COLONIAL BOTANY AND PLANT TRANSFER: THE CASE OF NATURAL RUBBER (1850 to 1910)

K. Tharian George

Rubber Research Institute of India, Kottayam-686 009, Kerala, India

Received: 18 May 2016 Accepted: 25 July 2016

George K.T. (2016). Colonial botany and plant transfer: The case of natural rubber (1850 to 1910). *Rubber Science*, **29**(3): 215-223.

This paper is primarily concerned with decomposition of the major contributory factors for the transplantation of natural rubber from Brazil to the South-East Asian colonies of Europe during 1850 to 1910. The analysis is contextualized to capture and reconstruct the missing links in the debate on the process of transfer of rubber from its natural habitat in the Amazon basin to South-East Asia. The conventional wisdom on the theme has been focused on the three region-specific factors, *viz*. organization of rubber production, supply of labour and plant diseases. However, a centralized system of research and development support provided by the colonial powers of Europe through a network of Botanical Gardens had been pivotal on providing a sustainable platform for transplantation of rubber from the Amazon basin. The unrivalled role of colonial Botany evolved by the network of Botanical Gardens is underlined by the commercialization of plantation rubber within two decades of the Wickham rubber mission in contrast to the stagnation of the interlocked wild rubber extraction system for about a century. In sum, R and D inputs provided by the colonial powers had been the centripetal force leading to the dynamic growth of a cost competitive Asian plantation rubber and gradual exit of the wild rubber from the world market.

Key words: Botanic gardens, Colonial botany, Natural rubber, Plant transfer

INTRODUCTION

The genesis of plant transfer since the first voyage of Christopher Columbus in 1492 and the aftermath had been unprecedented for the contributory factors and the outcomes. Despite the polemics on the same, the event heralded an array of developments leading to the Columbian Exchange which ended the biological separation of the world. The Columbian Exchange (Crosby, 1972) refers to widespread exchange of flora and fauna between the Western and Eastern Hemispheres as well as voluntary and involuntary migration of people to the Americas followed by the first voyage. Functionally, the Columbian Exchange had far reaching consequences on the prevailing agrarian systems of the world leading to the emergence of a new biological era marked by ecological imperialism (Mann, 2011) Broadly, the new biological era had been characterized by the evolution of three streams of agrarian systems with specefic geographical and organizational features over time. Among the three, the first phase beginning from the last decade of fifteenth century was characterized by exchange of food staples between the new

Correspondence: Tharian George K. (Email: thariangk@gmail.com)

world and the old world. The introduction of wheat and rice to the Americas and the gradual diffusion of maize and potato back to Europe witnessed post-Columbian world wide population explosion (Brockway, 1979; 2002; Foster, 1999). In retrospect, maize and potato enabled Europe to confront the potential threats of famine during the commercial revolution of the sixteenth through eighteenth centuries[1] (Foster, 1999). The first quarter of the sixteenth century marked the second phase with its characteristic focus on export-oriented cash crop production in the European colonies in the New World. The first cash crop cultivated in these colonies under monoculture oriented plantation system was sugarcane[2]. This phase is also remarkable for the involvement of European merchant capital in the triangular trade among Europe, Africa and the Americas leading to the peripheralisation of plantation agriculture and centralization and repatriation of surplus by the colonisers[3]. The involvement of European merchant capital in the triangular trade led to a shift from coastal mercantilism and subsistence farming to capitalist agriculture with backward and forward linkages to industry (George, 2011). To a large extent, arrangements evolved for plant transfer, organization of production and marketing in this phase set on template for perennial crop based plantations developed in the tropical colonies of South-East Asia by the colonial powers of Europe during the next phase.

