



Rubber and Man A Century of Partnership

**Since the first seedlings reached Ceylon,
man has wrought greater changes in
the rubber tree than in any other plant
by Richard Evans Schultes**

This is the second of two articles on rubber and man, tracing the impact of rubber on society since 1876.—Ed.

Man has never accepted nature as he finds it. He has never, for example, been content with many of his cultivated plants and has taken great pains to exaggerate their useful qualities through selection and breeding. In the case of rubber, perhaps the most important of cultivated plants, the improvements took on special urgency. Modern advances in the cultivation of rubber not only replaced the primitive plantation system of the Amazon; they set the course for a revolution in modern industry and became, due to ominous events that loomed ahead, a more immediate necessity for surviving world war. In the long run, natives in South America, rubber's original habitat, could never have supplied the world's explosive



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In a composite view above, workers at a Dutch East Indies plantation in 1914 collect latex from "spiral" tapped trees.

demand. More imminently, the Japanese were poised to seize new plantations in the East. Fortunately, by 1900 all was ready for a decisive step forward: the expansion of the cultivated rubber industry and its return to the New World.

Henry Wickham's voyage with seeds of *Hevea* from the Amazon to Britain in 1876 marked the birth of rubber in the Old World. For thirty years after Wickham's expedition and the distribution of his seeds to plantations in the East, little progress took place in the cultivation of the new seeds beyond observation and experimentation. But by 1912, the yield of plantation rubber equaled that of the Amazon forests. As Loren Polhamus put it, "the death knell of the wild industry had been sounded." By 1920, plantations in the East had produced 1,090,000 tons of rubber, the wild industry 4,600 tons. Most advances in

plantation rubber, however, took place between 1910 and 1941, when the Japanese occupation put an end to experiments in the East and touched off efforts in New World plantations to improve known species and find undiscovered ones.

The changes were of vital importance to the history of rubber and to a revolution in the life habits of the 20th century as well.

The odyssey of *Hevea brasiliensis* during the last century almost defies belief. In the early years of the Eastern plantation industry, all trees were planted from seed almost exclusively from the trees that grew from Henry Wickham's collection and their progeny in the Far East. Following the Wickham achievement in 1876, Brazil prohibited the exportation of rubber seed. Of the 2,000 Amazonian seeds that germinated at Kew Gardens in 1876, a number were sent to

Ceylon and survived. The year 1877 also saw shipments successfully made to Singapore, Malaya, Perak and Malacca. Slightly later, material went to Borneo, Burma and parts of India and to other parts of southwest Asia: Indochina, Siam, Sarawak and the Dutch East Indies. In 1928, plantations were established in the Philippines. *Hevea brasiliensis* spread to Africa, where extensive plantations were set out in the early 1920s, especially in Liberia and the Congo.

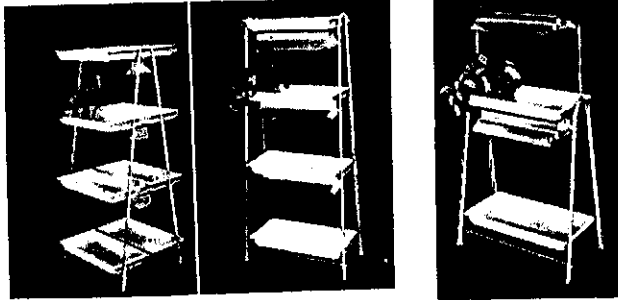
However, early attempts to establish plantations in the New World, especially in Trinidad, the British and Dutch Guianas, failed because of the leaf blight, *Dothidella Ulei*, a fungal disease present in the Western Hemisphere but fortunately absent in the

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Old World tropics. The successful return of natural rubber cultivation to the New World, which became necessary before long, would have to await a series of events no one could foresee.

