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Overview of Brown Bast Syndrome of *Hevea Brasiliensis*

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Abstract *Hevea brasiliensis* is one of the popular industrial crops in Malaysia better known as rubber tree belongs to the family *Euphorbiaceace*. From more than 12 species of *Hevea*, only *Hevea brasiliensis* is economically exploited because the milky latex extracted from the tree is the primary source of natural rubber. As in other crops, various plant physiological conditions and pathogenic diseases influence rubber production. Brown bast is one of the most serious threats to natural rubber production. In general, high-yielding clones of rubber tree are often considered to be more susceptible to this physiological disorder also commonly termed Tapping Panel Dryness (TPD). It is estimated that brown bast leads to approximately 15-20% decrease in yield. There is no known cure for brown bast yet. However, many plantation practices manage brown bast in rubber by giving tapping rest and changing tapping panel. Hence, this review condenses the causal of brown bast, symptoms of diseases and also control of brown bast affected *Hevea* tree.

Keywords: *Hevea brasiliensis*, *Hevea*, Rubber, Brown bast, Tapping Panel Dryness

Introduction

Hevea brasiliensis is one of the popular industrial crops in Malaysia better known as rubber tree belongs to the family *Euphorbiaceace*. Only *H. brasiliensis* from *Hevea* genus is economically exploited because the milky latex extracted from the tree is the primary source of natural rubber. The tree was originally from Amazonian rainforest of South America. Rubber tree is a tropical crop that can survive within 1,000 km north and south of the equator, except for the arid regions. It requires 180-250 cm of rainfall per year and a temperature of 25-35 ºC. It can be planted to a maximum elevation of 500 m above sea level. It requires a deep firm soil of the loamy texture with free drainage and tolerates a water table of 100 cm from the surface and below. It also has an economic life-span of approximately 30 years. When fully matured, it can reach a height of 18-20 metres. Originally identified as a forest vegetation, rubber wood is a valuable tropical timber which comes under the semi-hard category and most suitable for the furniture industry. Its latex, harvested from the tree, has been the major contributor to the natural rubber industry towards the development of various rubber and rubber-based products.

The natural rubber industry in Malaysia will continue to be one of the major contributors to the national economy. Demand for natural rubber will always rise in tandem with the growing global population and production industry. The rubber industry as a whole, including manufacture of rubber-based products, earned the country over RM 33 billion in 2013 export receipts. This is expected to continually increase thus contributing RM 53 billion to the country's gross national income by 2020 if we constantly revitalise the technology to boost natural rubber productivity.

World Natural Rubber Industry
International Rubber Study Group reported that natural rubber was greatly produced in South-East Asia particularly in Thailand, Indonesia and Malaysia. In 1994 these three countries produced more than 73% of the total rubber produced in the world. The other major rubber producing countries include India, China and Sri Lanka. However, India and China are both the net importers of rubber since the total consumption of rubber in these two countries exceed than that of their total production. Previously, Malaysia had been the leading producer of natural rubber. However, by 1980's, it was evident that Malaysia could no longer hold on to its position as the biggest rubber producer in the world. In 1991, both Thailand and Indonesia eventually overtook Malaysia to become the leading rubber producer in the world. Today, Thailand remains the largest producer of rubber, producing 3.05 million tonnes of rubber in 2015 (International Rubber Study Group, 2016).

The world total natural rubber consumption is forecast to grow in 2016 by 1.8%, marginally above the 1.2% growth in 2015. It is estimated to increase at an accelerating rate of 2.9% in 2017 and further at 3.3% in 2018 under the International Monetary Fund (IMF) scenario. Over 2016-2025, the world total natural rubber consumption will increase by an average 2.7% per annum. Under the downside scenario, the world total rubber consumption is estimated to increase by 1.4% to 27.1 million tonnes in 2016, before decreasing by 2.1% in 2017 to 27.7 million tonnes. Meanwhile, the world natural rubber demand is also estimated to increase by 1.3% to 12.3 million tonnes in 2016 under the IMF scenario, and by 3.2% in 2017. The world total natural rubber consumption would climb by an average of 3.0% during 2016-2025. Under the downside scenario, the world natural rubber demand is believed to expand by 0.9% to12.3 million tonnes in 2016, eventually increasing to 16.1 million tonnes in 2025 (International Rubber Study Group, 2016).

Malaysian Natural Rubber Industry
The rubber industry has been a backbone of the Malaysian economy since 1950's and continues to be one of the major contributor until now. Even though the planted area under rubber has been continuously decreased since 1982, natural rubber production remained at about 1 million tonnes since 2004 until 2008. However, the production started to reduce henceforth until present time (Natural Rubber Statistic, 2016).

