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Rubber Growing Soils of Northern Mizoram – Their Characteristics, and Limitations

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Abstract: Seven representative soil sites of major rubber growing areas in northern Mizoram were identified and their climatic, soil and site characteristics were studied and assessed for suitability through limitation approach. The suitability criteria for rubber cultivation were developed with special reference to hilly terrain of Mizoram. The prevailing land characteristics of each site were compared with these diagnostic limitations. The steep slopes and low winter temperature of less than 10 °C are the major constraints in the region. Most of the soil-sites studied are moderately suitable except for soils of rolling hills with very high steep slope at 400 and 750 m above mean sea level are marginally suitable for rubber cultivation. (**Key words:** *Hevea brasiliensis*, soil, characteristics, limitation, suitability).

Rubber (*Hevea brasiliensis*) is an important commercial plantation crop, intensively grown in Kerala and Kanyakumari district of Tamil Nadu and the scope for expansion in these regions is very much limited. The main potential for expansion lies in non-traditional areas like Tripura, Assam, Meghalaya, Mizoram, Nagaland and Karnataka, but variation in climate, physiography, nature and properties of soils generally affect the growth and distribution of the *Hevea* (Bhattacharyya *et al.* 1998; Kharche *et al.* 1995; Krishnakumar 1989; Rao & Vijaykumar 1992; Vilas Chandran *et al.* 1992).

Mizoram is a tiny hilly state in the North-Eastern region of India bordering Myanmar. The state has a geographical area of 21.08 lakh ha, supports a population of 6.68 lakh humans and 1.61 lakh livestock and it has endless variety of landscape and due to its complexity of physiography various micro-climates prevail from the higher elevation to the lower. The elevation

Mizo hills, known as Lusai hills ranges from 36 m to 1700 m above msl. Rubber (*Hevea brasiliensis*) is one of the major plantation crops introduced in foot hills developed under warm humid sub-tropical climate of northern Mizoram as an alternative to the existing cropping systems, *i.e.*, *jhumming*, for reasons namely soil loss control, employment generation and high economic returns. Despite high potentialities of soils of this region, constraints, such as undulating topography and frequent huge landslides limit their suitability for rubber cultivation. Very little is known of the characteristics of these soils, though a proper understanding of such information is essential for suggesting appropriate management practices for sustained rubber production. Efforts have earlier been made to evaluate soil-site criteria for rubber mainly in traditional rubber growing areas of India (Vilas Chandran *et al.* 1992; Kharche *et al.* 1995; Bhattacharyya *et al.* 1998). The present study was, therefore, undertaken to assess the soil-site characteristics and their limitation for suitability of rubber cultivation in northern Mizoram.

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Materials and Methods

The study area lies between 21°58" to 24°35" N latitude and 92°15" to 23°29" E longitude and runs from south to north along the western belt in North Mizoram which is a typical rubber growing belt. The climate is perhumid tropical and characterized by moist summer and moderate winter. Soil temperature and soil moisture regime are hyperthermic and udic, respectively (Soil Management Support Services 1985). Five representative sites at varying altitude in the region were identified.

The soil samples were analyzed for various physical and chemical properties by following standard procedures. The climatic data of these sites for the period of 5 years were recorded (Table 1). These soil-site conditions of the area were evaluated to assess their suitability for rubber following a modified approach of Sehgal (1986) based on the FAO (1976).

The structure of suitability classification developed by FAO (1976) involves four levels of classification, viz. orders reflecting kind of suitability, e.g. suitable (S)

Table 1. Climatic characteristics of the study area

| Location | Rainfall (mm) | Temperature (°C) | | | | Excessive rainfall (months) | Dry season (months) | Relative humidity (%) |
|--------------|---------------|------------------|-----------|-------------|-------------|-----------------------------|---------------------|-----------------------|
| | | Mean max. | Mean min. | Mean annual | Mean lowest | | | |
| Bairabi | 2745 | 32.19 | 17.46 | 25.22 | 17.33 | 1 | 1 | 78.6 |
| Tuichhuhen | 2618 | 31.29 | 18.30 | 24.80 | 18.00 | 2 | 2 | 79.5 |
| N-Chhimluang | 2610 | 30.60 | 19.00 | 23.72 | 16.81 | 2 | 2 | 80.3 |
| Bikhawthlir | 2506 | 27.81 | 18.56 | 23.20 | 16.94 | 1 | 2 | 83.2 |
| Thingdawl | 2877 | 26.62 | 21.33 | 24.10 | 17.48 | 2 | 2 | 75.8 |

