

BLACK STRIPE OR BARK ROT OF *HEVEA*

By

VIMALADEVI SATCHUTHANANTHAVALA

Black Stripe or Bark Rot of *Hevea* is essentially a wet season disease affecting the tapping panel and is of economic importance in Ceylon. It is also known by other names such as 'Black Thread' and 'Stripe Canker'. It was first recorded in Ceylon in 1903; since then it has been reported from all the countries in which *Hevea* is grown, the severity of the disease largely depending on environmental factors prevailing in each country.

The application of fungicides as preventive and curative measures for the control of Bark Rot had been in practice from 1916 (Petch, 1918). But their extensive use appears to have been practised only since the mid-1940s and today most estates use watermiscible fungicides throughout the year. Along with this, over 75% of the estates also apply waterproof panel dressings either at fortnightly or monthly intervals or once, twice or three times per year.

As a result of the studies on the biology of the pathogen, the susceptible stage of the host, the environmental and other factors which contribute to the initiation and spread of the disease, today we have a better understanding of the disease. In the light of this knowledge it has become necessary to consider the use of fungicides in the control of Bark Rot.

Symptoms of the disease

The first visible symptoms of Black Stripe or Bark Rot are vertical linear depressions seen on the renewing bark, just above the tapping cut. These lesions may coalesce to large patches extending above into the renewed bark and below into the untapped bark. When bark in these areas is cut open (Figs. 1 and 2) corresponding black lines are seen on the wood.

The disease takes its name Black Stripe or Black Thread from this characteristic symptom of black streaks. On wood, the lesions appear to be superficial with slight discolouration of the wood. In the untapped or renewed bark the pathogen attacks the soft tissues. Subsequently latex accumulates under the bark and later coagulates to form a pad emitting a foul odour. At this stage the bark above it bursts resulting in open wounds to cause Bark Rot and Canker.

When Black Stripe is neglected or not properly treated, the disease can spread to a great extent on either side on the trunk. An example of improper treatment resulting in the recurrence of the disease is shown in Fig. 3. A diseased patch on renewed bark was treated last year, but all the diseased tissue had not been removed and the disease had remained dormant. With favourable conditions this year, the pathogen had become active and spread on either side of the old wound to about 3 ft in length. There were no external symptoms on the trunk except for two or three points from which latex was oozing. This shows the importance of correct treatment of Black Stripe or Bark Rot.

Pathogen

Black Stripe or Bark Rot is caused by the same pathogen which causes pod rot, leaf fall and dieback of young shoots in *Hevea*. The fungus which causes these diseases is *Phytophthora palmivora* two forms of which are recognised as occurring on *Hevea* in Ceylon and in Liberia (Darley & Silverborg, 1952); however, the nomenclature of the fungus that affects rubber in Ceylon has not yet been clearly

defined. Thankamma *et al.* (1968) reported two species of *Phytophthora* as responsible for these diseases in India. In Malaya these diseases are attributed to *P. palmivora* and *P. botryosa* (Chee, 1969), *P. palmivora* is reported on a large number of hosts and is recorded in most of the countries in the tropics.

The vegetative thallus of the fungus consists of fine hyaline non-septate microscopic strands (mycelium). Growth of the mycelium is favoured by temperatures between 25° - 30°C. On depletion of the nutrients of the substrate on which it grows, it produces pear-shaped, thin-walled asexual spores (sporangia). In the presence of water and at a slightly lower temperature these sporangia liberate the swimming spores (zoospores) which after a period of swimming, encyst to germinate. On suitable substrates the zoospores grow into mycelium and continue the cycle. The fungus also produces resting spores and thick-walled hyphae by which it could tide over unfavourable periods. At lower temperatures 20 - 25°C sexual spores (oospores) are produced which are resistant to changes in environmental conditions. It is generally believed that it is in this form that the fungus over-winters for the next season. Oospores have been observed on infected pods and bark (Radhakrishna Pillai, 1969).