In 1984, rubber industry contributed around 39.8% in agriculture sector. However, the shift towards oil palm as the main commodity in Malaysia had rendered the decline of the contribution and total number of rubber estates in Malaysia. Land development programme organized by the government had further strengthened the switching of role from natural rubber as the main commodity into oil palm industry (Malaysian Rubber Research and Development Board, 1983).

Brown Bast
Brown bast is also known as tapping panel dryness imposes a serious problem to rubber plantations in most of the rubber growing countries resulting in severe loss of latex yield. This disorder derives its name from the effect it causes on the rubber tree which is reduction in latex yield leading to partial and eventually total dryness of the tapping panel.

Brown bast has been reported in plantations from the very early stages of rubber cultivation. It was reported for the first time in Brazil in wild rubber in the Amazon forest in 1887 (Rutgers and Dammerman, 1914), and at the beginning of 20th century in plantations in Asia (Keuchenius, 1924). (Nandris *et al*, 1991) found this syndrome in the 1980's in rubber trees of West African plantations and seen again in most modern rubber plantations worldwide with a wide range of severity. Tapping panel dryness syndrome was observed in 1909 as brown bast disease of Hevea in Malaya and Java (Petch, 1921). In another report, brown bast was first observed in Malaysia affecting mostly high yielding clones of rubber (Sharples, 1936). Rands (1921) noticed up to 52-85% incidence of brown bast in seedling trees in Java. Meanwhile, observation from China (Shaoqiong, 1989), Malaysia (Sivakumaran and Haridas, 1989) and Sri Lanka (Samaranayake and Yapa, 1989) uncover differences in susceptibility (Chua, 1967; Bealing and Chua, 1972).

Around 14.75% of rubber trees were harmed due to the brown bast of Hevea (D. L. Qi, *et al*, 2014). Some researchers call it a disease however it is not yet considered a disease as it is not connected with any pathogen such as a virus or mycoplasma (Liyanage *et al*, 1982). Thus, it is more generally recognized as a physiological disorder of the latex vessels in that no latex is produced when the bark is tapped away. A syndrome with browning and necrosis of the bark were sometimes observed on untapped or newly opened trees, which has been suspected to be influenced by other factors than over exploitation. An ecophysiological study has suggested that brown bast was assisted by some environmental factors such as, high soil compaction (Nandris *et al*, 2004). Despite decades of study has been done, the etiology of this disease remains ambiguous. As rubber is a perennial tree crop with a life span of nearly 25 years, the loss due to brown bast is enormous.

Symptoms and Signs of Brown Bast

The most important symptoms of brown bast syndrome are the appearance of small patches of dry bark on the tapping cut. These are clearly visible immediately after tapping and before the latex begin to flow along the tapping cut. The amount of latex that could be obtained by tapping of such a tree is very low and the whole tree would go completely dry at the end. The loss of yield is of a serious concern to planters, although this disorder does not lead to the death of the rubber tree. This phenomenon of bark dryness has long been recognized as the first obvious sign of brown bast symptom (Petch, 1921; Sanderson and Sutcliffe,1921). Incident of brown bast syndrome even in untapped trees has also been detected.

Another striking feature of brown bast is, its apparent failure to spread from virgin bark to regenerated bark as well as the failure to spread from one regenerated panel to another (Paranjothy *et. al*, 1975). It is essentially a disorder of the latex vessels, originating in and along the vessels. There is no flow of latex from vessels in diseased bark because the latex in the vessels is coagulated. The coagulation of latex within the vessels would naturally lead to the death of the vessels. Another group of researchers found that the phloem necrosis and phloem senescence could be the primary cause for brown bast (Horne *et al*., 1925). However, the finding of Paranjothy et.al, in 1975 revealed that the necrosis of phloem elements in brown bast material was not clearly seen.

Besides reduction and stoppage of the latex flow, terminal symptoms such as formation of woody burrs and cracking of the bark have been reported (Pillay, 1968). Late dripping is regarded as the first indication of brown bast. The brown bast occurring randomly in a plantation and then spreading along the lanes of trees, and later being a physiological fatigue feature (Lacrotte et al., 1997). The symptoms range from partial dryness with no browning of the tapping cut, browning and thickening of the bark and in some cases also the presence of cracking and deformation of the bark (Pakianathan et al., 1992; Gomez et al., 1990). The diseased zone occurring on the first tapping panel can spread quickly onto the second panel (Murong et al.,1994).

According to de Fay and Jacob (1989), external symptoms of natural bark dryness is the drying of the tapping cut. Observation of the bark during tapping and a thorough study of tapping panel bark show that drying up can reach various degrees namely simple tendency to dryness, typical dryness, more or less extensive and complete dryness. The simple tendency to dryness is the starting stage of dryness in rubber tree (de Fay and Jacob, 1989). The drops of latex emerge irregularly and swell slowly in the fresh cut (Rands, 1921; de Fay 1981). Two other types of flow have often been described, either extreme fluidity of the latex, which flows from the cut for a long time (Petch, 1921; Rands, 1921), or in contrast, very viscous latex leading to premature coagulation on the cut. These features are often interpreted as prediction of the typical dryness caused by brown bast (Petch, 1921; Rands.1921; Peries et al., 1964).