The third phase beginning from the second quarter of the nineteenth century witnessed plant transfer of perennial crops from the natural habitats and evolution of plantation agriculture in South-East Asian colonies of Europe backed by the exploratory experimental inputs by the botanical gardens. Among the three agrarian systems, plantation agriculture evolved in South-East Asia during the nineteenth century had four major distinct features *vis-a-vis* the export-oriented cash crop production during the second phase, *viz*. (i) unlike in the Americas movement of capital from Europe was not followed by movement of people for settlement; (ii) the indentured labour was the major source of labour in South-East Asian tropical plantations in contrast to the imported slave labour in the Americas; (iii) short-term crops dominated the pattern of agriculture developed in the Americas whereas, perennial crops prevailed in the tropical Asia; and (iv) a centralized system of research and development support provided by the colonial powers of Europe at various stages of establishing plantations in South-East Asia (Dean, 1987; Brockway, 2002; Jackson, 2008; George, 2011). This phase also coincided with the ascendancy of industrial capitalism over mercantilism in the backdrop of industrial revolution in Britain. The contexts and contributory factors of plant transfers from the natural habitats in the Americas to the South-East Asian colonies of Europe have a long and rich intellectual pedigree encompassing various schools of thought[4].

Among the plant transfers during the nineteenth century the case of natural rubber (*Hevea brasiliensis*) deserve a revisit for its pivotal role in the industrial revolution and unparalleled commercialization in the South-East Asian colonies[5]. However, consensus is missing on the major contributory factors for the transfer of rubber from its natural habitat in the Amazon basin to South-East Asia. The debate is revolved around three region-specific factors, *viz*. the organization of rubber production in Brazil, supply of labour, plant diseases, and the research and development support provided by the colonial powers in establishing plantation rubber in the colonies.

This paper is primarily concerned with a decomposition of the major contributory factors listed above with a view to reconstruct the process of transplantation of natural rubber from Brazil to the South-East Asian colonies of Europe during 1850 to 1910. The choice of the period was guided by the opening of Amazon to foreign commerce (Dean, 1987) and the accelerated boom in demand for rubber (Weinstein, 1983) in the 1850s and gradual replacement of wild rubber by the plantation rubber in the world market since the second decade of the twentieth century[6].

ORGANIZATION OF PRODUCTION

The decisive roles of markets and technological progress in the evolution of agrarian systems have been widely recognized. The case of rubber is unique for the boom in demand triggered by a number of technological innovations in its industrial uses[7] during the first half of the nineteenth century and the subsequent geographical transplantation of the crop from its natural habitat within six decades of integration of Amazon basin with the world economy. These developments had the effect of 'transforming rubber from a natural oddity to a world commodity' (Jackson, 2008). The organizational structure evolved in Brazil for wild rubber extraction was characterized by a four-tier system consisting of tapper, patron, river trader and the export house. The structure is devoid of the cardinal element of cultivation as rubber production was dominated by extraction of latex from wild rubber trees. Hence, the system is considered as collecting expeditions (Weinstein, 1983) under comparable modes of extraction. Though the Spanish voyagers were the first to notice rubber in the Americas, it was the Portuguese colonization of Brazil since the dawn of the sixteenth century institutionalized the extraction of products from wild plants and animals[8]. Functionally, the four-tier system for rubber extraction was interlocked by a debt-merchandise contract in which the export house provided credit to river traders who in turn supplied goods on credit to patrons and the tappers were given advances and provisions by the patrons. On the reverse side of the exchange relations, rubber extracted by the tappers was delivered to the patron for upward transaction to the river trader and finally to the export houses for shipments to Europe and America (Akers, 1914; Coomes and Barham, 1994; Jackson, 2008).

