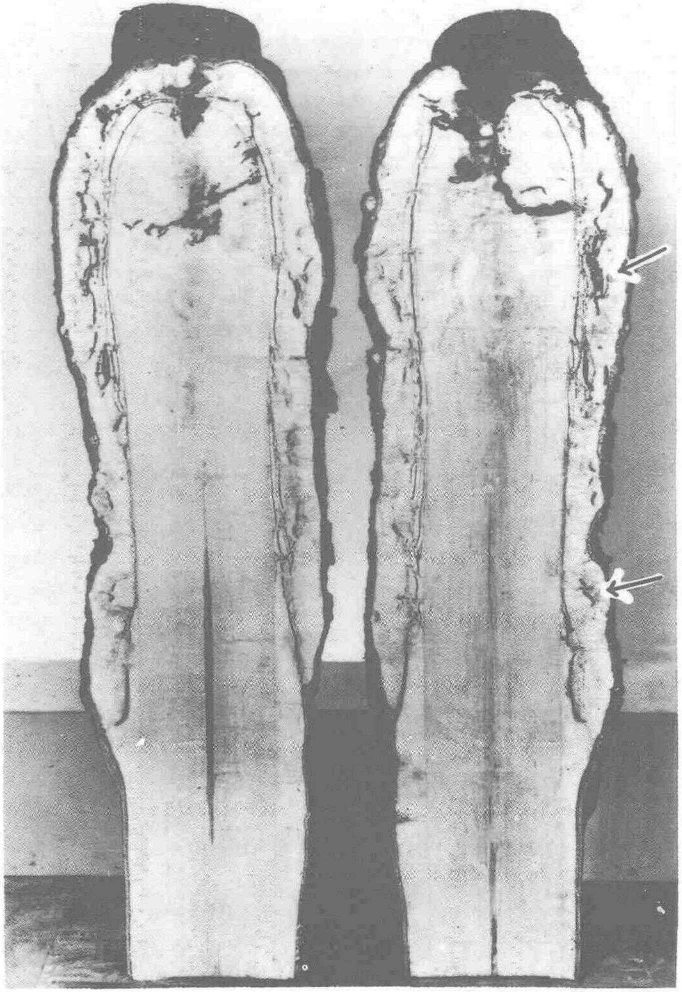

Figure 4. Sectional view of a long rested brown bast tree. Note that the occluded xylem has fused with the main xylem. Streaks of phloem can be seen embedded in the adventitious xylem (arrows).

Figure 5. Cross section through bark showing the brownish streaks along two rows of latex vessels. Stained in Sudan III. Magnification 20×.

