POLICY BRIEF

Study on Benefit of Environmental friendly Rubber Plantation

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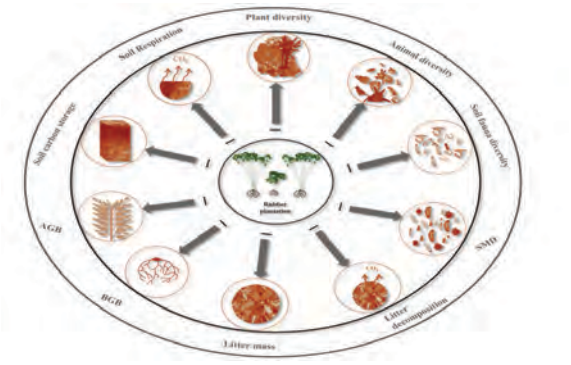
The Renaissance of Natural Rubber

As a kind of rubber yielding tree planted in a large scale around the world, the hevea brasiliensis has the advantages such as high yield, good quality, long economic life, easy latex exploitation, and fast latex regeneration. Originating in the tropical rainforest in Amazon Basin in South America, during the process of evolution for thousands of years, the hevea brasiliensis forms the unique habit of adaptation to high-temperature, high-humidity and calm wind environment gradually, has the physiological characteristics of rapid growth, sensitive reaction to low temperature, undeveloped wood and mechanical tissue, fragile trunk vulnerable to wind damage attacks, and has higher requirement for organic matter content of the soil. Due to such characteristics, the rubber trees are planted in a limited area around the world. At present, under the constraints of the planting conditions, 90% of the rubber trees in the world are mainly planted in Thailand, Indonesia, Malaysia, Vietnam and other Southeast Asian countries, as well as a few African countries such as Nigeria, indicating that the natural rubber is a typical environmental constraint resource.

By planting of the natural rubber, it is possible to not only meet the demands for relevant products in production and life, but also enhance the income of farmers, increase the employment opportunities, and improve livelihoods to a great extent. However, it is an indisputable fact that the planting of the natural rubber leads to the problems in land occupation and food security; furthermore, it has outstanding negative impact on the ecological environment, such as loss of tropical rainforest, reduction in biodiversity, soil erosion, and decrease in soil fertility.



Rubber plantation has a preferentially negative net effect on ecosystem functions when compared to adjacent tropical forest (Singh et al., 2021)

Background of construction of environmental friendly rubber forest

The monoculture of rubber trees in large area leads to a series of problems in ecological environment, such as:

Decreased soil fertility

There are few undergrowth vegetation layers and few litter species in the rubber forest. Compared with the tropical rainforest, the rubber forest has poor soil fertility. From the perspective of nutrient retention benefit, that of the tropical rainforest is 2.11 times as much as that of the rubber forest. The soil quality will be degraded to certain extent if the natural forest is converted into the rubber forest. The monoculture and tapping of the rubber forest will also cause the loss of soil nutrients easily.

Reduced biodiversity

Due to the obvious vegetation stratification and the rich species, the biodiversity and the germplasm gene bank are established in the tropical rainforest; however, due to the simple structure of the community, the diversity and the stability of species in the rubber forest are destroyed. The large-scale planting of the hevea brasiliensis leads to the significant decline in the coverage rate of the tropical rainforest, the destruction of the habitat environment of animals and plants, the degradation of ecological environment, and the reduction in biodiversity. Compared with natural forest, the number of birds in the pure artificial rubber forest decreases by at least 70%, and the number of mammals decreases by at least 80%.

Sharp decline in tropical rainforest, loss of biodiversity, and frequent occurrence of plant diseases and insect pests

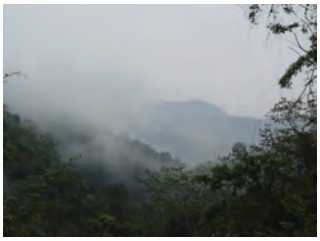
(Li et al., 2007; Guan Zhibin et al., 2005; Li Jiazhi et al., 2008).

Severe soil erosion, change in physical and chemical properties of soil, and decrease in soil fertility

(Wang Huihai et al., 2003; Pang Jiaping, 2009; Yang et al., 2004).

