

RUBBER GROWING SOILS AND THEIR CHARACTERISTICS

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INTRODUCTION

The rubber tree is grown on vast majority of acid soils of the humid tropics, but its performance and economic viability can be restricted severely where there is a limitation of a particular soil characteristic. Soil is an important edaphic component influencing the establishment, growth and yield of rubber. An understanding of the numerous soil factors affecting soil fertility is a prerequisite to proper management of soils for better performance of rubber.

In essence, rubber can best be grown in areas where the soil is deep and readily drained with no compacted or impermeable horizons close to the surface with no toxic or extreme deficiency levels of nutrients. At the same time, the soil should be able to retain and supply sufficient nutrients and moisture for proper plant growth.

Classification of rubber growing soils of Sri Lanka

In order to facilitate the extrapolation of experience and experimental work between regions, attempts have been made to fit the rubber growing soils into international systems of nomenclature. Planting of rubber in Sri Lanka is mostly confined to two Great Soil Groups; Red Yellow Podzol (RYP) and Reddish Brown Latosol (RBL). The Red Yellow Podzolic soils are predominant in the rubber growing districts of Kalutara, Galle, Matara, Ratnapura, Avissawella and Monaragala. The Reddish Brown Latosolic soils occur mainly in the Kegalle, Mawanella, Kurunegala and Matale regions.

Soil series

In these rubber growing areas seven important soils units have been identified by the Rubber Research Institute (RRI), taking into consideration only the parent material from which the soils were derived (Table 1 and Fig. 1). However, this soil classification does not directly reconciled with the Great Soil Groups. Nevertheless, it has practical advantages for research and extension purposes. A brief description of each soil unit (series) is given below.