Table 2. Morphological characteristics of soils under rubber in North Mizoram

| Physiography | Description of soils | Colour | Structure | Consistence | | | Textural class | Coarse fragments (> mm, %) |
|--|---|------------|-----------|-------------|-------|-------|----------------|----------------------------|
| | | | | Dry | Moist | Wet | | |
| L1 – Bairabi (36 m asl altitude) | | | | | | | | |
| Undulated low ridges with gentle slope (17%) | Deep, well drained and fine | 5YR 2/2 | m2sbk | sh | fr | s/p | sicl | – |
| L2-Tuichhuhen (150 m asl altitude) | | | | | | | | |
| Undulated low hills & ridges with gentle slope (12%) | Deep, well drained and fine | 5YR 3/3 | m2sbk | sh | fr | ss/vp | sicl | – |
| L3-Tuichhuhen (150 m asl altitude) | | | | | | | | |
| Rolling hills with moderate side slope (30%) | Deep, well drained and fine | 5YR 3/3 | c3sbk | sh | fr | ss/sp | sicl | 15 |
| L4-N-Chhimluang (280 m asl altitude) | | | | | | | | |
| Rolling hills with moderate side slope (32%) | Deep well drained and fine. | 5YR 4/4 | m2sbk | sh | fr | s/p | sicl | 10 |
| L5-Bikhawthlir (400 m asl altitude) | | | | | | | | |
| Lows hills with moderate slope (28%) | Deep well drained | 10YR 5/6 | m2sbk | sh | fr | ss/ps | cl | 8 |
| L6-Bikhawthlir (400 m asl altitude) | | | | | | | | |
| Rolling high hills with very steep slope (45%) | Deep, well drained and sandy clay loam. | 7.5 YR 5/4 | m2sbk | sh | vfr | ss/po | gscl | 40 |
| L7-Thingdawl (750 m asl altitude) | | | | | | | | |
| Rolling hill crest with very steep slope (41%) | Deep, well drained and sandy clay loam. | 10YR 4/3 | c3sbk | sh | fr | ss/ps | gscl | 34 |

Texture: sicl-silty clay loam, cl-clay loam, scl-sandy clay loam, g-gravelly

Structure: m-medium, c-coarse, 2-moderately, 3-strongly developed, sbk-subangular blocky

Consistence: s-slightly, fr-friable, v-very, p-plastic, ps-slightly plastic, po-nonplastic, s-sticky, ss-slightly sticky

and not suitable (N), classes reflecting degree of suitability like highly suitable (S1) - land having no significant limitations or slight limitations causing low severity, moderately suitable (S2) - land having moderate limitations or aggregation of slight limitations causing moderate severity, marginally suitable (S3) - land having aggregation of severe limitations, currently not suitable (N1) - land having limitations which cannot be corrected by acceptable methods and permanently not suitable (N2) and subclass reflecting kind of limitation within classes and unit reflecting minor differences in a required management within subclass (Dent & Young 1981).

Results and Discussion

The climatic data (Table 1) show that the annual rainfall in the region ranges from 2610 (N-Chhimluang) to 2877 mm (Thingdawl) and the distribution is uneven. The relative humidity remains very high in all the sites varied from 75.8 (Thingdawl) to 83.2 per cent (Bilkhawthlir). The number of dry months varies from

one to two. The mean annual temperature ranges from 23.2 °C (Bilkhawthlir) to 25.2 °C (Bairabi).

Soils under study vary in their morphological and chemical properties reflecting the ability of roots to penetrate, availability of soil water, slope, resistance to erosion etc., for the growth of rubber. In general, they are very deep, well drained and fine loamy in texture (Table 2). Soils in the area are Ultisols and Inceptisols (Satisha *et al.* 1998) with high amount of organic carbon in the surface ranging from 10.0 to 19.0 g kg⁻¹. The cation exchange capacity of the soils varies from 8.4 to 11.6 cmol(p⁺)kg⁻¹. Base saturation of these soils is low and varies from 35.6 to 50.5 per cent indicating high leaching of the soils. They are acidic in reaction with pH ranging from 4.6 to 5.6 (Table 3). The elevation ranges from 36 to 750 m above msl with gentle to very steep side slopes (Table 3).