The most distinctive feature of the organizational structure of wild rubber extraction was the virtual absence of development cost related to cultivation. In practice, wild rubber was treated like any other extractable forest produce with important implications on the sustainability of the organizational structure of the four-tier system. The ownership of land and trees was vested with the patron under the six types of land tenure prevailed in the Amazon Valley during this period[9]. The patron was also entrusted with the recruitment of tappers and monitoring of rubber extraction and primary processing. In practice, the tapper was a sub contract rubber collector who controlled the production by virtue of the predominance of the crop sharing system[10]. The river traders and export houses controlled tail end of the network with ample scope for surplus generation and appropriation. Moreover, the trading capital dominated network had been effective in appropriating huge margins ranging from 300-400 per cent on the goods and provisions sold to the tappers (Akers, 1914; Dean, 1987). The dependence on the four-tier system of wild rubber extraction was sustained till the development

of plantation rubber in South-East Asia since the last decade of the nineteenth century. During the six decades from 1850 to 1910, Amazon accounted for 50-60 per cent of world's rubber consumption requirements and about 40 per cent of Brazil's export earnings was from the commodity (Dean, 1987; Coomes and Barham, 1994).

SUPPLY OF LABOUR

Perhaps, among the various region-specific factors discussed in the vast volume of literature on the plant transfer of rubber from Brazil to South-East Asian colonies the pivotal role of labour has been widely recognized. The three salient features of labour engaged in rubber production during the initial phase in Brazil were: (i) dependence on native labour unlike the slave labour based sugar plantations in the Americas of the sixteenth century[11]; (ii) labour was employed for extraction and primary processing of wild rubber in the absence of rubber cultivation; and (iii) wage payment system based on crop sharing. After the unsuccessful attempts to encourage immigration from Portugal, Spain and Italy a proposal was mooted to recruit Chinese labour. However, this proposal was rejected on the grounds of high transaction costs related to recruitment and transportation (Akers, 1914). Therefore, native labour was primarily drawn from the drought-stricken Ceara region and other northern states. In 1912, an estimated number of 190,000 rubber workers were engaged in the Amazon basin (Tully, 2011). A higher turnout of migrant labour was recorded during periods of higher prices could be due to wage payment system based on crop sharing. However, at times of higher rubber prices the output was increased by moving into untapped remote areas incurring higher transaction costs (Coomes and Barham, 1994). The tapping task ranged from 130 to 150 trees as the tappable trees were widely scattered in the forest[12]. Therefore, the working hours and frequency of tapping were depended on the density of trees in the allotted area of individual tapper.[13] In effect, the tappers were reported to be in perpetual indebtedness primarily due to the pre-capitalist exchange relations within the four-tier system. The cumulative effect of a higher opportunity cost of native labour arising from the higher wage rates in the port cities of Brazil and cheaper wage rates of plantation labour in Asia[14] had been serious impediments in the transformation of tappers to wage labour.

PLANT DISEASES

Among the three regional factors, vulnerability of plantation rubber to plant diseases; especially South American Leaf Blight (SALB), in its natural habitat has been widely recognized as the major contributory factor for thwarting development of rubber plantations in Brazil and the plant transfer (Hilton, 1955; John *et al*., 1977; Dean, 1987). The contentions of the Ecological School are focused on the incidence of SALB coinciding with 'attempts to cultivate it on plantation lines……' whereas the tree had an uninterrupted growth in its forest base (Dean, 1987; Tully, 2011). Though several species of leaf-infecting fungi were observed in the Belem Botanical Garden of Brazil in 1907, Leaf Blight was first recorded in Surinam in 1910 (Hilton, 1955; Dean,1987). Subsequently, it was reported in Trinidad in 1916, state of Bahia in Brazil in 1930, Panama and Costa Rica in 1935, Mexico in 1946 and Guatemala and Honduras in 1948 (John *et al*., 1977).

In this context, two points deserve attention: (i) the transfer of *Hevea* from Brazil leading to the development of plantation rubber in South-East Asia was initiated more

than three decades before the first reporting of SALB in the Americas and (ii) the state sponsored efforts to develop plantation rubber in the Americas during the first decade of the twentieth century were not based on knowledge of leaf blight (Coomes and Barham, 1994). Alternatively, while the availability of wild rubber as a natural resource enabled the natives to by-pass the grueling pace of long gestation period, the interlocked exchange relations ensured appropriation of margins by the patrons, traders and export houses[15]. Moreover, the outcomes of research and development effort initiated in the native states of the Americas could not match the proactive interventions by the network of botanical gardens controlled by the colonial powers. In fact, planting materials from South-East Asia were liberally utilised for the development of plantation rubber in the Americas since the early decades of the twentieth century (Hilton, 1955).