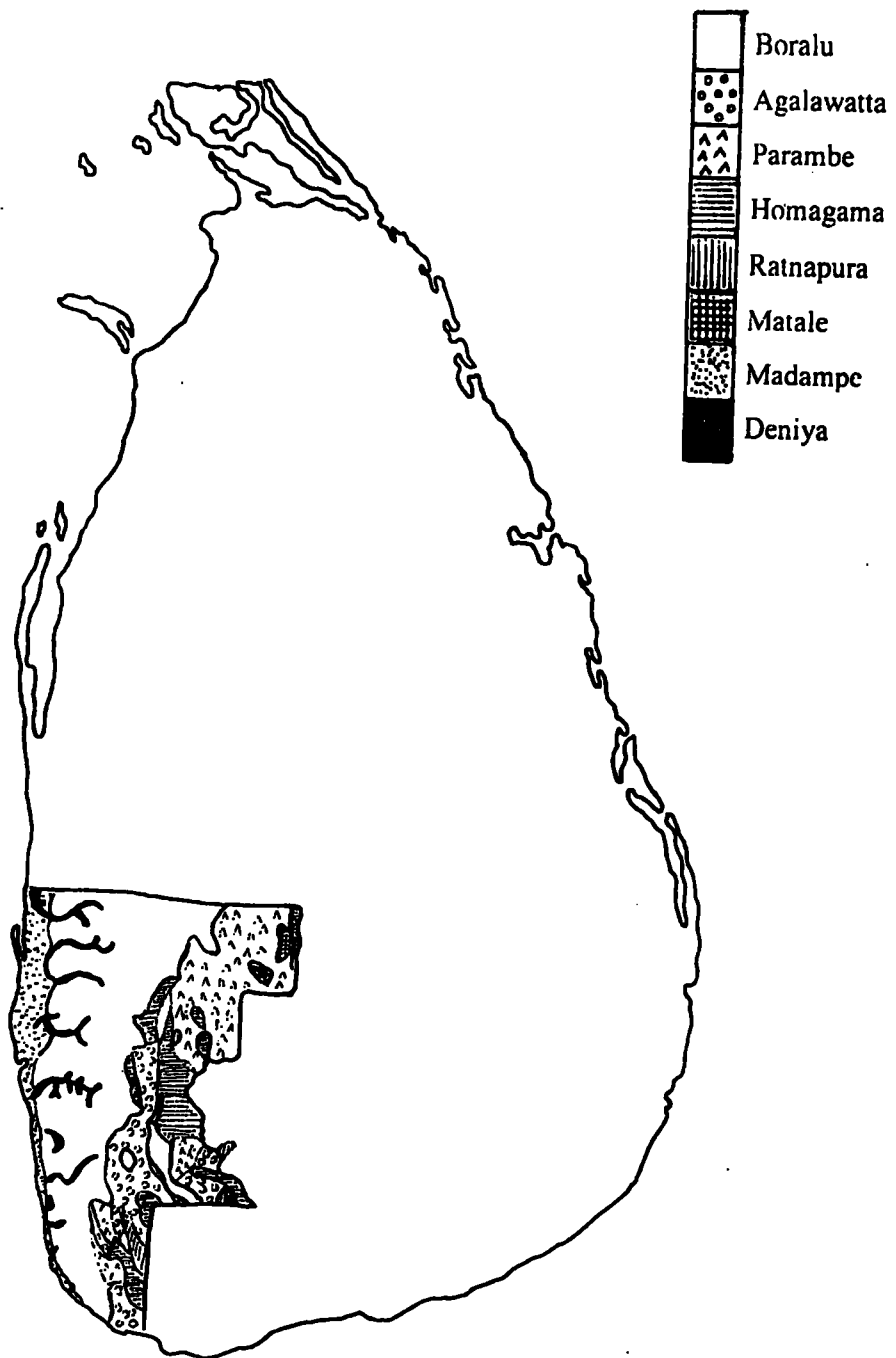


Fig. 1. Rubber growing soils of Sri Lanka

Table 1. *Different soil series of rubber growing areas*

Soil series	Location	Great Soil Group	Soil Taxonomy
<i>Parambe</i>	Kegalle/Kurunegala	Reddish Brown Latosol	Ultisol
<i>Matale</i>	Matale	Reddish Brown Latosol	Ultisol
<i>Homagama</i>	Yatiantota/Dehiowita/ Deraniyagala	Red Yellow Podzol	Ultisol
<i>Agalawatta</i>	Around Sinharaja forest	Red Yellow Podzol	Ultisol
<i>Ratnapura</i>	Ratnapura/Meegahatenna	Red Yellow Podzol	Ultisol
<i>Boralu</i>	Southern coastal area	Red Yellow Podzol	Ultisol
<i>Deniya</i>		Low humic gley	Alfisol

Parambe series

Parambe series soils are derived from micaceous parent materials, biotite gneiss. These soils are deep, sandy clay loam in texture and brown in colour. There are glistening specks of mica throughout the soil mass. These soils are high in potassium. The main areas where *Parambe* series soils occur are the Kegalle and Kandy districts.

Matale series

Matale series soils are deep, sandy clay loam in texture and dark brown to reddish brown in colour, occurring in localities where soil formation has been influenced by the drainage of lime rich solutions from adjacent outcrops of crystalline limestone. The limited, sporadic occurrences of these fertile soils are confined to the Matale district.

Homagama series

Homagama series soils are derived from highly quartzitic rocks. They have a very scattered distribution and are easily identified by the presence of quartz gravel in the profile. These soils are moderately deep, sandy loam in texture and strong brown to reddish brown in colour. They have a low potassium status. *Homagama* series soils occur extensively around Yatiantota, Dehiowita and Deraniyagala.

Agalawatta series

Agalawatta series soils are of variable depth, with boulders and outcrops of the granitic rocks from which they are derived, a large percentage of hypersthene granite. They are sandy clay loam in texture and strong brown to yellowish red in colour. They

have a medium potassium status. These soils occur over a wide area of the steeply dissected hills which flank the Sinharaja forest.

Ratnapura series

Ratnapura series are residual soils derived from garnetiferous parent materials. These soils are rather shallow, sandy clay loam in texture and yellowish brown in colour, overlying more yellowish sub-soil, characteristically containing small amounts of garnetiferous gravels. They have a medium potassium status. These soils occur only in the Meegahatenne and Ratnapura areas.

Boralu series

Boralu soils are derived from rocks of the Vijayan and Khondalite rock series. In soils of this series the parent material appears to reflect less on profile development and the processes of laterisation are predominant. The presence of laterite at different depths is a diagnostic character of this soil series. These soils are shallow, sandy clay loam in texture, brown to reddish yellow in colour and overlying cabook. They have a low potassium status. These soils are found in the gently undulating mounds and low hills, on which the southern rubber producing areas extend westward towards the coast.

Deniya series

Deniya soils are shallow soils, variable in texture, poorly drained, frequently water logged and often subject to flooding. These soils occur extensively in valley bottoms where they are used for rice cultivation; very little rubber growing is attempted on them.

Soil characteristics and soil requirements

Soil is a heterogenous, disperse and porous system, having a large surface area. The dispersed nature of the soil and its consequent interfacial activity give rise to such phenomena as absorption of water and chemicals, ion exchange, swelling and shrinking, dispersion and flocculation and capillarity. For optimum growth and productivity of rubber, both the physical and chemical aspects of soil fertility need to be considered are discussed.

