Soil Brief *China 2*

PEOPLE'S REPUBLIC OF CHINA

Reference soil ("Latosol") of tropical southern Yunnan Province

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ISRIC

International Soil Reference and Information Centre

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Reference soil ("Latosol") of tropical southern Yunnan Province

ISRIC Soil Monolith:

Number	*FAO-Unesco*	*Soil Taxonomy*	*Chinese Classification*
CN 44	Ferralic Cambisol	Fluventic Umbric Dystrochrept	Haplic Latosol

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ABSTRACT

A representative soil located in the Dai Autonomous Prefecture of Xishuangbanna, Tropical South Yunnan Province was studied for the establishment of a Chinese soil reference collection and pedon database. Description and sampling was carried out in the framework of an European Community supported cooperation programme between the "Institute of Soil Science, Academia Sinica", Nanjing, People's Republic of China and the "International Soil Reference and Information Centre", Wageningen, The Netherlands.

The climate of the Xishuangbanna subregion is hot and humid. The precipitation is unevenly distributed, resulting in marked dry and wet seasons. Near the Xishuangbanna Institute of Tropical Ecology, Menglun, a very deep, well drained, dark reddish brown to red clay loam soil, developed from alluvial sandstone deposits was studied. The soil is classified as a Haplic Latosol (Chinese) or a Ferralic Cambisol (FAO-Unesco).

The upland soils in the area, like reference soil CN 44 are used for rubber cultivation or food crops. Climatic conditions are favourable for rubber, although the occurrence of typhoons, low temperatures and drought stress may affects its growth. Rooting conditions are optimal. The soil has low levels of available nutrients and low nutrients reserves. Very high percentages of exchangeable aluminium are tolerated by rubber and tea but certainly affect other crops. Experiments with rubber and tea intercropping are successful and results need to be disseminated. Agriculture and nature conservation are, however, competing and require sound land use planning.

摘 要

爲建立中國土壤樣品參比庫和土壤剖面數據庫，一個典型土壤剖面采自位于熱帶的雲南省西雙版納傣族自治區。該項目在歐共體STD2項目資助下，由中國科學院南京土壤所和荷蘭國際土壤信息參比中心合作實施。

西雙版納地區氣候濕熱，降雨不均，旱季和雨季分明。土壤剖面采集地在西雙版納熱帶生態研究所附近，土層非常深厚，排水良好，暗紅棕到紅色粘壤質，發育于砂岩冲積物上。該土壤分類爲普通磚紅壤(中國土壤系統分類，1990)即鐵鋁雛形土(FAO土壤分類，1989)。

該地區旱地一般種植橡膠或糧食作物。雖然受到台風，低温和干旱的威脅，一般而言，氣候是適宜于橡膠的種植，土壤也有利于根系生長。但土壤速效和緩效養分缺乏。另外，土壤中交換性鋁的比例非常高，盡管它對橡膠樹并無什么影響，但對一些敏感的作物會産生不利的影響。試驗表明，橡膠和茶樹間種取得良好的效果。但農業用地和自然保護存在競爭，土地利用需要進一步合理化。

FOREWORD

The objective of a Soil Brief is to provide a description of a reference soil typical for a certain agro-ecological zone. The Soil Brief is composed of a text part which includes some graphical presentations of the most outstanding phenomena as well as data annexes. The reference soil is a representative red soil situated in the southern part of the Yunnan Province of the People's Republic of China.

The Soil Brief is written for soil specialists and non-soil specialists. For the latter the comprehensive field and laboratory data as being processed with the ISRIC's Soil Information System (ISIS) are often too complex and/or too detailed and therefore require clarification in the text. For the soil scientist the text part can be of use as it summarizes the important land and soil qualities, relevant aspects of soil management and soil formation. Furthermore, it provides access to additional information from research and discussions, which cannot be stored in the computerized database. Also within the text reference is made to specific literature that can be consulted in order to enter more in detail.

In this Soil Brief, the text part includes a general characterization of the southern part of Yunnan Province presenting climate, geology and geomorphology (Chapter 1). Also a more specific description is given of the subregion in which the studied soil is situated (Chapter 2). Next a description and discussion of the major characteristics of the soil and its taxonomical classification follows, as well as its location (Chapter 3). An evaluation of the land qualities and limitations for assessing appropriate land use is included. In the annexes the soil and environmental data, available from field, laboratory and office work are given.