Source of inoculum

McRae (1918) reported after an extensive study of the *Phytophthora* diseases of *Hevea*, that the fungus over-wintered on the host itself. The fungus has been isolated from various plant parts off-season (Peries, 1966). Observations made in Dartonfield on the incidence of leaf fall over a number of years show that the disease occurs year after year in certain localities and always the same trees suffer from leaf fall. From this we may infer that the pathogen tides over the unfavourable period on the host itself in some form which is resistant to various environmental hazards. Although Turner (1968) is of the opinion that there is no proven connection between leaf fall and incidence of Black Stripe, occurrence of these two diseases following one another almost within a few weeks in July 1970, has clearly indicated that, in Ceylon, the inoculum for infection of the panels had originated from the trees affected with pod rot and leaf fall.

Again in India, Black Stripe is not a problem compared to the severity of leaf fall. This is attributed to cessation of tapping during the rainy season, thereby avoiding the exposure of the susceptible tissues of the bark to the inoculum potential present in the field during leaf fall.

Pods

The importance of pods in the initiation of *Phytophthora* diseases had been known as far back as 1918. McRae (1918) demonstrated this by hand picking the pods and thus controlling the leaf disease. All those who worked on the *Phytophthora* diseases of *Hevea* have stressed on the importance of pods. The control of fruit-set by chemicals has been attempted but the period of flowering in *Hevea* is protracted and total destruction of flowers could not be achieved (Ramakrishnan, 1960 ; Riggenbach, 1961).

Young (1952) recorded that in Ceylon, at the beginning of the century, pod disease was causing serious defoliation each year and Bark Rot was very active but after *Oidium* became established there was a reduction in these diseases, because *Oidium* attacked flowers and reduced the number of pods available for the multiplication of *Phytophthora*. Hence the disease was indirectly controlled. Once *Oidium* leaf disease was effectively controlled by dusting with sulphur, an increase in the *Phytophthora* diseases was observed. This year, estates which experienced severe leaf fall and Black Stripe due to *Phytophthora* would not have failed to note that the incidence of *Oidium* leaf disease was either negligible or very mild this year (1970) compared to the incidence last year.

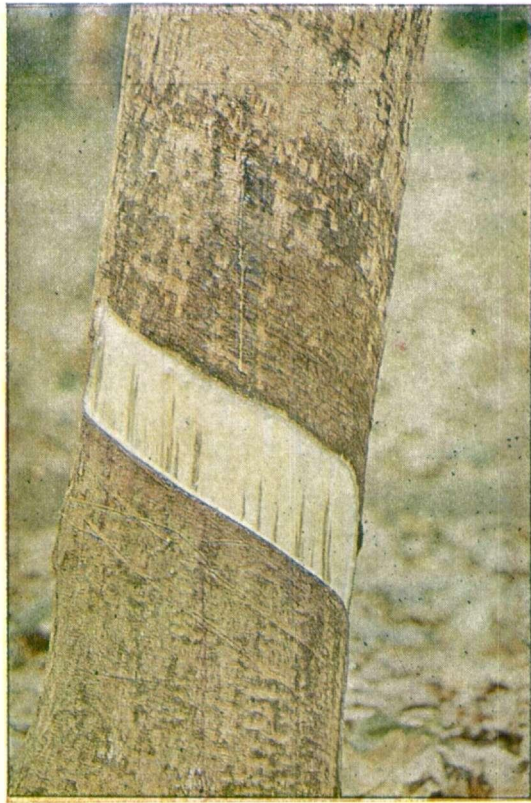


Fig. 1. Initial symptoms of Black Stripe. The bark has been removed to expose the underlying cambial tissue.



Fig. 2. Same as Fig. 1, but showing the extent to which the pathogen can spread on the panel in a couple of weeks of initial infection.