Physical characteristics

Soil physical properties remain as the least amenable characteristics and these properties of a soil which determine growth of rubber plants are generally those which

influence the extent of root proliferation, air and water movement and availability of water. If the productivity of soil is to be maintained, the physical condition of the soil must be preserved satisfactorily. The soil degradation is usually described as a deterioration of soil physical properties. In the soil surface the physical degradation implies a loss of porosity, often expressed by the formation of surface crust which leads to decreased water entry, increased runoff and increased erosion in rubber lands. In the subsoil, compaction will lead to decreased water storage and hindered development of roots in rubber plants. A good soil physical condition is therefore, more important in promoting better growth and yield of rubber.

Soil texture

Physically, soil is made up of sand, silt and clay in different proportions. Soil texture refers to the relative proportion of these primary particles of sand (0.02-2.0mm), silt (0.002-0.02mm) and clay (<0.002mm). Other inclusions like gravel and stones are larger than 2mm in diameter. The sand fraction consists of quartz, but may contain other minerals also. Silt is of intermediate size and resembles sand particles in terms of mineralogy and physical properties. The clay fraction represents the smallest particles, being formed during the course of weathering of primary minerals in the original rock. The various combinations of sand, silt and clay give rise to different textures. For example, a clayey soil has a dominant clay content while, a sandy soil has a dominant sand content. The particle size distribution and textural class of different soil series are given in Table 2.

Table 2. The particle size distribution and textural class of different soil series

Soil series	Particle distribution (%)				Texture
	Coarse sand	Fine sand	Silt	Clay	
<i>Parambe</i>	40-52	15-18	10-15	28-34	sandy clay loam
<i>Matale</i>	42-54	18-20	7-10	20-30	sandy clay loam
<i>Homagama</i>	57-65	17-28	4-5	10-20	sandy loam
<i>Agalawatta</i>	42-55	13-18	9-12	20-30	sandy clay loam
<i>Ratnapura</i>	42-54	16-19	7-12	20-30	sandy clay loam
<i>Boralu</i>	49-55	19-22	5-8	20-30	sandy clay loam

Texture of soils influences their physical properties and behavior under cultivation. For example, a sandy loam soil like *Homagama* series is usually loose, drained and retains less available water for growth of rubber plants. It has high permeability to downward water movement because of its sandy nature. Better growth and establishment of rubber are obtained on clayey than sandy soils. This is expected since the inherent physical and chemical characteristics of clay give it the capacity to

retain nutrients and water. When water is limiting, the yield of rubber can also be lower on sandy soil compared to clayey soil. However, a correlation study on the effect of soil texture on root development showed that the root density was positively correlated with the sand content and negatively correlated with the clay content.

Soil texture with sufficient clay, preferably a minimum amount of 35% to retain adequate moisture and nutrients and about 50% sand to allow for expression of good physical soil properties like aeration and drainage can be considered as desirable for successful optimum rubber cultivation.

Soil structure

The soil structure is perhaps the most important physical property. It refers to the arrangement and organization of the solid particles. The clay and silt fractions bind the soil together and various combinations of sand, silt and clay can give rise to different shapes and sizes of soil structure. Soils are made up of natural soil aggregates, also known as soil peds. A soil has a friable consistency if the soil peds are easily broken and if the peds can barely be crushed, the consistency is firm.

From the aspect of soil management, soil structure is the property of a soil that regulates a continuous array of various sizes of interconnected pores and their stability. It governs retention and movement of water, regulates gaseous diffusion and controls root proliferation and development.

Soil structural properties has major influence on root growth. A soil with good structure and friable consistency is a good medium for root growth. This will allow the soil to be exploited fully. As such, the tree can have a good anchorage and be able to have a large source of water and nutrients. In fact, good soil structural properties have a better effect on the growth of rubber than a high soil chemical fertility. In other words, rubber trees will grow better on a good structured soil of lower chemical fertility than on a poorly structured soil with very high chemical fertility. This is obvious since the presence of an insufficient amount of roots in a poorly structured soil will mean that the tree cannot exploit the high fertility to its maximum. Furthermore, the low chemical fertility status of a soil can easily be amended with fertilizer application.

Soil is the medium where the rubber tree is anchored and will be more critical for a tree crop like *Hevea*, which extends its roots far and deep. Basically, a good structured deep soil is found to sustain better wind resistant than a poorly structured shallow soil. Shallowness of a soil is mainly the result of the presence of a compact lateritic band, quartzite band or a laterized parent material layer in the profile or due to soil compaction. These less penetrable zones impede downward root penetration. The depth at which the compacted band occurs within a soil series can vary. Soil compaction has a similar effect on wind damage like the presence of an impenetrable layer. Rubber plants tend to form stunted and knotty roots when grown on compacted soils.