RESEARCH AND DEVELOPMENT SUPPORT

The pivotal role of a centralized system of research and development support provided by the colonial powers of Europe through a network of Botanical Gardens in the transplantation of rubber to South-East Asia require careful analysis for its magnitude and validity over time. Unlike the plant transfer in the two earlier phases the crops involved in the third phase were perennial crops such as tea, cinchona and rubber in the backdrop of growth in world markets triggered by the industrial revolution. In the case of rubber, though the Amazon basin was the only source of supply till 1880 (Weinstein, 1983) its interlocked four-tier system of wild rubber extraction was inelastic to the growth in demand since the second half of the nineteenth century. Hence, a shift from the Amazonian mode of extractive rubber production was inevitable but for the internal contradictions of the prevailing system of arrangements in adopting plantation mode of rubber cultivation. The three intrinsic traits associated with the organized plantation mode of rubber cultivation are higher initial investment, longer gestation period and economic life. Therefore, the prevailing equations in the Amazonian rubber sector were ripe for an explicit intervention by the colonial powers for ensuring stable supply of the raw material. However, unlike the effective tea transfer from China in the aftermath of the Opium War (1840-42) the edge in scientific knowledge on various aspects of plant sciences had been catalytic to the successful transplantation of both cinchona and rubber from the Americas by the colonial powers during the second half of the nineteenth century[16]. However, the intellectual platform for the plant transfer was provided by the voluntary associations of the societies and Botanical Gardens as the prominent British universities viewed the science of botany with disdain[17]. While the Royal Societies were mainly concerned with the debates and exploratory missions on the multifarious aspects of plant sciences, the Botanical Gardens focused on the applied and commercial versions masterminded the plant transfers.

Initially, though the Botanic Gardens were considered as collection centers of tropical plants, the scope and range of activities have undergone important changes during the nineteenth century. Apart from collection and classification of plants, research, publication, information storage and retrieval and training programme for creating manpower useful to plant transfer had been added in the transition from classical Botany to colonial Botany. The establishment of Royal Botanic Gardens at

Kew as a state funded institution in 1841 explicitly set the agenda containing three well defined objectives of the colonial government, *viz.* (i) to evolve as a world centre for economic botany 'by closely tying the young science of botany with the rising fortunes of the empire'; (ii) co-ordinate the work done in the Botanical Gardens of the colonies and (iii) act as a clearing house for the plant transfer throughout the empire. In fact, the establishment of the Kew Gardens as a state funded institution in 1841 was preceded by its satellites in the British colonies[18]. In practice, the botanic gardens adopted a consortium approach from the stage of plant exploration to final transplantation of the improved planting material as illustrated by the case of rubber.

As in the case of cinchona, the Royal Botanic Gardens at Kew and its satellites were instrumental in the transfer and the subsequent successful transplantation of rubber in 1876. Another important feature of the rubber mission was combining the financial prowess of the India office of the colonial government with the technical expertise of the Kew Gardens as in the case of cinchona project. Unlike the earlier attempts on rubber transplantation[19], the successful Wickham mission was the largest in terms of the scale of operation and the outcomes. From the reported 2700 germinated seedlings, 1919 were shipped to Peradeniya Botanical Garden in Ceylon from Kew for propagation, experimentation and distribution to other colonial Botanic Gardens (Dean, 1987; Brockway, 2002)[20]. Subsequently, Ceylon emerged as the major center of rubber propagation supplying rubber seeds and seedlings to all potential areas identified for rubber cultivation in Asia. However, concerted efforts on evolving and standardizing protocols for planting density, cover crop establishment, manuring, disease control, crop harvesting and processing of latex are the major contributions of Singapore Botanic Gardens under the leadership of H.N. Ridley (Dean, 1987; Thomas and Panikkar, 2000; Brockway, 2002). Simultaneously, there had been systematic R & D initiatives by the Dutch in Bogor Botanic Gardens of the Netherlands East Indies on various aspects related to rubber cultivation. The first attempt to develop rubber plantations of indigenous *Ficus elastica* in 1864 was primarily confined to government's plantations in Java (Tengwall, 1945). The pioneering contributions of the Dutch were in standardizing the procedure for bud-grafting in 1914 and doubling the yield from 500 to 1000 kg ha^{-1} based on the trials initiated since 1910 (Tengwall, 1945; Dean, 1987). A unique feature of the R & D efforts undertaken by the Botanic Gardens had been close co-operation and sharing of information on the new methods of cultivation, harvesting and processing of rubber in spite of the competition in the commercial side as evidenced by the interactive relationship among the British, Dutch and French institutions (Brockway, 2002; Tully, 2011). In 1940, the French colony of Indo-China had the highest share of bud-grafted materials in the total planted area (McFadyean, 1944).