Poor water conservation capacity of rubber forest, and shortage of water in rubber planting area

(Tan et al. 2011; Zhou Wai et al., 2011; Zhou Zong and Hu Shaoyun, 2008)



Changes in local climate: Decrease in number of foggy days, reduction in duration of thick fog, and decline in the relative humidity

(Yu Yan et al., 2007; Dai Bo, 2008; Liu et al., 2007).

Decreased water conservation capacity

After the tropical rainforest is converted into rubber forest by cutting down, under the influence of aggravated soil erosion, the soil layer becomes thinner, the water retention capacity and water storage capacity of the soil are degraded, the permeability of the soil is reduced to certain extent, and the water conservation function of the soil is decreased. At the annual scale, the evapotranspiration of the rubber forest is larger than that of the tropical rainforest, and the water stored in the rubber forest in the rainy season is not sufficient to sustain vigorous evapotranspiration in the dry season, resulting in the runoff of the rubber forest less than that of the tropical rainforest in the dry season. If a large number of tropical rainforest is replaced by the single rubber forest, the actual repellency of soil in the rubber forest is higher than that in the tropical rainforest, resulting in serious soil erosion in the rubber forest, while the tropical rainforest with good vegetation and complex structure has little impact on soil erosion.

Aggravated plant diseases and insect pests

The rapid increase in planting area and too simple planting structure of the rubber forest provide sufficient space for pests to survive and develop, but there is no suitable habitat for natural enemies of pests, so it is easy for pest populations to “avoid natural enemies, and develop and grow stronger”.

In addition, the excessive use of ethephon (which can stimulate the yield of rubber) by the rubber farmers, even exceeding the safety threshold, results in the reduction in resistance of the rubber forest in the large area, the decline in the yield of rubber, and the early occurrence of decline of rubber trees, which are the dominant factors for serious damage caused by cambium beetle.

Fragmentation of tropical rainforest landscape

More and more rubber patches are gradually replacing other types of patches, leading to the convergent development of land utilization in the rubber planting area. For example, in Xishuangbanna, the steep slope and low-grass shrub land at a high altitude of about 1,200 m are evolving into the rubber forest quickly, and the sporadic distribution of the patches increases the fragmentation degree of the landscape. Based on the analysis of the ecological quantitative indicators, it can be seen that rubber has formed the regional characteristics such as high contrast, segmentation and fragmentation. The segmentation and fragmentation of the tropical rainforest landscape ecosystem will affect the material cycle, energy flow, and species flow in the ecosystem. The decline in landscape dominance index and the increase in fragmentation mean that the original landscape dominance of tropical rainforest in this region is no longer prominent, the serious segmentation and fragmentation have occurred, the hierarchical structure of the tropical rainforest has undergone the qualitative change, and the succession and restoration cycle of the natural vegetation no longer exists.