In 1993 the "Institute of Soil Science, Academia Sinica" (ISS-AS), Nanjing, People's Republic of China and the "International Soil Reference and Information Centre" (ISRIC), Wageningen, The Netherlands described and sampled in SW-China nine reference soils for the establishment of a Chinese soil reference collection and pedon database at ISS-AS. Duplicates of these soils were collected for ISRIC's world soil collection. In this Soil Brief one of these reference soils is discussed.

Valuable comments on draft versions of this report were received from ISSAS and ISRIC staff, and by Dr. T. de Meester. Soil analytical work was carried out at the soil laboratories of ISSAS and ISRIC. The editing and final lay-out of the document was done at ISRIC with contributions of Dr. E.M. Bridges (editing), Ms M.B. Clabaut (text processing) and Ms J.W. Resink (map compilation). Useful comments on the draft of this Soil Brief were obtained from Mr. A.E. Hartemink.

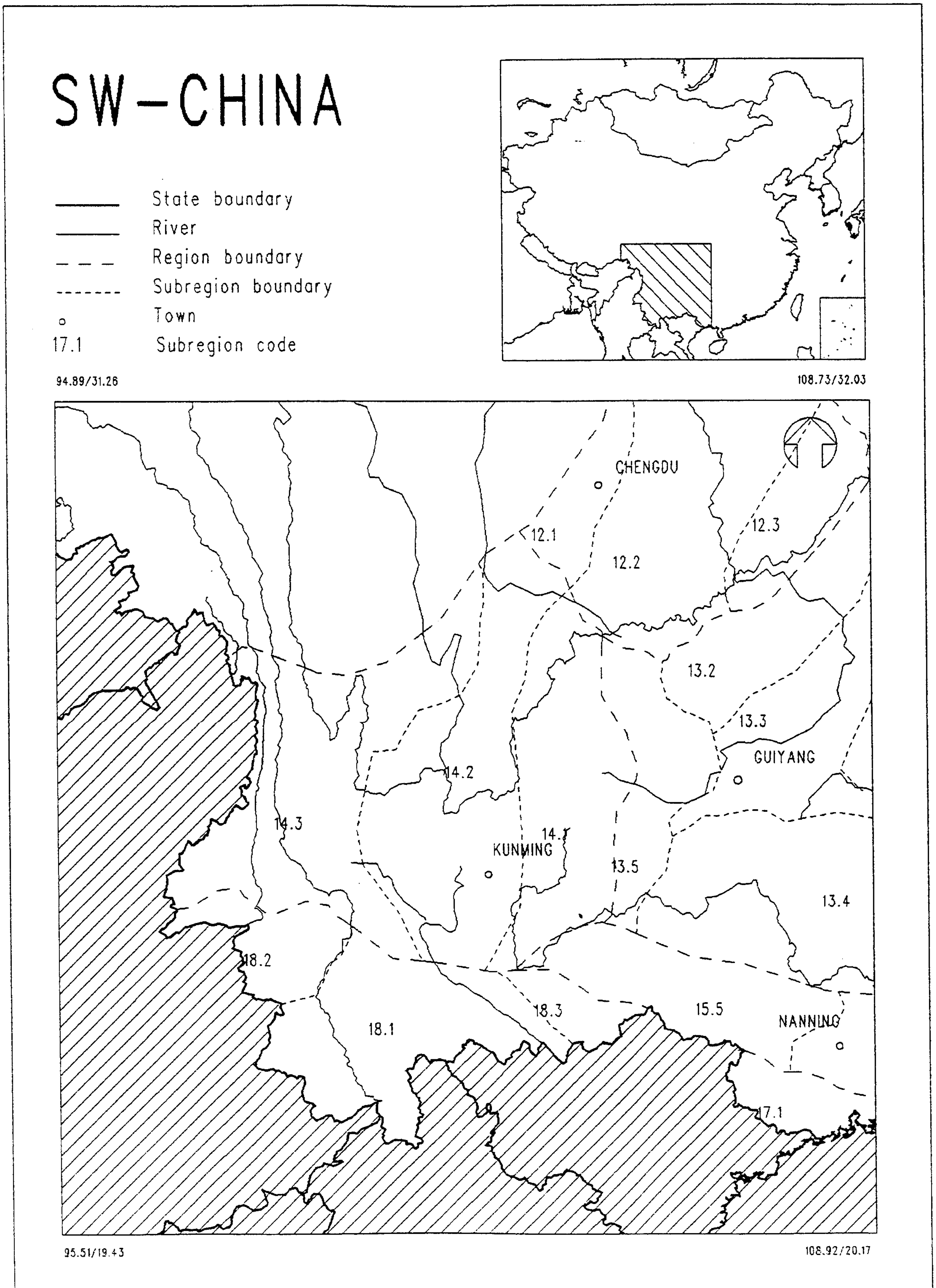

Figure 1 Major physiographic (sub)regions of South-western China.