CONCLUSIONS

The successful Wickham rubber mission in 1876 marks the transition of rubber from its natural resource extraction mode under pre-capitalist production relations to a low wage commodity production in the backdrop of industrial revolution during the nineteenth century. The rubber mission is considered as the first case of massive bio piracy (Jackson, 2008) in the modern era leading to the transplantation of rubber from the natural complexity of its forest habitat

to the artificial homogeneity of man made plantations in the colonies. However, the consensus in the unsettled debate has been more on the three region-specific factors than on the pivotal role of a centralized R & D support spearheaded by the Kew Gardens enabling a sustainable platform for transplantation of rubber from the Amazon basin. The colonial Botany evolved by the network of Botanical Gardens had been equivalent to transformation of science in to capital than mere accumulation of scientific knowledge. This proposition had been amply demonstrated by the commercialization of plantation rubber within two decades of the Wickham rubber mission in contrast to the stagnation of the interlocked wild rubber extraction system for about a century. The interlocked wild rubber extraction system would have prolonged but for the emergence of the institution of Botanical Gardens constantly engaged in the collection and selection of species, hybridization, new methods and areas of cultivation and innovations in harvesting and processing of rubber. The unrivalled role of R & D inputs and scientific application of the same by the colonial power had been the centripetal forces leading to the dynamic growth of a cost competitive (Akers, 1914) Asian plantation rubber and gradual exit of the wild rubber from the world market.

NOTES

1. Exchange of new crops not only enlarged the narrow genetic base of native societies but also enabled higher output per unit area as observed in the case of potato (Ponting, 2007). The introduction of maize thoroughly transformed the food complexes of China and Europe as it thrives on drier soils of Southern Europe and dry uplands of China (Brockway, 2002; Jackson, 2008)
2. Sugarcane is considered to be a native of India. However, sugarcane cultivation on plantation lines was evolved by the Portuguese and Spanish in the Atlantic islands of Madeira and the Canaries since the mid-fifteenth century (Foster, 1999; Brockway, 2002).
3. In the triangular trade, finished products from Europe were shipped to Africa and bartered for slaves to be sold to plantation owners in the Americas. From the Americas sugar, silver, molasses, tobacco and cotton were purchased for sale in Europe (Foster, 1999).
4. The two major schools of thought on the theme are the Ecological School and the Plantation School. The conceptual framework of the former is focused on the ecological factors whereas the latter is concerned with the predatory nature of colonialism explaining the inner dynamics of both mercantilist-era slave plantations in the New World and the twentieth century plantations evolved in Asia (Best, 1968; Brockway, 1979; Beckford, 1985, Dean, 1987; Coomes and Barham, 1994; Thomas, 2006; Tully, 2011; George, 2011).
5. Natural rubber is considered as an exemplary raw material of the 'Second Industrial Revolution' of the late nineteenth century characterized by a wave of technological innovations using new materials and new ways of making old materials (Murray, 1992). Though rubber remained a curiosity for more than three centuries, the invention of rubber vulcanization in 1839 had a profound impact on the pace and profile of the industrial revolution (Dean, 1987).
6. Since the year 1910, rubber exports from Brazil stagnated and had been declining. From 1911 onwards rubber prices plummeted due to the arrival of plantation rubber (Dean, 1987; Jackson, 2008). In 1913, output of plantation rubber from South-East Asia exceeded the output of Amazon valley by 25 per cent (Akers, 1914).
7. The important technological innovations during this period included the discovery of naphtha as an efficient solvent for rubber in 1818 (Shurer, 1952), invention of masticator in 1821(Coates, 1987), invention of vulcanization in 1839, vulcanized rubber condom in 1843 and finally patenting and pneumatic tyre in 1845 (Tully, 2011).
8. The extraction of cinchona was by felling the tree for collecting the bark. The plant was