Fig. 3. Bark Rot, the advanced stage of Black Stripe

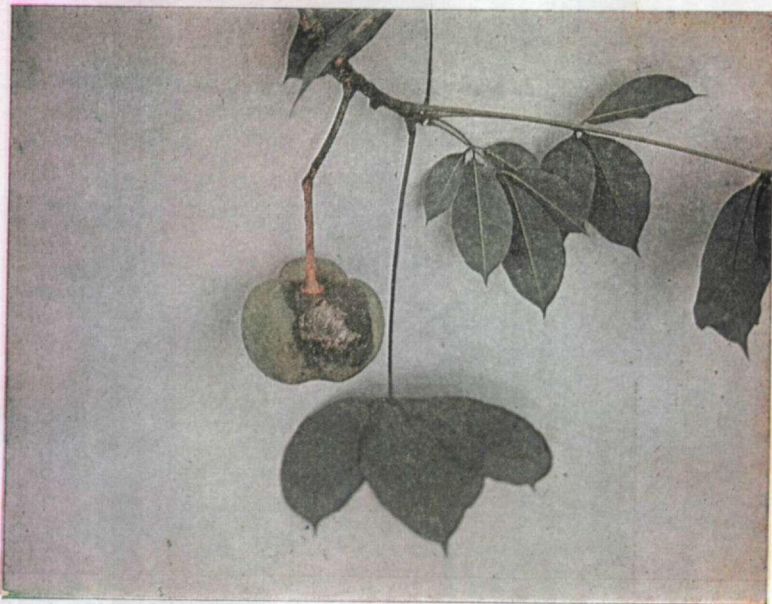


Fig. 4. *Phytophthora* - infected pod, showing heavy sporulation of the fungus



Fig. 5. Trees in which lower half of the crown is completely defoliated due to the presence of infected pods. Very few pods are present in the upper half of the crown, which is unaffected.

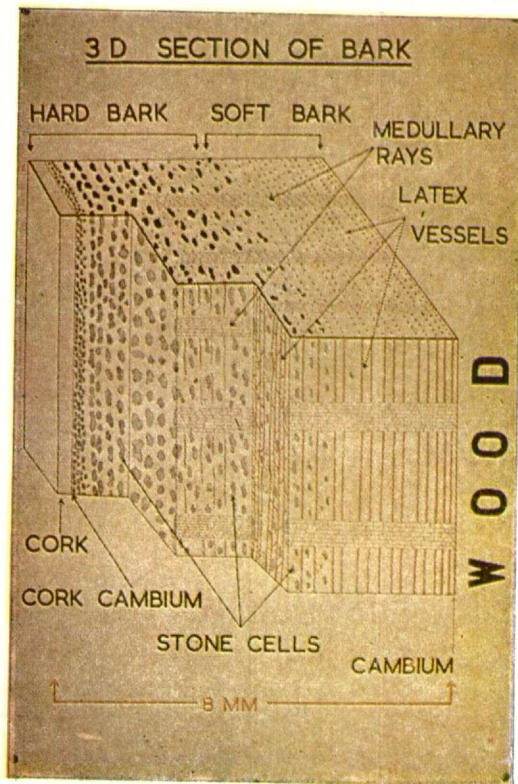


Fig. 6. A three-dimensional diagrammatic view of *Hevea* bark.

Hevea pods form a suitable substrate for growth and sporulation of the fungus (Fig. 4). On a half centimetre square of pod area, sporulation could range from 500 to 59,000 sporangia depending on the maturity of the pod, mature pods being a better substrate than immature ones. The clones PB 86 and Mil 3/2 are very susceptible to leaf fall and Black Stripe, susceptibility in this instance could be correlated to profuse pod-set in these clones.

Rainfall

Rainfall appears to be the most important factor influencing the onset of leaf fall (Ramakrishnan & Radhakrishna Pillai, 1961). In India, in the rubber growing areas, leaf fall is prevalent wherever a monthly average rainfall of over 15 in. falls during the period May to August. In our opinion, a period of continuous rain should coincide with a good crop of mature pods for defoliation and development of Black Stripe. Satchuthananthavale (1968) observed that during the 1967 *Phytophthora* season, leaf fall was negligible or light in some estates which had a rainfall over 90 in. for the period May to September; in these estates pod-set was low. Estates which had a rainfall between 65 to 85 in. for the same period reported heavy leaf fall and also heavy pod-set. In 1970 Eladuwa and Yatadola Estates experienced either negligible or light leaf fall; pod-set was normal but rainfall for June and July was below 10 in. for each month. There was no continuous spell of rain and these estates escaped a heavy incidence of leaf fall. These observations bring out the correlation that exists between rainfall, pod-set and leaf fall which again would reflect on the incidence of Black Stripe (Fig. 5).