1 THE SOUTHERN YUNNAN REGION

1.1 Introduction

The tropical area of China is not extensive, and covers 1.6% of the total land area. There is some disagreement about the northern boundary of the area. The controversy extends over a width of 21 to 25°C. The southern part of Yunnan Province forms undoubtedly part of tropical China. Heavy precipitation and constant high temperatures generate continuous plant growth and a profuse, varied flora.

1.2 Climate

Due to the barrier function of the elevated Qinghai-Xizang Plateau in the north, the latitude as well as the dissected plateau topography of the area itself, the humid tropical climate is characterised by warm winters and frequently occurring temperature inversions. Summer temperatures reach 21 to 25°C and the mean annual temperature is 18 to 22°C. The mean January temperature is 11 to 16°C and the accumulated temperature during the >10°C period is above 8000°C. In areas between 1300 and 1600 m a.s.l. there is an eternal spring and in areas of around 900 to 1300 m, there is a summer and spring (autumn) but no winter.
Another climatic feature is the abundant precipitation and a sharp distinction between the rainy and dry season. The precipitation derives mainly from the Indian Ocean without influence of the Pacific typhoons. Annual precipitation totals 1200 to 1600 mm, decreasing from both southwest and southeast to middle north. 80 to 90% of the annual precipitation is concentrated in the rainy season (May to October), contrasting markedly with the dry season (November to April). Precipitation mostly comes in sudden and brief showers. In low valleys, fogs occur frequently, and about 120 foggy days annually are common. Fogs occur mostly in the dry season and may compense for the moisture deficiency.
According to the Köppen classification the southern part of the Yunnan Province belongs to the area with a Tropical Monsoon Climate, characterised by a short dry season (Am).

1.3 Geology and geomorphology

The Yunnan area is the southward extension of the Hengduan Mountains, with high mountains and deep valleys parallel to eachother. It is composed mainly of dissected plateaus and broad valleys at 700 to 1500 m a.s.l., interspersed with mountains above 1500 m a.s.l. and low valleys below 700 to 900 m a.s.l. The population is concentrated in the intermontane basins and valleys, the so-called "batzi".

The strong relief exerts a great influence on the vertical zonation of climate and vegetation. Especially in southern Yunnan, there often occur inversions of temperature in areas below 400 to 500 m a.s.l. in elevation, with a temperature increase rate of +1.0°C for every increase of 100 m. Consequently, tropical monsoon forest may be found up to 800 to 900 m a.s.l., sometimes even higher than 1000 m a.s.l.

1.4 Vegetation and land use

The deciduous tropical monsoon forest is the typical zonal vegetation type for this part of China. As mentioned in section 1.2 the area is characterised by an annual precipitation of less than 1600 mm and a relative long dry season. As high temperatures coincide with the rainy season, and somewhat lower temperatures with the dry season, there are periods with different growth rates: the luxuriant, rapid growth rainy season and the less luxuriant, slow growth dry season. The distinction between the greenish phase in summer and the yellowish phase in winter is particularly prominent.
The upland soils in the area are commonly used for rubber cultivation or food crops. Under the rubber trees tea, cacao, cinchona, devil pepper (*Rauvolfia Sp.*), cassiabark tree (*Cinnamomum cassia*) and sanchi, a medical herb (*Panax pseudo-ginseng*), are intercropped. On newly reclaimed soils, upland rice can be grown with high yields even without fertilizing. The growing season lasts the year around and 3 crops of rice can be grown. Slash and burn cultivation is being practised in many areas. With the increase of population and decrease of forest coverage, it has become a very destructive land use: large quantities of forest resources are ruined, leading to soil erosion. There is also a decline in land productivity (Xu Yue *et al.*, 1991). As an illustration, the following fact may serve: 15 years after deforestation only about 40% of the original organic matter content in the topsoil was found (Xu Yue *et al.*, 1991).