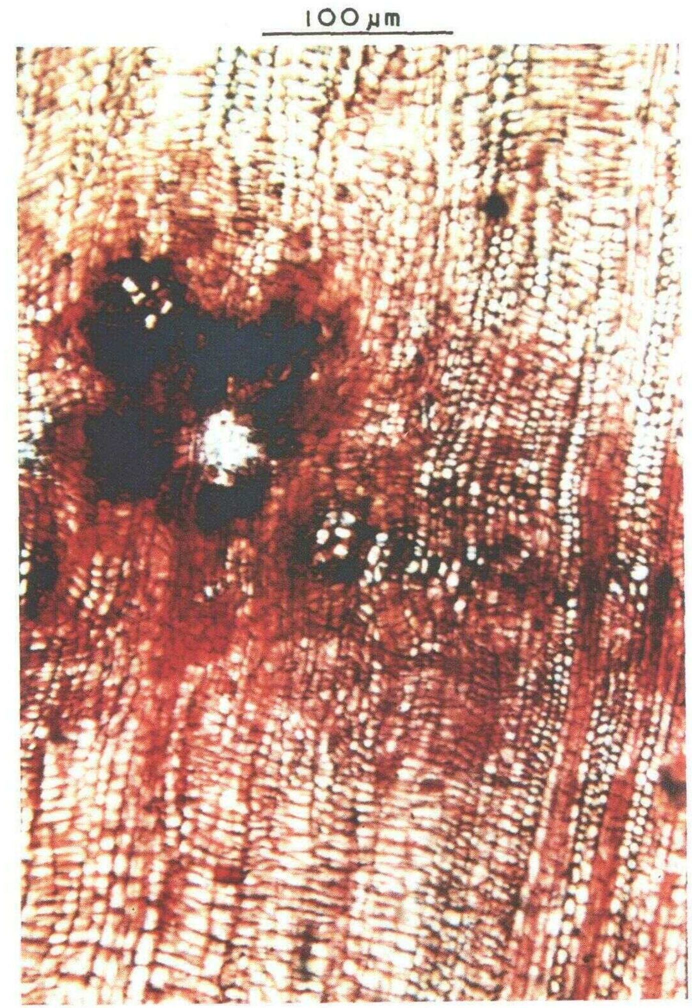

Figure 6. Section passing through a brown streak showing necrosis, gummosis and increased meristematic activity. Stained in safranin. Magnification 256×.

Figure 7. Section through a necrotic zone indicating cellular disruption and the beginning of tissue repair. Stained in safranin/fast green. Magnification 50×.

Figure 8. Section through a nodule embedded in a long rested diseased tree showing xylem elements surrounding the necrotic spot. Stained in safranin/fast green. Magnification 256×.

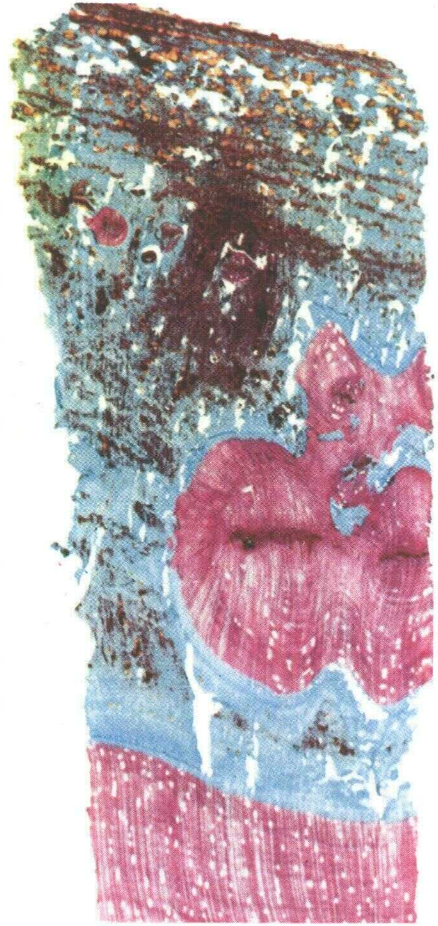

Figure 9. Occluded xylem in the long rested bark of brown bast affected tree. Stained in safranin/fast green. Magnification 4×.