Sporangia are easily washed off by rain splash from infected pods. Peries (1969) has shown that water running off infected pods could carry sufficient inoculum for infection of other plant parts. Spores could be splashed on the panel from low hanging branches or weeds or covers growing close to panels or washed down the trunk on to the panel.

Susceptible stage of the host (Fig. 5)

Phytophthora spp. are not capable of penetrating the intact bark. Infection takes place mainly through fresh open wounds. The corky layer of the bark is resistant to *Phytophthora* attack but all the other tissues below this layer are penetrated by the pathogen. The outer hard bark consists of groups of stone cells and thin-walled parenchymatous cells in varying amounts while the soft bark is composed mainly of parenchymatous tissue, which is the most susceptible region of the bark. When a tapping cut is made the inner tissues are exposed and these tissues are prone to infection for the first forty eight-hour period from the time the cut is made. But a cut surface would remain susceptible for six days before it becomes immune to infection as the result of natural wound healing and cork formation. Darley & Silverborg (1952) made similar observations on the susceptible period of exposed bark. The fungus is capable of entry through cracks and wounds as well and hence injury to bark in any form would serve as infection sites.

Watermiscible fungicides

In the light of the above facts let us consider the use of fungicides as practised now in Ceylon. Most of the estates apply the fungicides before tapping. Soon after the application the bark tissue coated with the fungicide is shaved off. This means that once latex flow ceases, the cut surface will remain exposed to infection. If, estates which adhere to this practice have either low or negligible incidence of Bark Rot they should not attribute the low incidence of the disease to protection afforded by the fungicide, far from it. It only means that they have been fortunate not to have had sufficient inoculum potential for infection of bark or for that matter leaf fall.

Some estates apply fungicides the day following tapping, that is the cut surface of the bark would remain exposed to infection for the first twenty four hours of the critical infection period. This time of application although it does not give total protection against the disease does protect the bark at least during the second half of the critical infection period. The presence of scrap does not protect the cut in any way from infection.

The best time for application of fungicides would be at the time of collection of latex. One drawback is that the effectiveness of the watermiscible fungicides will be diminished if rain follows application. When fungicides are used, the dilutions recommended by the Institute should be applied, if they are to be effective and be of any value in the control of Bark Rot.

At present, watermiscible fungicides are used right through the year irrespective of the weather. It was shown earlier that the inoculum potential is abundant in the field only during the period when the presence of mature pods in the field coincides with continuous wet weather (June and July). After this, depending on the dry weather in August-September the fungus propagules diminish and gradually fall off the negligible numbers. It is during this period, May to October, that precautions should be taken to protect the panels from infection. Hence the application of fungicides, if any, should be made only during wet weather. Dry weather application is redundant. It is not necessary to apply preservatives to renewing bark in the dry season (Petch, 1918).

Waterproof panel dressings

Very few panel dressings have a fungicidal effect but none exert any beneficial effect on the renewal of bark. Any protective effect that could be attributed to those panel dressings of fungicidal value could therefore be only from the day of application to the next tapping day. This protection is already afforded by the watermiscible fungicides in routine use. It is apparent from the irregular use of panel dressings, their effectiveness on protection and bark renewal that their use in the control of Black Stripe or Bark Rot is not justified. Non-effectiveness of panel dressings has been pointed out earlier (Peries, 1965).

Fungicides available at present cannot be considered as the absolute solution for prevention of Bark Rot. The Institute has been advocating now for a number of years, the cessation of tapping of trees when wet. The panel and the untapped bark above the panel must be dry to commence tapping. A few estates which strictly adhere to this recommendation, attribute the absence of Bark Rot to this practice. These estates did at one time have a very high incidence of Bark Rot.

Cultural practices which would facilitate quick drying of the surface moisture of bark are very desirable and these would be: grooming of trees, good sanitation of the field, less plant density especially in valleys, conditions that would allow free circulation of air and sunlight. Grooming of trees if resorted to should be carried out well before the monsoon sets in.