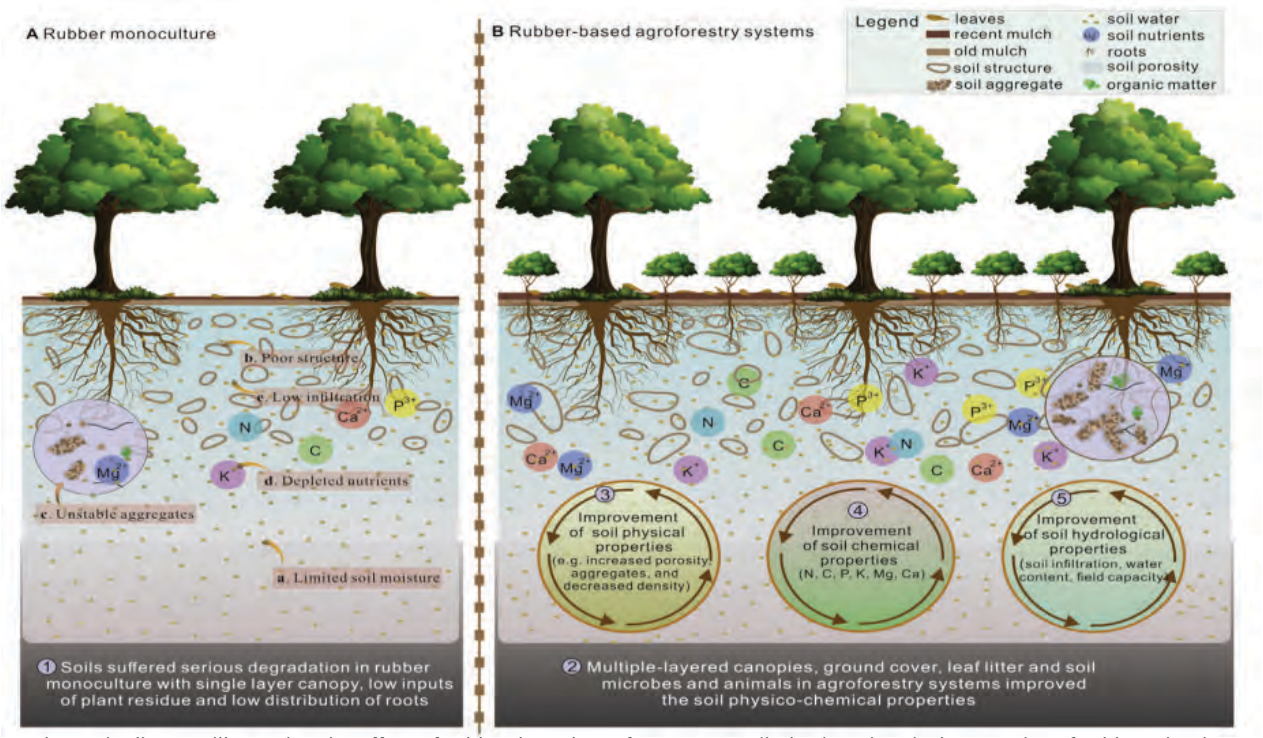
Intensified human-animal conflict

With the rapid growth of population, the space of population mobility in the rubber planting area is increasing gradually, and the area covered by crops and the construction area of the infrastructure are also increasing gradually, exerting certain impact on the wild natural resource areas. Most wild species, such as the Asian elephant, tend to be found in the tropical rainforest that is suitable for rubber cultivation, but due to the gradual decrease in the area of the tropical rainforest, the living space of the wild Asian elephant is reduced to a great extent. Especially in recent years, as the planting area of the rubber as an economic crop increases gradually, and the maximum altitude for planting of the rubber also increases, resulting in more overlapping between the rubber planting area and the living area of the wild species area. This not only leads to damage of the economic crops, also ruduces living area of the wild species, resulting in the human-animal conflict.

In addition to the environmental impact, the rubber industry itself cannot be "immune". The environmental problems caused by the large-scale planting of the single rubber will in turn affect the sustainable development of the rubber industry.

Exploration on planting model and benefit of environmental friendly rubber forest

According to the principles of ecology and economics, by certain biological, ecological and engineering techniques and approaches, it is possible to establish the multilayer and multiple-species compound ecosystem of rubber forest, which is a kind of high-efficient artificial ecosystem with the structure and functions achieving a stable state of dynamic balance, and with the impact on environment falling within the resource supply capacity and the environmental self-purification capacity of its system. This composite ecosystem can achieve the economic yield of rubber without obvious adverse impact on the environment.



Schematic diagram illustrating the effect of rubber-based agroforestry on soil physico-chemical properties of rubber planting (Chen et al., 2019)

The commonly used environmental friendly rubber forest transformation models include the jungle-type rubber forest transformation mode and the agroforestry rubber forest transformation mode.

Jungle-type rubber forest transformation mode

The jungle-type rubber forest, as a kind of compound rubber planting mode constructed by imitating the structure of tropical rainforest, is a balanced and diversified planting mode, meaning the planting of the artificial forest dominated by hevea brasiliensis on the fallow land. The annual yield of rubber in the jungle-type rubber forest is approximately 640 kg·hm-2, and the income from rubber yield accounts for approximately 60% of the total income from the forest. In the jungle-type rubber forest, the income before the rubber tapping period (approximately 7 years) can be gained by the other grains and crops, and the main income gained by the rubber farmers in the later stage comes from rubber. Other plants growing naturally in the rubber forest can provide fruits, fuelwood, wood and other resources, which are mainly used by farmers for self-sufficiency and almost require no labor input. This planting pattern is friendly to small-scale farmers, because it can not only meet the needs of the growing population for economic growth, but also protect the precious forest environment.