In second stage of dryness in typical dryness, the latex no longer flows at all unless the tapping cut is made deeper. The dry part of the tapping cut is distributed in one or two zones of whole tapping cut and later it will become completely dry (de Fay and Jacob, 1989). It is generally considered that dryness begins at the tapping cut and then extends sideways and downwards very rapidly (Rands, 1921).

In the last stage of dryness, the drops of latex do not appear even in the deepest of tapping, known as complete dryness. In complete dryness 100% dryness of tapping panel is observed (de Fay and Jacob, 1989). Other observations in the dry zones of bark are browning, a tendency to thicken, cracking and peeling, deformation and abnormal trunk structure (de Fay and Jacob, 1989; Gomez and Gandhimati, 1990).

Many workers reported that browning of dry bark and abnormal coloration is appeared on affected rubber tree (Rands, 1921; Petch, 1921; Sanderson and Sutcliffe, 1921). Cracking in vertically may occur in the outer part of the bark. It is generally observed beneath the tapping cut where it runs towards the base of the trunk (Petch, 1921; Rands, 1921) and enables the old, diseased bark to flake off. It dies and separates off as a thick scale that is hard, brittle and cracked (de Fay, 1981). Another important sign of brown bast is the formation of abnormal bulges on the lower part of the tree trunk. (Rands, 1921; Sanderson and Sucifee, 1921). It has also been observed that though the occurrence of brown bast is at random in plantations, there is some level of clustering of infected plants since row of four or five diseased trees are commonly observed (Taysum, 1960; de Fay, 1981).

Factors of Brown Bast

One of the factors of brown bast is over exploitation. It is understood that the repeated removal of large quantities of latex causes nutrient stress on the tissue of the bark that is exploited. Experimental evidence for this has been reported by de Fay in 1982, by inducing dryness in clone GT 1 rubber trees, which have been tapped twice a week, by tapping them 6 times a day. He observed histological changes such as coagulation of latex and noted some evidence that continued tapping of trees shows symptoms of exhaustion. Therefore, susceptibility to brown bast remains an important factor determining tapping intensities hence indirectly determining yield.

Considering the work done on brown bast in past, some workers have suggested that the water and nutrients stress are important in the development of brown bast (Schwelzer, 1936). Vollema (1949) and Compagnon (1953) observed a greater incidence of brown bast development during and after wintering period where the availability of soil water was limited. Therefore, root cannot absorb water in such condition causing a considerable water stress. The development of brown bast could occur when a large of quantities of latex is removed repeatedly and caused water available in bark is fluctuate (Sharples and Lambourne, 1924). According to Compagnon *et. al* (1953) nutrient stress is also important as brown bast has shown varied response to treatment with potassium.

The yield of rubber tree is latex which is formed within the tree thus tightly in association with physiological and biochemical reactions. Sype (1984) observed that the physiological characteristics of the latex of affected trees were not markedly different from those of healthy trees but were distinguished by weak metabolism and by lutoid weakness. Regarding the hormonal factor, Chrestin (1984) commented that intensive hormonal treatment of bark increases toxic oxygen generating activity and leads to the lysis of the latex organells and especially of the lutoids. Tupy (1958) pointed out an association of low sucrose availability in latex vessels with pre-matured degeneration of vessels and bark dryness.

Brown Bast Management

Through some observations and experience, a tree affected with brown bast could overcome its bark dryness by having considerable time of rest. In other words, if tapping of such a tree is stopped for some time there is a chance for it to recover. This idea is used in estate practices. They rest trees affected by brown bast and recommend tapping of such trees later when they are thought to have recovered from the brown bast. However, it is only temporary remedy.

Isolation of pre-tapping panel, by making grooves on both sides of tapping cut up to tapping depth is often practised in smallholding as a method to control panel dryness. Anthony et. al, (1981) had discussed similar methods of controlling panel dryness of rubber tree, including isolation of pre-tapping panel on virgin bark, and treatment of partially or totally dry cuts. They had also introduced a schedule of recommended tapping practices of dry rubber trees.

Conclusion

Brown bast is a physiological disorder of the economically important rubber trees. The disease often affects the high yielding clones of rubber trees. Although there is a considerable amount of information on brown bast, natural rubber researchers have so far failed to find the exact cause of this disorder. Therefore, a coordinated study approach that incorporates all elements influencing infection brown bast development is crucial to control and foresee future natural rubber production. To start with, further study will open the possibility to better understanding the histological changes during brown bast development. Long term research endeavors are needed to find the best cure of brown bast syndrome while improving sustainable natural rubber production nationwide.

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