Bulk density

An important measurable property of the structure of soils is the bulk density. Root density of rubber plants have the tendency to decrease with increasing soil bulk density. The bulk density of different soil series are given in Table 3.

Porosity

The porosity indicates the proportion of soil volume not occupied by solids. The porosity significantly characterizes the gaseous phase and refers to the process of gaseous exchange between soil and atmosphere. Restricted soil aeration inhibits root development, impairs processes of respiration of the root system and inhibits beneficial microbial activities. The total and air-filled porosities of some common soil series under *Hevea* are shown in Table 3.

Table 3. *Bulk density and porosity of different soil series*

Soil series	Bulk density (g/cm ³)	porosity (%)
<i>Parambe</i>	1.49	53.1
<i>Matale</i>	1.33	54.7
<i>Homagama</i>	1.12	56.2
<i>Agalawatta</i>	1.51	52.0
<i>Ratnapura</i>	1.36	54.6
<i>Boralu</i>	1.38	53.2

Water holding capacity

The availability of water to the plants is determined not only by the intensity and distribution of rainfall, but also by the quantity of water that is actually retained in the soil. Thus moisture characteristics are important physical properties of soils (Table 4). The maximum capacity of the soil to hold water is termed "water holding capacity". This is equivalent to the amount of water held at saturation. However, the water that is considered to be available to the plant is limited to the field capacity as the upper limit and the permanent wilting percentage as the lower limit.

Table 4. Availability of moisture in different soil series

Soil series	SMSC* (cm)	Volumetric moisture content (%)		
		-10kPa	-500kPa	-1500kPa
<i>Parambe</i>	22.9	37.5	34.7	32.8
<i>Matale</i>	22.4	36.3	33.4	32.5
<i>Homagama</i>	18.3	31.2	29.2	28.7
<i>Agalawatta</i>	19.7	33.4	31.1	29.3
<i>Ratnapura</i>	20.3	32.9	30.5	29.5
<i>Boralu</i>	19.3	32.7	30.1	29.6

* Soil Moisture Storage Capacity (SMSC) for 90 cm soil profile

Soil colour

Generally soil colour is important to identify a soil and also in soil classification. This parameter depends on some inorganic ions like Fe and Cu. The hydrated Fe usually gives a yellow colour to the soil while dehydrated Fe gives a red colour. Soil colour also depends on the drainage condition and organic matter content of the soil. The soil colour of different soil series are given in Table 5.

Table 5. Soil colour of different soil series

Soil series	Soil colour
<i>Parambe</i>	Brown
<i>Matale</i>	Dark brown to reddish brown
<i>Homagama</i>	Brown to reddish brown
<i>Agalawatta</i>	Brown to yellowish red
<i>Ratnapura</i>	Yellowish brown
<i>Boralu</i>	Brown to reddish yellow

Chemical characteristics

Owing to the humid tropical climate prevailing, the soils of Sri Lanka are highly weathered and leached. Agriculturally speaking, most of the soils are highly impoverished and of low chemical fertility, except in some situations, where their nutrient supplying power is relatively higher. Factors such as pH, organic matter content, cation exchange capacity, base saturation, sesquioxide content, physical

characteristics of the soil also influence the chemical fertility of the soil. On the basis of chemical soil fertility, various desirable chemical properties for successful, optimum rubber cultivation have been identified.

Nutrient status

Soils normally play a major role in dictating the availability of nutrients to plants. The influence on this availability is primarily through the mineral reserves in the soil and the nutrients added to the soil. Chemically, soils contain different proportions of nutrients considered to be important for the rubber trees, viz. nitrogen, phosphorus, potassium and magnesium (Table 6). Because of the intense hot and wet tropical climate, the highly weathered soils of Sri Lanka, on its own, is incapable of supplying adequately all the nutrients which are required by the rubber plants. Depletion of soil nutrients attributed to losses such as leaching, immobilisation, volatilisation or uptake by the plant will inevitably impoverish the capacity of the soil to supply nutrients. In overcoming this depletion, nutrients in the form of fertilizers are often added to the soils and rubber trees respond positively to fertilizer applications.

From the point of view of soil nutrient status, rubber will grow reasonably well for some period of time during the immature phase, if planted newly on jungle clearings. However, in replanted areas, growth will not be satisfactory from the beginning after planting. On all soil generally, growth and latex production will be depressed, if the trees are not manured from planting. Research over the years have indicated that fertilizer application will be necessary from the onset of planting on most Sri Lankan soils, in order to sustain optimum growth and productivity.