Agroforestry rubber forest transformation mode

As an important measure to increase the benefit of the rubber plantation rapidly and effectively, the intercropping of rubber plantation can increase the yield of the rubber plantation to a great extent. At present, the intercropping of rubber plantation is carried out mainly in the young rubber plantation. During the sapling period, most crops can be intercropped, while only a few shade-tolerant crops can be intercropped after growing up, so the intercropping cycle is short. The rubber yield of the rubber plantation in which the planting mode is adjusted and the wide-narrow row planting is adopted is similar to that of the traditional rubber plantation. After growing up, more crops can be intercropped, so the intercropping production is allowed during the whole production cycle. More and more rubber plantations with the whole-cycle intercropping mode are used.

In addition to economic benefits, the environmental-friendly rubber forest can also produce the following ecological benefits:

To improve the microclimate characteristics of the compound system

The suitable intercropping compound eco-system can improve the microclimate in the eco-environment of the rubber plantation. In summer and autumn at the high temperature, it can reduce the temperature of near-ground air and surface soil significantly, reduce the evaporation of soil moisture, and increase the air humidity, so as to mitigate the damage of high temperature and drought to hevea brasiliensis. Due to the improved micro-growing environment of hevea brasiliensis, and the increased photosynthetic efficiency and the light energy utilization rate of hevea brasiliensis, the stem diameter of hevea brasiliensis, especially young hevea brasiliensis, also grow better.

To conserve water and soil, and improve soil efficiency

The effect of intercropping system of rubber plantation on soil and water conservation and soil improvement has been verified by a great number of researches. In case of the down slope planting and the cross slope planting for intercropping of pineapple in the young rubber forest, the total runoff is reduced by 1403.23 m3/hm2 and 2580.47 m3/hm2, and the total erosion amount is reduced by 560 kg/hm2 and 769 kg/hm2, respectively compared with those of the rubber forest without planting of the pineapple. The total runoff and the total erosion amount in the cross slope planting are lower than those in the down slope planting to a great extent. By intercropping cinnamon in the rubber plantation, it is possible to avoid the direct impact and scouring of rainwater against the topsoil, slow down surface runoff, and promote the infiltration of rainwater into the soil layer, so as to prevent the soil erosion in the rubber plantation and increase the water storage in the soil layer. Furthermore, it is found that the intercropping can increase the soil available nutrients, improve the soil structure, and improve the soil fertility to a great extent.

To improve the biodiversity and stability of the system

With multiple components, complex system structure, and good ecological environment, it is possible to improve the biodiversity of the intercropping compound system in the rubber plantation. The number of birds recorded in the environmental-friendly ecological rubber plantation is much more than that recorded in the pure rubber forest, and the habitat selected by birds shows the characteristics of forest thicket > nearshore water area > environmental-friendly ecological rubber plantation > pure forest. In the soil layer with the depth of 0-10 cm, the amount of roots in the sole cropping rubber plantation is less compared with that in the intercropping rubber plantation, so as to provide enough space for the survival and reproduction of soil animals. However, within the scope of in the rubber-tea community forest, most of the roots occupies the soil space, leading to the decrease in the number of soil animals. The termite richness in

the agroforestry planting mode dominated by rubber is higher than that of the sole cropping rubber plantation, playing a positive role in the conservation of termite diversity.

The soil in the rubber plantation with intercropping has a higher microbial biomass and a shorter microbial transformation cycle than that in the sole cropping rubber plantation, resulting in more forest-substitute land per year. By intercropping in the young rubber plantation, it is possible to improve the urease and phosphatase activity of the soil in the rubber plantation. By intercropping of kudzu in the young rubber plantation, it is possible to improve catalase and polyphenol oxidase activity of the soil in the young rubber plantation. In addition, the community structure constructed by compound planting of rubber and dictyophora can improve the functional diversity of the soil microbial community.

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Find out more about the project here