In the Far East, rubber trees were first planted in low, swampy ground, mainly because, in the Amazon, *Hevea brasiliensis* is usually found in this habitat. A report from the Singapore Botanic Gardens in 1891 stated optimistically: ". . . this plant will be well worthy of cultivation in many spots of damp waste land in which few other crops can be grown without great expense in draining." When later experiments indicated that the tree grew better on higher, well drained sites, a great step forward in plantation practice took place.

Since the Spanish explorer Oveido first described articles made of Hevea rubber in 1535, Amazon natives have followed the tedious, untechnical and unhealthy practice of smoking latex to coagulate it. Experimenters in Asian plantations learned, as early as 1899, that a cleaner, stronger rubber resulted, with far less labor, from the use of an acid—first acetic and now generally formic—to induce coagulation. Poured into trays, the latex becomes a thick curd with a consistency like that of cottage cheese. These curds, squeezed between rollers, emerge as thin, tough sheets which are hung up over a slow fire to dry and acquire a smoke-resin capable of hindering the growth of moulds on the rubber.

Planters soon found that this kind of rubber was preferred by industry, and today all plantation rubber is produced and sold either as concentrated or "creamed" latex or as laminated sheets. A further refinement is crepe rubber, made by passing sheet rubber through rollers running at unequal speeds to create a tearing action and later drying in a warm, building without smoke.

Would plantation rubber withstand tapping? That was the enigma in the early days of cultivation. And if so, when could tapping begin and what method would be safest for the trees? Absolutely nothing was known about this basic aspect of the industry although obviously the crude methods of the Amazon would have been disastrous.

As early as 1872, in his official report recommending cultivation o

rubber, James Collins, curator of the Museum of the Pharmaceutical Society in Britain, had suggested that a waiting period of 25 years might be required before tapping *Hevea brasiliensis*. Since that time experience has shown that trees may be cut within six or eight years without injury. The earliest tapping occurred experimentally in Ceylon in 1882. Tapping for rubber production did not begin until 1888, and even then it was done timidly and only every other year.

Perhaps the most important trees to have germinated from Henry Wickham's original seeds were the 22 seedlings that went to the Singapore Botanic Gardens in 1877, following a prior shipment which did not survive. The success of these Singapore seedlings augured well for the future of rubber, because at that time the Botanic Gardens boasted the presence of an economic botanist of extraordinary vision and ability: Dr. H. N. Ridley, Director of Gardens and Forests in the Straits Settlements. Dr. Ridley's subsequent life was dedicated mainly to *Hevea brasiliensis*, the species Wickham brought to Britain in 1876.

Ridley set up bold experiments in Singapore between 1888 and 1897. He recommended long and deep cuts in *Hevea* trees in a herring-bone fashion and re-opening of the cuts but he warned that the decorticated areas should not exceed one-half inch. In the meantime, a new system was inaugurated in Ceylon: a series of V-cuts, one above the other in a vertical series, each 10 inches apart, and collection of the latex in a clay gutter ringing the trunk—a method borrowed from tappers of wild rubber in northern Brazil. It is interesting that similar tapping methods developed divergently in Malaya and Ceylon.

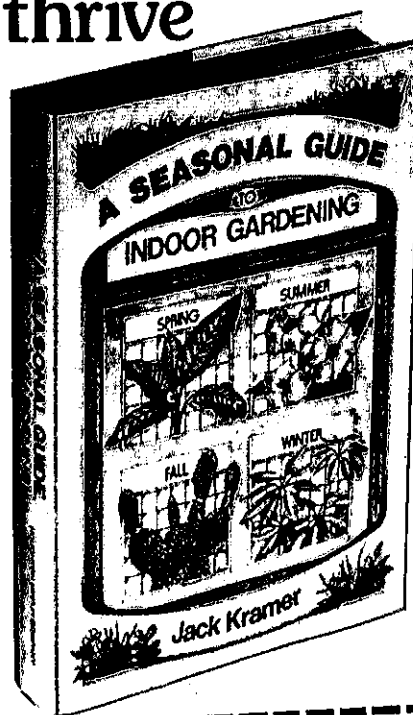
During these early days of experimentation, John Willis and J. Parkin in Ceylon made a significant discovery in the history of *Hevea*: that *Hevea brasiliensis* recovered rapidly from wounds induced by tapping, and that the second cut yielded more than the first. The implication of this discovery was at first lost to early experimenters, although it led to disagreement between the rubber specialists in Ceylon and Malaya. It eventually did lead, however, to the modern scientific tapping systems.