The climatic and land quality requirement of rubber (Sys *et al.* 1993) were developed by referring the available literature (Pushparajah 1977; Sys 1985; Rao & Vijaykumar 1992; Potty & Mannothea 1993) and con-

Table 3. Physico-chemical characteristics of soils under rubber in North Mizoram

| Physiography | Soil Taxonomy | Soil separates (%) | | | Textural class | WHC (%) | pH (1:2.5) | OC | CEC | BSP |
|---|-----------------------|--------------------|------|------|-------------------|------------|---------------|------|------|------|
| | | sand | silt | clay | | | | | | |
| L1-Bairabi (36 m asl altitude) | | | | | | | | | | |
| Undulated low ridges with gentle slope (17%) | Typic Hapludults | 34.7 | 29.7 | 35.6 | sic1 | 57 | 5.6 | 17.5 | 10.7 | 40.4 |
| L2-Tuichhuhen (150 m asl altitude) | | | | | | | | | | |
| Undulated low hills & ridges with gentle slope (12%) | Typic Hapludults | 17.5 | 43.7 | 38.8 | sic1 | 50 | 5.4 | 13.6 | 9.8 | 47.0 |
| L3-Tuichhuhen (150 m asl altitude) | | | | | | | | | | |
| Rolling hills with moderate Side slope (30%) | Typic Hapludults | 43.8 | 25.8 | 30.4 | sic1 | 60 | 5.0 | 15.0 | 8.4 | 50.5 |
| L4-N-Chhimluang (280 m asl altitude) | | | | | | | | | | |
| Rolling hills with moderate side slope (32%) | Typic Hapludults | 36.7 | 27.7 | 35.6 | sic1 | 66 | 4.6 | 10.0 | 9.5 | 42.0 |
| L5-Bikhawthlir (400 m asl altitude) | | | | | | | | | | |
| Low hills with moderate slope steep slope (45%) | Umbric Dystrudepts | 44.3 | 20.5 | 35.2 | cl | 68 | 5.1 | 12.0 | 10.5 | 35.6 |
| L6-Bikhawthlir (400 m asl altitude) | | | | | | | | | | |
| Rolling high hills with very steep slope (45%) | Umbric Dystrudepts | 60.5 | 13.8 | 25.7 | gscl | 50 | 5.0 | 17.4 | 11.6 | 45.0 |
| L7-Thingdawl (750 m asl altitude) | | | | | | | | | | |
| Rolling hill crest with very steep slope (41%) | Typic Hapludults | 51.2 | 22.4 | 26.4 | gscl | 46 | 4.7 | 19.0 | 9.3 | 45.1 |

WHC - water holding capacity; OC - organic carbon (g kg⁻¹); CEC - Cation exchange capacity [cmol (p⁺)kg⁻¹]; BS - Base saturation percentage

Table 4. Criteria and rating of land use requirement for rubber (*Hevea brasiliensis*)

| Soil-site characteristics | Degree of limitation | | | | |
|--|----------------------|-----------------------------|-----------------|--------------|-----------------------|
| | None S1 | Slight S1 | Moderate S2 | Severe S3 | Very severe N |
| Climatic characteristics | | | | | |
| Annual rain fall (mm) | 2000-4000 | 1700-2000 | 1500-1700 | 1250-1500 | <1250 & >4500 |
| Excessive rain (months) | <1 | 1-2 | 2-4 | 5 | - |
| Dry season (months) | <1 | 1-2 | 2-3 | 3-4 | >4 |
| Mean annual temperature (°C) | 25-28 | 28-34 | 34-40 | - | - |
| Mean max. temperature (°C) | 29-34 | 26-29 | 22-26 | 20-22 | <20 |
| Mean min. temperature (°C) | >20 | 17-20 | 14-17 | 10-14 | <10 |
| Mean relative humidity (%) | 66-90 | - | <66 | - | - |
| Average min. temperature (°C)-coldest month | >20 | 18-20 | 16-18 | 14-16 | <14 |
| Topography, land scape and wetness | | | | | |
| Elevation (m) | <450 | 450-500 | 500-550 | 550-650 | >650 |
| Slope (%) | 3-10 | 10-15 | 15-35 | 35-50 | >50 |
| Drainage | Well | Well | Moderate | Imperfect | Very poor |
| Flooding | No | - | - | Occasional | Severe |
| Ground water depth (m) | >10 | 5-10 | 5-10 | 2-5 | <2 |
| Soil characteristics | | | | | |
| Texture | Loam/clay loam | Sandy loam, sandy clay loam | Silty clay loam | Loamy sand | Sandy/clay/sandy clay |
| Coarse fragments (%) | <5 | 20-45 | 45-60 | 60-75 | >75 |
| Depth (cm) | >150 | 100-150 | 50-100 | - | <50 |
| Soil fertility | | | | | |
| pH | 4.3-5.5 | 3.8-4.3 & 5.5-6.0 | 6.0-7.0 | <3.8 | - |
| CEC [cmol(p ⁺)kg ⁻¹] | 3-13 | - | <3 | - | - |
| Organic carbon (g kg ⁻¹) | >10.0 | 7-10 | - | - | - |
| Base saturation (%) | 20-35 | <20 | 35-50 | 50-80 | >80 |