Since 1949, cultivated lands has increased from 36700 ha to 92700 ha and rubber plantations from nil to nearly 30000 ha. A series of problems in regional development present themselves. The most critical one is the struggle between natural conservation and rubber plantation below an altitude of 900 m a.s.l. From the national point of view, rubber and other tropical crops could have priority as rubber is an important industrial and strategic material (Lu Xing-zheng, 1988). Land suitable for rubber plantation in the area is estimated to be 127000 ha. Current productivity of rubber reaches 810 kg ha^{-1}, and this could also be increased.
A balanced and planned economy should be maintained in combination with a conservation of natural resources.

The restricted flat plains are better devoted to intensive farming, whereas slopes and hills below 900 m a.s.l. can be used for rubber and other tropical crops. Montane areas above 900 m a.s.l. could be used for nature conservation and forestry.

2 DAI AUTONOMOUS PREFECTURE OF XISHUANGBANNA

2.1 Introduction

The southern part of Yunnan Province (Figure 1) is considered as the "treasure garden" of plants in China. Parts of it is considered as natural resources. Representative for this tropical part of China is "Dai Autonomous Prefecture of Xishuangbanna" with an area of 19200 km^2 and an elevation ranging from 540 to 2400 m a.s.l. It is one the best sites for developing tropical crops in China and it has been cultivated and developed by the Dai and other peoples since ancient times.

2.2 Climate

The Xishuangbanna area lays south of the Tropic of Cancer. The climate is hot and humid, with mean January temperature above 16°C, an absolute minimum temperature above 10°C, and an annual precipitation above 1500 mm. Fig. 2 shows monthly data of the maximum, average and minimum temperatures, corresponding to the meteorological station Mengla, located at about 59 km from site CN 44. Figure 3 presents mean monthly data for the average precipitation and evaporation measured in Mengla. Both figures were made with SOLGRAPH (Brunt & Kauffman, 1995).

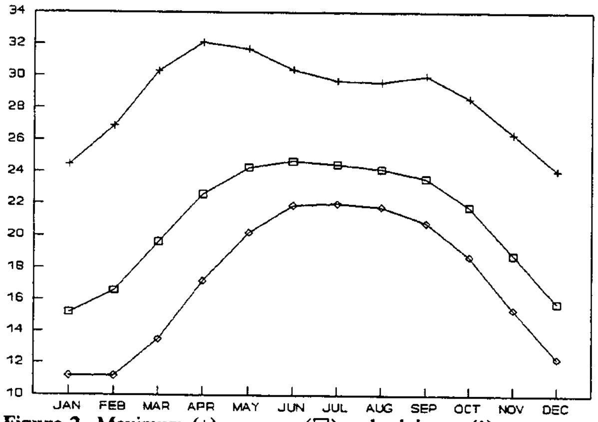

Figure 2 Maximum (+), average (□) and minimum (◊) temperature in °C at the Mengla meteorological station.

There is some evidence that deforestation in the Xishuangbanna region has resulted in a local climatical change as temperatures in the cool season have decreased and increased in the dry season. It seems that also the amount of sunshine hours has increased. These changes of the climate may result in crop damage due to drought, cold injury, or perhaps flooding damage and the damage from gales (Zhang Keying, 1991).

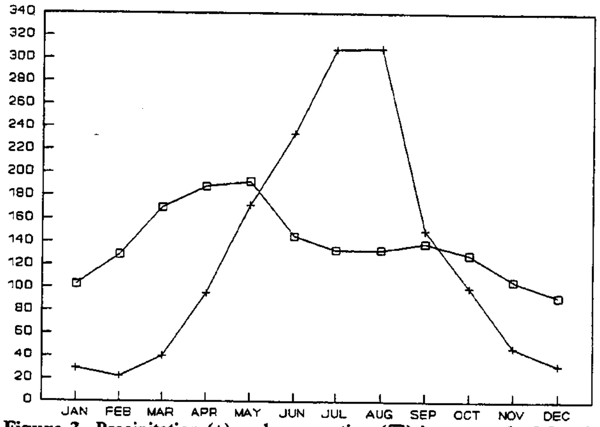

Figure 3 Precipitation (+) and evaporation (□) in mm at the Mengla meteorological station.

2.3 Land use

In the low valleys (700- 900 m a.s.l.), evergreen tropical monsoon forests dominate. Patches of tropical rain forest are found (in low valleys below 500 m a.s.l.). Deciduous tropical monsoon forest are common in some drier sheltered valleys. Montane areas above 700 to 900 m a.s.l. are mainly covered with subtropic evergreen broad-leaved forest.