transplanted from its natural habitat in the Americas to India by the British in 1860 (Brockway, 1979; 2002).

9. These are:(i) old grants issued by the Portuguese Crown during the colonial period; (2) grants given under the Empire; (3) concessions sanctioned after the establishment of the Republic in 1889; (4) lands sold or conceded for a nominal consideration by the authorities of the States of Para, Amazonas, and MattoGrosso; (5) lands purchased outright from the National or State Government and (6) lands acquired by occupation under the conditions of settlers' rights (Akers, 1914).

10. The crop share of the tappers was 50 per cent (*ibid*).

11. The abolition of slave trade and slavery by various European and American countries during the nineteenth century was the main reason for the dependence on native labour.

12. Rubber trees were found in the forests at distances varying from 200 to 250 feet (*ibid*). Sometimes, only two or three tappable trees were available in a hectare (Dean, 1987).

13. The working day lasted ten hours (Tully, 2011) and the annual average yield per tapper was below 500 Kg (Dean, 1987).

14. The daily wages in Asian plantations were about one-eighth level of those in Amazonia (Coomes and Barham, 1994).

15. The neglect of plantation rubber in Brazil from the very beginning was reported. The retarded growth of young rubber trees was mainly on account of rank vegetation leading to longer gestation period and poor survival rate (Akers, 1914).

16. Though tea seeds from China were brought to India under the British initiative in 1835 (Hajra, 2001), the method of cultivation and processing were effectively transferred after the war (Brockway, 2002; Cassan, 2005). Cinchona and rubber were smuggled to Kew Gardens from the Americas in 1859 and 1876 (Brockway, 2002; Jackson, 2008), respectively.

17. Oxford and Cambridge universities did not consider study of science as a gentlemanly pursuit. However, Scottish universities of Edinburgh and Glasgow taught Botany and had Botanical collections. The Royal Societies were voluntary associations of intellectuals concerned with the study of various disciplines of natural sciences since the seventeenth century. The earliest Botanical Gardens were established in Pisa, Florence and Padua in Italy during the sixteenth century (Brockway, 1979; 2002).

18. The first British colonial Botanic Garden was established at St. Vincent in the West Indies 1765. The Calcutta Botanic Garden was established in 1786 (Thomas, 2006).

19. The rubber mission was a complex and lengthy bureaucratic project around fifty years in execution (Dean, 1987). Among the various unsuccessful earlier attempts prior to the Wickham Mission, the India Office commissioned Mr. James Cross, a qualified Botanist, in 1872 (Tully, 2011).

20. An important technical innovation accelerating the process of safe transport of plants was the 'Wardian Case' in 1829 (Foster, 1999; Brockway, 2002).

REFERENCES

Akers, C.E (1914).*The rubber industry in Brazil and the orient*, Methuen&Co., London,320p.

Beckford, G. L. (1985).Caribbean peasantry in the confines of the plantation mode of production, *International Social Science Journal*,37(3):401-414.

Best, L. (1968), The mechanisms of plantation – type economies: Outlines of a model pure plantation economy, *Social and Economic Studies*, **17**(3):283-326.