Strictly avoiding the tapping of wet trees, adopting proper cultural practices and the judicious use of fungicides at the proper time will reduce the incidence of Black Stripe. The familiar dictum "prevention is better than cure" is truly applicable to Bark Rot. Thus we feel that the prevention of Black Stripe is mainly a supervisory problem which could be tackled by properly trained field staff.

ACKNOWLEDGEMENT

The author wishes to thank Dr. R. Satchuthananthavale, Botanist, for the helpful discussions and for the preparation of the slides presented with this paper.

REFERENCES

- CHEE, K. H. (1969). Variability of *Phytophthora* isolates from *Hevea brasiliensis*. *Trans. Br. mycol. Soc.* **52**, 425—436.
- DARLEY, E. F. AND SILVERBORG, S. B. (1952). Black Thread of *Hevea brasiliensis* in Liberia. *Phytopathology* **42**, 547—557.
- MCRAB, W. (1918). *Phytophthora meadii* n. sp. on *Hevea brasiliensis*. *Mem. Dept. Agr. India, Bot. Ser.* **9**, 219—273.
- PERIES, O. S. (1965). Recent developments in the control of the diseases of the *Hevea* rubber tree. *Q. Jl. Rubb. Res. Inst. Ceylon* **41**, 33—46.
- PERIES, O. S. (1966). Review of the Plant Pathology Division. *A. Rev. Rubb. Res. Inst. Ceylon* 1965, 45.
- PERIES, O. S. (1969). Studies on epidemiology of *Phytophthora* leaf disease of *Hevea brasiliensis* in Ceylon. *J. Rubb. Res. Inst. Malaya* **21**, 73—78.
- PETCH, T. (1918). The application of preservatives to renewing bark of rubber. Leaflet No. 9, Dept. of Agric. Ceylon.
- RADHAKRISHNA PILLAI, P. N. (1969). Panel diseases of rubber. *Rubb. Bd. Bull.* **10**, 141—143.
- RAMAKRISHNAN, T. S. (1960). Experiments on the control of abnormal leaf fall of *Hevea* caused by *Phytophthora palmivora* in South India. *Proc. Nat. Rubb. Res. Conf., Kuala Lumpur* 1960, 454—467.
- RAMAKRISHNAN, T. S. AND RADHAKRISHNA PILLAI, P. N. (1961). Abnormal leaf fall of rubber (*Hevea brasiliensis*) caused by *Phytophthora palmivora* Butl. in South India. *Rubb. Bd. Bull.* **5**, 11—19.
- RIGGENBACH, A. (1961). Review of the Plant Pathology Department. *A. Rev. Rubb. Res. Inst. Ceylon* 1960, 52.
- SATCHUTHANANTHAVALA, V. (1968). Review of the Plant Pathology Division. *A. Rev. Rubb. Res. Inst. Ceylon* 1967, 45.
- THANKAMMA, L; GEORGE, M. K. AND GEORGE, K. V. (1968) Occurrence of two spp. of *Phytophthora* on *Hevea brasiliensis* in India. *Rubb. Bd. Bull.* **10**, 43.

QUESTIONS AND ANSWERS

- Question: With regard to the control of Bark Rot, much was said about the use of a watermiscible fungicide. Could you also comment on the use of waterproof fungicides? (Mr. R. S. Howie).
- Answer: The use of waterproof fungicides in the control of Bark Rot is not justified.
- Question: When a fungicide is applied after tapping at the time of collection would not latex in the tapping cut get smeared on the panel? If this happens will it affect the panel in any way? (Anon).
- Answer: No.
- Question: Has the RRIC laid down field trials for Bark Rot in the major planting districts? If so, were results ever published? (Anon).
- Answer: A number of experiments were laid out in Kalutara and Kelani Valley Districts. Incidence was negligible in all these trials. These experiments were reported in the reviews of the Plant Pathology Department in the Annual Review of the Institute.

Question: As you are perhaps aware there is at least one estate in the Kalutara District that has not used watermiscible fungicides for the past seven to eight years with no cases of Bark Rot. So why can't we do away with these expensive fungicides thus saving a great deal of foreign exchange?