Table 6. *Categorization of nutrient contents in rubber growing soils*

Nutrient	Very Low	Low	Medium	High	Very High
N (%)	<0.05	0.05-0.10	0.11-0.25	0.25-0.40	>0.4
P (ppm)	<100	100-250	250-350	350-600	>600
K (meq/100g)	<0.25	0.25-0.5	0.5-2.0	2.0-4.0	>4.0
Mg (meq/100g)	<0.5	0.5-1.0	1.0-4.0	4.0-8.0	>8.0

Soil nitrogen

Nitrogen is an important major nutrient required for all growth phases of rubber plant. In all the soil series total nitrogen levels are low, ranging between 0.07% to 0.17% (Table 7).

Soil phosphorus

Total Phosphorus contents are highest in the *Matale* series followed by the *Parambe* series and lowest in the *Boralu* series (Table 7).

Soil potassium

Reserve potassium is highest in the *Parambe* series soil, while relatively low level is encountered in *Homagama* series. In the other soil series, total potassium levels are in the medium range between 1-2 meq/100g (Table 7).

Soil magnesium

The total magnesium values are highest in the *Matale* series which has about 7.25meq/100g. This of course is quite understandable because the *Matale* series soils are derived from dolomitic limestone which is rich in both calcium and magnesium (Table 7).

Table 7. Approximate major nutrient contents in different soil series

Soil series	N (%)	P (mg/kg)	K (meq/100g)	Mg (meq/100g)
<i>Parambe</i>	0.148	310	4.47	2.81
<i>Matale</i>	0.174	317	1.84	7.25
<i>Homagama</i>	0.088	127	0.29	1.02
<i>Agalawatta</i>	0.117	233	1.17	0.79
<i>Ratnapura</i>	0.119	241	1.53	0.95
<i>Boralu</i>	0.071	112	0.31	1.26

Secondary and micro nutrients

The micronutrient status of Sri Lankan soils have not as yet, become critical for *Hevea* cultivation (Table 8). Rubber trees are yet to display lack of these nutrients for normal growth and yield, although rubber cultivation in Sri Lanka is currently in the third to fourth cycle, with nutrients being removed via the timber from the ecosystem (soil) during each felling at replanting. While lack of macro-nutrients often limits rubber tree performance, high amounts of trace elements are toxic to rubber plants. For example, high amounts of manganese or boron may cause stunted plants.

Table 8. Secondary and micro nutrient contents in different soil series

Soil series	Ca (mg/kg)	S (mg/kg)	Mn (mg/kg)	Mo (mg/kg)	Zn (mg/kg)	Cu (mg/kg)
<i>Parambe</i>	453	409	282	90	21	28
<i>Matale</i>	654	388	1945	41	45	59
<i>Homagama</i>	190	205	47	47	09	06
<i>Agalawatta</i>	201	278	33	51	15	16
<i>Rainapura</i>	208	289	689	83	24	37
<i>Boralu</i>	200	233	22	39	11	06

Soil pH

Rubber generally grows well in acid soils in Sri Lanka. However, extreme pH conditions are not favourable for good performance of rubber trees. Nearly all the soils, except for localised soils formed from limestone outcrops, are of low pH (Table 9). Their pH values range between 4 to 5.

Soil organic carbon

It is known that rubber plantations undergo a very effective self sustaining recycling system where the soil organic matter content is maintained at the required level (Table 9), although the tropical soils in Sri Lanka contain relatively low amounts of organic matter.

Cation exchange capacity

CEC is the soils capacity to hold and exchange cations. The strength of a cations positive charge varies, enabling one cation to replace another on a negatively charged soil particle. This is measured as the amount of the cation in milli equivalents absorbed by 100g of soils. This gives an indication of the ability to retain nutrients.

CEC of most rubber growing soils in Sri Lanka are low (Table 9). Due to low values of CEC in *Homagama* series, when nutrients are supplemented by the addition of fertilizers, losses by leaching can be high. To overcome this problem, an integrated approach including the use of appropriate fertilizer levels in split application and proper organic matter/crop residue management practices appears to hold promise.

Table 9. Soil pH, organic C and cation exchange capacity (CEC) of different soil series

Soil series	pH	Organic C (%)	CEC (meq/100g)
<i>Parambe</i>	4.4	1.8	4.7
<i>Matale</i>	5.0	1.9	7.5
<i>Homagama</i>	4.1	0.9	2.0
<i>Agalawatta</i>	4.3	1.5	3.5
<i>Ratnapura</i>	4.3	1.6	3.6
<i>Boralu</i>	4.4	1.2	3.2