Hevea rubber, the species chosen

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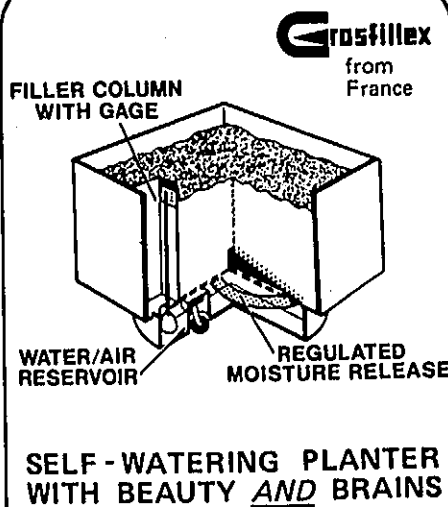


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by Wickham to cultivate in the Old World, has a bark of unusual texture and rejuvenative vitality. The bark lacks fibres and has a soft consistency. A very thin slice can be severed from a previous cut to open the latex tubes without injuring internal layers, especially the cambium. This unusual characteristic, not found in other rubber trees such as Castilla and Manihot, permitted the re-opening of a cut in the same place rather than making a new incision in a different location on the trunk. It has been called "ibidem tapping," from the Latin, "in the same place." That a latex flow is stimulated by *ibidem* tapping was soon experimentally shown, leading eventually to the accepted modern partial or full spiral panel system of tapping. It is almost certain that no other tapping system—one that opened many separate wounds instead of reopening one cut—would have proven to be commercially acceptable in the Old World plantations.

Tapping is a delicate operation requiring practice and skill. It involves the shaving off of a very thin layer of bark. Perfect tapping requires cuts to within 1/25 of an inch of the wood; if they are deeper, they penetrate the cambium and interfere with the regeneration of the bark.

The modern "full spiral" tapping method involves a left to right cut (since latex vessels are situated in a right to left inclination and, for greatest yield, should be severed at right angles: left to right) starting at the tapper's eye level and at a 45 degree angle. At the end of the incision, directly under the point of origin of the cut, a spout inserted in the bark leads the latex, flowing down the length of the cut, into a tin cup. The tree may be tapped every second or third day throughout the tapping season, which varies from six to ten months, according to weather and environment. Each cut is self-sealed by coagulation of the latex. Thus, a panel—a decorticated area—of from six to ten inches may be exposed in a tapping season. In the subsequent season, tapping resumed below this panel, which rapidly regenerates bark with little or no abnormal wound response if the cambium has not been injured.

The prime target, however, in the improvement of rubber concern yield, and it is certain that the domestication of rubber in 1876 would have

proved of little consequence without the immense strides that agriculturists made in improving the productivity of trees in Eastern plantations. These experiments set the stage for the enormous increase in the modern use of rubber in industry, science, medicine and the arts. The natural yields of rubber in the primitive Amazon plantations could never have kept pace with the approaching revolution in rubber use.