I wonder how much the country spends per year on watermiscible and waterproof fungicides? (Anon).

Answer: This particular estate does not tap the trees when the panel and the bark above it are wet. Quick drying of bark is facilitated by adopting certain cultural practices; hence the number of tapping days is not adversely affected.

If you are prepared to strictly adhere to the measures practised in the above estate you too can give up the use of fungicides in your estate. I agree that if the estates will follow the recommendations of the Institute then there will be a great deal of foreign exchange savings on fungicides.

We have not been able to assess the actual amount spent on these fungicides but we know that 95% of the rubber estates use watermiscible fungicides throughout the year and 75% use waterproof panel dressings.

The expenditure on fungicides for the control of Bark Rot can be cut down to 25% or less of the amount spent presently.

Question: (i) Is it necessary to scrape Black Stripe in clone PB 86? Wouldn't the application of watermiscibles at higher strengths by tappers suffice scraping to be done only of bleeding cases where there is a 'pad'? (Anon).

(ii) For how long has the tree to be rested after scraping?

Answer: Application of fungicides on the surface of the bark will not penetrate the entire depth of the tissues in which the fungus is present. If the fungus is not removed it will spread in the soft tissues of the bark. It is important in the treatment of Black Stripe to remove all the affected tissues of the bark and isolate the discoloured patch on the wood by cutting out half an inch of the healthy bark. Then apply a watermiscible fungicide and seal off with a waterproof panel dressing.

You may have to rest the tree only if a large area of bark has been removed. The period of resting will again depend on the severity of the disease.

Question: What concentration of Antimucin would you recommend for the daily application of tappers during the following weather conditions.

(1) monsoonal weather, (2) general weather conditions, (3) dry weather conditions. (Anon).

Answer: Application of fungicides for the control of Bark Rot is now restricted only to the wet period of the year when the inoculum of the fungus is present in the field, *i.e.* from mid-June to mid-September.

Antimucin is recommended at the strength 1 : 120 for daily application only during the period mentioned above.

Question: Have you tried out any experiments to destroy flowers on rubber trees in bearing? (Anon).

Answer: Yes, experiments were carried out in 1959 and in 1960. The period of flower opening is not simultaneous and fruits did set. The strength of the chemical that induces flower drop is critical and a slight variation in the strength would affect the tender leaves and therefore is not suitable for use on a large scale.

Question: *Phytophthora palmivora* 'Bud Rot' of coconuts, 'Pod Rot' of cacao and 'Pod Rot' of rubber are all caused by *P. palmivora*. In areas where these three crops are grown in proximity as in the Kurunegala District (Mawatagama area rubber and coconuts) and Matale/Kurunegala area (cacao, coconuts and rubber) can cross-infection take place i.e. can *P. palmivora* causing cacao Pod Rot infect coconut palms causing Bud Rot and vice versa?

2. Are these different strains of *Phytophthora palmivora*? (Anon).

Answer: Cross-infection may take place in nature where these three crops are grown together. When an isolate of the fungus gets adapted to one host then the possibilities are that it may not infect another host with the same virulence. When *Phytophthora palmivora* is isolated from the three hosts from areas where these are grown exclusively then the isolate from each host may behave as a different strain.

Question: Has the appearance of this *Phytophthora* leaf disease anything to do with the present manurial record or chemicals used in weed killers? (Anon).

Answer: I do not think that there is any connection. (Dr. O. S. Peries).

Question: Yesterday Dr. Peries promised this assembly that he would discuss the effect of mercurial-based watermissible fungicides on the plugging effect. Will this be explained please? (Anon).

Answer: We have very little information on this. Theoretically, mercury can promote coagulation of latex as it denatures proteins. This was discussed in some detail by our Mr. M. Nadarajah in the 1965 conference. Coagulated latex can, of course, plug the latex vessels and this will have an effect on the plugging index. We also have the evidence from Malaysia that mercurial fungicides should not be used with Ethrel stimulation, as it leads to drying of the tapping panel. This may not be connected to the point at issue. (Dr. O. S. Peries).