Brockway, L.H. (1979). Science and colonial expansion: The role of the British Royal botanic gardens, *American Ethnologist, **6**(3) Interdisciplinary Anthropology,* pp.449-465.

Brockway, L. H. (2002).*Science and colonial expansion: The role of the British Royal botanic gardens,* Yale University Press, New Haven.212p.

Cassan, B. (2005). William Jardine: Architect of the first opium war,eastern Illinois University Department of History, [online] **14**(1):107-117. Available at: http://www.eiu.edu/historia/Cassan.pdf [Accessed 3 Apr. 2015].

Coates, A. (1987).*The commerce in rubber: The first two*

hundred and fifty years, Oxford University Press, Singapore. 380p.

Coomes, O. T. and Barham, B. L. (1994). The Amazon rubber boom: Labour control, resistance, and failed plantation development revisited, *The Hispanic American Historical Review*, **74**(2): 231-257.

Crosby, A.W. (1972). *The Columbian exchange: Biological and cultural consequences of 1492*, Greenwood Press, Westport.268p.

Dean, W. (1987). *Brazil and struggle for rubber: A study in environmental history*, Cambridge University Press,Cambridge.234p.

Foster, J.B. (1999). The vulnerable planet: A short economic history of the environment, Calcutta, Cornerstone Publications.160p.

George, K.T. (2011). From merchants to multinational enterprises: European trading firms in South India's plantation sector, In:*Shaping India: Economic Change in historical perspective* (Eds. D. Narayana. and R. Mahadevan), Routledge, New Delhi. pp. 149-181.

Hajra, G. N. (2001). *Tea cultivation: Comprehensive treatise*, International book publishing company, Lucknow. 518p

Hilton, R. N. (1955). South American leaf blight. A review of literature relatingto its depredations in South America, its threat to the Far East and methods available for its control. *Journal of Rubber Research Institute of Malaysia*, pp.287-337.

Jackson, Joe (2008).*The thief at the end of the world: rubber, power, and the seeds of empire*, New York, Viking. 414p.

John, C.K., Kadir Abdul A. andSubrmaniam S. (1977). South American Leaf Blight — an overview, *Journal of Rubber Research Institute of Sri Lanka*, **54**, 373—380.

Mann, Charles C. (2011).*1493: Uncovering the new world Columbus created*, Alfred A. Knopf, New York. 535 p.

McFadyean, Andrew (1944), *The history of rubber regulation (1934-43)*, George Allen & Unwin, London. 219 p.

Murray, Martin J. (1992)."White gold' or 'White blood'? The rubber plantations of Indochina, 1910-40, In: *Plantations, Peasants and Proletarians in colonial Asia* (Eds.V.E Daniel, H. Bernstein and T.Brass), Frank Cass & Co., London, pp. 41-67

Ponting, Clive (2007). *A new green history of the world*, London, Penguin Books. 452 p.

Shurer,H, (1952). The Macintosh: Paternity of an invention, The India-Rubber Journal,**122**:632-637.

Tengwall, T.A. (1945). History of rubber cultivation and research in the Netherlands East Indies, In: *Science and Scientists in the Netherlands Indies*, (Eds. P.Honigand F.Verdoorn) Board for Netherlands Indies, New York.pp.344-351

Thomas, Adrian P. (2006). The establishment of Calcutta botanic garden: Plant transfer, science and the East India Company, *Journal of Royal Asiatic Society*, Series 3, 16(2), pp.165-177.

Thomas, Kurian K. and Panikkar A.O.N (2000). Indian rubber plantation industry: genesis and development, In: *Natural Rubber: Agromanagement and Crop Processing* (Eds. P. J. George and C. Kuruvilla, Jacob), Rubber Research Institute of India,Kottayam.pp.1-19

Tully, J. (2011). *Devil's milk: A social history of rubber*, Monthly Review Press,New York.480 p.

Weinstein, Barbara (1983). *The Amazon rubber boom, 1850–1920*, Stanford, Stanford University Press, Stanford. 370 p.