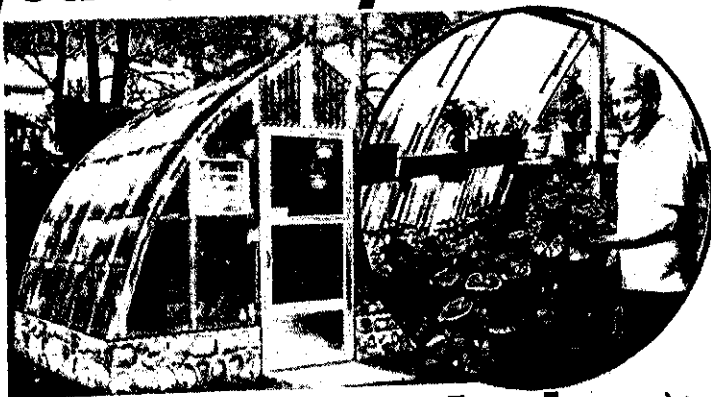
By the turn of the century, Brazil, sensing the danger that plantation rubber posed to its near-monopoly of wild rubber, began economic maneuverings that brought the world price of rubber up to \$1.05 a pound by 1905. But it was too late. These conditions merely persuaded the British and the Dutch to intensify heavy investment in cultivated Hevea. Furthermore, the tea, coffee, cacao and tobacco industries in the Asiatic colonies suffered either economic or agricultural set-backs during the 1890s. Especially severe was a fungal disease that hit coffee in Java and Ceylon, wreaking devastation on this once lucrative industry. Then, finally, the birth and expansion of the motor car industry (with production by 1910 of 180,000 automobiles) promised the growing commercial interests an outlet for a steady, reliable flow of rubber of high quality which only plantations could supply.

Increasing yield had obvious commercial advantages. A tree of *Hevea brasiliensis* is a lucrative investment. Today it costs \$200 to \$400 an acre to plant and maintain a plantation in the Far East until tapping age. The normal life of a tree in plantations was once estimated to be from 25 to 50 years in production. But even in Brazil many trees 200 years old still yield rubber, even under nearly a century of primitive tapping conditions.

It is now known that the strain of Hevea characteristic of the locality where the Wickham seed originated does not yield the highest quality or quantity of latex that this species can produce. However, the increase in the yield achieved in plantation rubber from that limited germ plasm has been astonishing.

The first trees to flower in Asia blossomed in March, 1880, in Malaya; this blossoming was closely followed by that of a tree in Ceylon. Very little was known at that time about the bot-

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any of *Hevea* and its flowering habits. Yet in the Far Eastern plantation, it early appeared that breeding could be employed in the creation of new high yielders. In fact, the genetic method of improving yields was one of the most fascinating, though fraught with difficulties.

Inherent in the difficulties of improving yields by genetic means is its slowness. It normally takes from five to seven years for a tree to flower (and hybridization can't take place before flowering) and even longer for a maximum yield to be determined.

The first plantings from seeds gave populations heterogeneous in yield: most trees were mediocre, a few were high yielders, a few were very low. The average for plantings from this seed stock in 1900 was 300 pounds of dry rubber per acre per year. Agriculturists then began to select seed for planting from special high-yielding trees—the so called “mother seed trees”—in the belief that they promised greater yields than those of randomly selected trees that had been pollinated unscientifically. The improvement in trees from mother seed trees was noticeable over the years, attaining yields of 650 pounds per acre; but it was not enough. By 1940, grafting techniques had produced Eastern clones yielding 1,800 pounds per acre, and yields of 2,500 pounds from modern clones are expected.

One of the most successful methods of increasing yield was bud-grafting, the discovery of a Dutch rubber specialist, Peter J. S. Cramer. Bud-grafting began in the Dutch colonies as early as 1910. By 1918, great success attended this operation; by 1922, it was demonstrated that bud-grafting was the answer to higher yields; by 1940, there were clones producing six times the yield of trees from unselected seed, and modern clones promised to yield nine times the production of seed trees.

Bud-grafting is merely a multiplication of individuals of a tree of a proven high yield: a clone. A bud from a clone was inserted under a flap of bark of a year-old rubber seedling. When the bud “took,” the top of the original seedling was cut off, stimulating the growth of the bud of the high-yielding clone. The final producing tree was a composite of two individuals: the rootstock, from seed of whatever source; and the trunk and

crown, from a clone of proven superiority in yield.