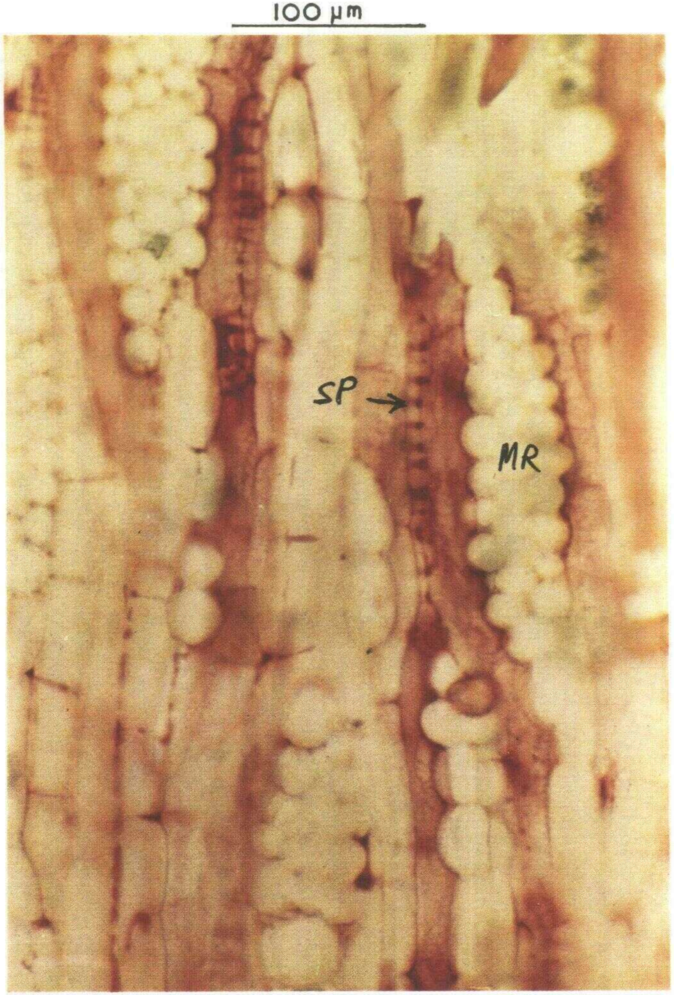

Figure 10. Gummosis in sieve tubes and the intercellular spaces of medullary ray boundaries. Stained in safranin. Magnification 256×.
MR: Medullary ray SP: Sieve plate

Figure 11. A long rested brown bast affected tree showing bark cracking and sloughing-off reaction.

in this tissue or were synthesised in the tissue due to factors which triggered such physiological activity.

The results reported in this study show that in cases of nodule formation, the nodules contain remnants of necrotic tissue and hence by surmise indicate the presence of necrosis preceding nodule formation.

The characteristic zone of brownish discolouration of inner bark which gave the disease its name from olden times indicates not only the presence of a brownish substance which appears to be a tannin-like material as far as histological techniques can tell, but also shows evidence of increased adventitious cell division surrounding such brownish spots. Presumably these zones of meristematic activity result in the ultimate formation of nodules except when the histological changes take other directions[10]. Evidence that a spot of necrosis is immediately surrounded by a meristem is also an indication that primary stages of nodule formation followed cell death in a limited area and the trees' reaction to this form of danger was to form a woody nodule which would embed this debris inside it and protect the surrounding tissue from further damage.

What then, was the primary cause? The authors tend to agree with Rhodes[8] that brown bast is essentially a wound reaction of the tree to the repeated and frequent wounding inflicted on it by the tapping process. Most researchers would agree that tapping is controlled wounding and that the severity of the reaction to wounding can depend on many aspects such as vigour of the tree, susceptibility of the clone to wounding in terms of physiological capacity for reaction, perhaps nutritional status or other hitherto not understood immunological phenomena. It is possible to conclude that when wounding exceeds a threshold level, other physiological mechanisms intervene.

The authors are also in agreement with Paranjothy *et al.*[12] and Jacob and Prevot[13] on the question of which tissue is most affected due to reasons which are best discussed in a subsequent paper[10]. However, it may be mentioned that the key to further discoveries related to brown bast and control of it lies in the physiology of the laticiferous system despite the fact that associated tissue also shows reactions characteristic of brown bast. In the view of the present authors, the most detectable primary histological symptoms are seen in the laticiferous system.

CONCLUSIONS

Morphological examination of trees rested due to the onset of dryness generally shows the sloughing off reaction in the external bark, a feature in which the tree discards dead tissue external to an underlying meristematic zone or retains the affected bark in which various malformations occur during a period of time. Hyperplasic development of tissue due to higher activity of the vascular cambium and activity of several meristems surrounding necrotic spots in the tissue is most noticeable. Histological observations of the affected tissue reveal a brown streaky region in the inner bark in the early stages of the disease and signs of meristematic activity peripheral to it. Ultimately, nodules are seen embedded in the surviving bark, resulting in the formation of occluded xylem. Obviously in cases where the bark sloughs off, these processes need not occur.

Other changes noticed in the laticiferous system and adjacent tissue will be reported in a forthcoming paper[10]. All these developments in the hyperplasic tissue indicate that the tree is reacting to some form of physiological stress and creates new tissue suitable for overcoming the stress. These observations are consistent with earlier findings of other researchers who concluded that brown bast is essentially a wound reaction of the trees and that the earliest relevant principal changes occur in the laticiferous system.

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