S1 – Very suitable, S2 – Moderately suitable, S3 – Marginally suitable, N – Not suitable

sidering the local experience (Table 4). The various soil-site characteristics used for such comparison included data on annual rainfall, mean temperature, relative humidity, soil depth, slope, texture, drainage, pH, organic carbon, CEC and base saturation. These characteristics are in accordance with those considered by Bhattacharyya *et al.* (1988) in evaluating suitability of rubber under non-traditional areas in India. The existing climatic and soil-site characteristics at each site in the study areas (Table 1, 2, 3) were compared with the criteria listed in Table 4 and evaluated by kind and degree of limitations. Soil/site characteristics were categorised into highly suitable (with nil/minor limitations, 0-1), moderately suitable (moderate limitations, 2), marginally suitable (severe limitations, 3) and not suitable (very severe limitations, 4).

A perusal of data on degree of limitation and suitability of soil (Table 5) for rubber reveals that soils of L6 and L7 are marginally suitable for growing rubber due to severe limitations of slope and coarse fragments while texture, slope and low minimum temperature are moderate limitations in soils of L1, L2, L3, L4 and L5

(Table 5) and grouped under S2 class. The rainfall in these areas favours the growth of rubber without limitation but its growth gets affected by extreme temperature. The fall in winter temperature below 10 °C in the area is considered to be a very severe limitation for the growth of rubber plant since it affects the production of latex. In addition, steep landform with high amount of coarse fragments and high relative elevation are considered to be severe limitations for growth of rubber in Thingdawl area and considered as marginally suitable. Thus, these are evaluated and grouped under S3 class. However, cultivation of rubber in these areas requires identification of limiting factors and adoption of suitable measures to rectify them. Management requirements to combat the problem of poor moisture retention especially in higher elevation and fertility include maintenance of a relatively higher organic matter through organic matter recycling along with inorganic fertilizers. But soils of L6 and L7, which are marginally suitable (S3) for rubber due to permanent limitations of very steep slope, may adversely affect penetration due to low soil depth and presence of coarse fragments. However, undulated

Table 5. Degree of limitation and suitability of soils for rubber (*Hevea brasiliensis*) in North Mizoram

| Characteristics | Soil – site location | | | | | | |
|--|----------------------|-----------|-----------|-----------|-----------|-----------|-----------|
| | L1 | L2 | L3 | L4 | L5 | L6 | L7 |
| Climate Characteristics | | | | | | | |
| Annual rainfall (mm) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Excessive rainfall (months) | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Length of dry season (months) | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Mean annual temperature (°C) | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Mean max. temperature (°C) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean min. temperature (°C) | 1 | 1 | 1 | 2 | 2 | 1 | 1 |
| Mean relative humidity (%) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Site characteristics | | | | | | | |
| Elevation (m) | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Slope (%) | 2 | 1 | 2 | 2 | 2 | 3 | 3 |
| Drainage | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Soil Fertility | | | | | | | |
| pH | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| CEC [cmol (p ⁺) kg ⁻¹] | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Organic carbon (g kg ⁻¹) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Base saturation (%) | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Suitability Class | S2 | S2 | S2 | S2 | S2 | S3 | S3 |

S2-Moderately suitable, S3-Marginally suitable

low hills and ridges with gentle to moderate side slope could be made suitable by constructing field bunds and silt pits across the slope to reduce erosion.

Thus, the soil-site suitability assessment of different soils in North Mizoram reveals that the soils occurring in the areas of Bairabi, Tuichhuh, N-Chhimluang and undulated low hills of Bikhawthlir are moderately suitable for rubber cultivation.

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