By the 1930s, the Japanese invasions in the East would spell the end of these long-range experiments and, paradoxically, a new opportunity for scientific strides in the New World. In the 1920s and early 1930s, British and Dutch attempts to monopolize rubber cultivation, controlling the prices and production, had spurred American efforts to plant rubber in plantations of the New World. In 1927 Henry Ford had set up two plantations covering 2,500,000 acres in the Rio Tapajoz in Amazonian Brazil; and in 1935, Goodyear Tire and Rubber Company had planted *Hevea brasiliensis* in Panama and Costa Rica. But they met with a serious problem, a fungal leaf blight, which caused black lesions on leaves and quickly grew endemic, rapidly and disastrously defoliating trees and throwing American efforts for a tremendous commercial loss.

Now, as the Japanese moved in to occupy the rubber plantations of the East Indies and Malaya, the efforts to overcome the blight—and to bring *Hevea* back to the New World—took on new urgency. They led not only to the rebirth of wild rubber tapping in the Amazon valley, but to the establishment, during the 1940s, of plantations in several tropical American countries, especially Brazil, Colombia and Peru. A number of these war-time plantations are still in active production today.

The concentration of the major rubber producing areas in Asia has always worried the United States, the world's greatest user of rubber. In 1940, the United States imported amounts of crude rubber estimated at \$318,000,000, less than 3 percent of it from the Americas. But the war now impressed on the United States the importance of protecting its strategic supply of rubber. Even before the Japanese take-over of most of the Asian plantations, the Americans had inaugurated a program to tap all available wild sources in the New World, to reactivate existing plantations and, in cooperation with Latin American governments, to encourage new ones.

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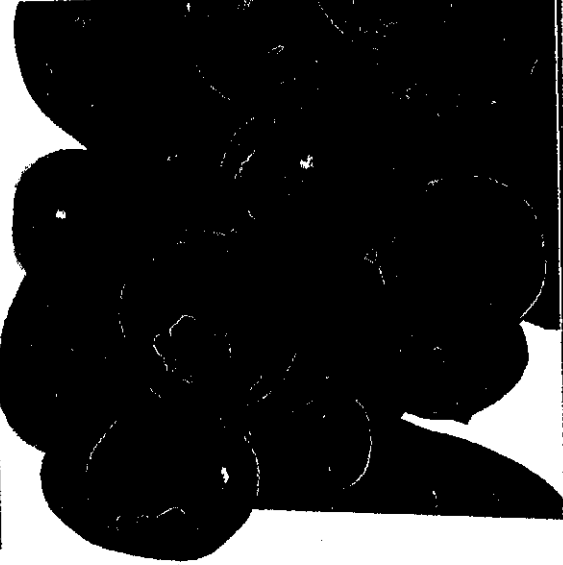
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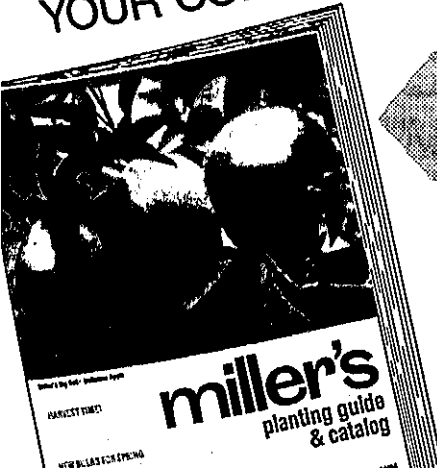
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conditions of cultivation were different. A high price was offered; credit, food, tools, medicines and other inducements were provided on a grand scale; technical help was made available; explorers set out to scout areas of the densest concentration of trees; air strips were constructed in remote localities for communication and transportation. By the end of the war, tropical America was producing 45,000 tons of rubber—most of it from *Hevea*—as much as the all-time high of American production in 1912. Without the return of *Hevea* to the New World—and the influx of aid and technical help—the war might have turned out quite differently.

We must thank these developments for ensuring an adequate supply of rubber during war, but perhaps even more important were the renewed opportunities they presented for extraordinary strides in improving rubber for the future.

The lessons learned in the disastrous experiences with diseases in the earlier New World plantations turned into an investment for future plantings. Agronomists noticed that, in the Amazon forests, certain trees appeared to have leaves resistant or immune to the disease. They selected a number of resistant clones and evolved a technique known as top- or crown-budding. Trees in these New World plantations were the bud-grafted, high-yielding clones developed in Asia. When the trees were two years old, a second graft was made near the top of the trunk: a bud from one of the resistant wild clones was inserted under the bark of the young tree; when it “took,” the original crown was cut off, thus stimulating the new bud to grow and produce a wholly new top. The final tree then would be a composite of three individuals: rootstock from randomly collected seed; trunk of a high yielding Eastern clone; crown of a resistant clone from the Amazon. Once this technique was initiated, New World plantations could prosper.

In the meantime, an effort was launched to seek out untapped species of rubber for further improvements. In 1942 and 1943, teams of botanists mapped and surveyed rivers by canal in South America, counting visible *Hevea* trees along the banks, for tapping in localities of greatest densities. My own involvement in this effort be-

gan in 1942 and lasted for 12 years, during which I surveyed the Apaporis river, which was rumored to have exceptional stands of rubber, though it was all but unknown. A seven-month study, during which I counted *Hevea* species along its 1,400 miles, revealed 1,700,000 trees, representing an estimated 10 percent of the total *Hevea* population of that one river basin.

The desirability of establishing more plantations in the New World was clear. High-yielding eastern clones and disease resistant New World clones for crown budding were available, and, by 1944, 30,000,000 elite budded trees had already been made ready in 100 nurseries throughout tropical America. This stock served for the establishment of New World plantations primarily in Brazil, Colombia and Peru.



The *Hevea brasiliensis* tree above, tapped in the 1940s in the Amazon, was selected by the author as an “elite” tree for its high yield and resistance to disease.

With the rebirth of wild rubber exploitation over such a vast area, it occurred to scientists in charge of these programs that an opportunity was at hand for examining a wide source of germplasm, not only of *Hevea brasiliensis* but of other wild species, as germplasm that would be valuable for future genetic work. A team of several botanists was commissioned to collect living material of all possible species, varieties and strains of *Hevea* and of elite clones of *H. brasiliensis*, *H. Benthamiana* and *H. guianensis* that were under exploitation.

From 1944 through 1954, those efforts helped to establish in “living museums” representatives of as many species, varieties and strains of *Hevea* as could be found and collections of

budwood from individual high-yielding, disease-resistant trees chosen from tapping circuits of wild trees.

The importance of these efforts is the promise they hold for establishing plantations with yields far above average combined with resistance to blight. Budwood from these trees was sent to nurseries for testing and possible use in selecting and breeding programs of the future. While my field work was centered in Colombia and adjacent parts of Brazil, other botanists were busy with similar assignments in other Amazonian areas.

The availability of outstanding individuals of *Hevea brasiliensis* from a wide geographical area has now injected a new dimension into the prospects for improving rubber: the greatly expanded sampling of germplasm almost assures even more impressive strides in yield and in other characteristics than those achieved so dramatically with the seeds that Wickham brought to Britain in 1876.

An unprecedented range of material of all species of *Hevea* is now open for experimentation—the three (*H. brasiliensis*, *H. Benthamiana* and *H. guianensis*) which yield commercially valuable rubber as well as those for which we have yet to find any industrial use. The importance of the latter species is not only in the scientific prospects for improving our known species. The elastomer industry—now producing so many synthetic substitutes for rubber—stands in need of many diverse types of natural latexes for use as “fillers” to alter in a variety of ways the artificial “rubbers” and their characteristics. But these species may one day also be of value for tapping themselves and play a significant role in the progress of natural rubber cultivation.

It has quite truthfully been said that “*Hevea* is a long lived tree, and in the jungle, a century makes little change in the resident population.” But the changes brought about in rubber since man tamed it from the wild in 1876 are greater than those made in any other cultivated plant in such a short time. They can honestly be described as incredible. We can now look forward to even greater progress in the next 100 years. ☛

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