In the Xishuangbanna area, the lower tropical forest occupies about 29% of the total land area, whereas the upper subtropic forest type accounts for 42%. Relative relief also plays an important role. Low flat plains are usually cultivated with rice which can be harvested twice a year. Hill and terrace land are cultivated with rubber and other tropical crops, whereas low and middle mountains are mainly under forest. This is one of the most northern and highest (900 m a.s.l.) rubber areas in the world.

3 THE REFERENCE SOIL

In this chapter, a selection of data and research information of reference soil CN 44 is discussed. Detailed description and sampling and the taking of a monolith of the reference soil was carried out in 1993 by scientists of ISRIC and the Chinese Institute of Soil Science.
Field and laboratory data are given in Annex 1.

3.1 Location

Reference soil CN 44 is located along the entrance road to the Xishuangbanna Institute of Tropical Ecology, Menglun (Figure 4). The soil type is typical for the tropical region south of 22°N latitude with a characteristic monsoon climate.

3.2 Landscape

Soil CN 44 is situated on a terrace of a side branch of the Lancang Jiang (Mekong) River. The topography is hilly and the slope gradient is 16%. The parent material is alluvial deposits, from sandstone and lime-sandstone. The land use type is semi-natural shrubs with scattered rubber trees. The land is extensively grazed by cattle. Fungi problems are treated with small quantities of fungicides. The area forms a part of a botanical garden founded in 1960.
Since then, experiments are conducted on intercropping of tea with rubber, coffee with rubber, and cacao with rubber. In 1970, the garden was officially converted into an ecological station, located in Damenglong.

3.3 Soil characterisation

3.3.1 Brief field description

CN 44 is a very deep, well drained, dark reddish brown to red, clay loam soil. At the soil surface, a moderately decomposed thin litter layer is found. The soil is moderately to weakly structured; and moderately porous. The boundaries between the different horizons are gradual.

3.3.2 Brief analytical characterisation

Soil samples were analyzed at ISRIC's soil laboratory according to the procedures described by van Reeuwijk (1992).
Some important soil data are presented graphically, using SOLGRAPH (Brunt & Kauffman, 1995).

Fig. 5 shows the textural composition of soil CN 44 with depth. The sand, silt and clay content of soil CN 44 does not change very much with depth, only in the deep subsoil clay contents decreases. The presence of adhering particles of iron oxides (goethite) may have prevented proper soil dispersion, or have affected grossly the sedimentation rate of the soil particles (Loveland and Whalley, 1991). No special pretreatment was used for the removal of these coatings and the textural composition should therefore be interpreted with care.
Fig. 6 presents chemical properties with depth. The organic C content, the sum of the exchangeable cations (Ca, Mg, K and Na), and the soil acidity (pH-H_2O and pH-KCl). The organic C content of the soil gradually decreases with depth. The exchange capacity equals the sum of the exchangeable bases; which is extremely low for CN 44, exchange acidity is high, and closely related to the low base saturation and the low pH of the soil (pH-H_20 4). The pH is fairly constant with depth.
Fig. 7 presents the moisture retention curve. The intersection point of the curve with the x-axis, gives the water content of the soil under saturated conditions, which indicates the total pore-volume. The quantity of soil moisture between pF 0 and pF 2 is expressed by the air capacity which is a measure for the drainage and aeration conditions of a soil. The available soil moisture (ASM) for plant growth is the quantity of moisture between pF 2 (field capacity) and pF 4.2 (permanent wilting point). The available moisture stored in soil CN 44 is higher in the topsoil then in the subsoil. Large pores are found in a reasonable quantity throughout the profile, but their amount decreases with depth. The overall porosity of the soil is moderate.

3.4 Soil classification

FAO-Unesco (1988)
The soil classifies as a Ferralic Cambisol, having an ochric A horizon (too light in colour, too low base saturation to be a mollic or umbric A horizon) and a cambic B horizon with ferralic properties (CEC < 24 $cmol_c\ kg^{-1}$ clay in at least some subhorizon of the cambic B horizon). Is does not show vertic or gleyic properties. The B horizon can not be classified as an argic B horizon, as there is not enough clay illuviation and clay cutans are absent.
The soil does not meet all the requirements of a Ferralic B-horizon since the silt-clay ratio is too high and the water dispersable clay content is not in all parts of the B-horizon < 10%. On the other hand the CEC in the whole profile is < 16 $cmol_c\ kg^{-1}$ clay. Because of the red colour of the B-horizon the soil could be classified as a Rhodic Ferralsol.

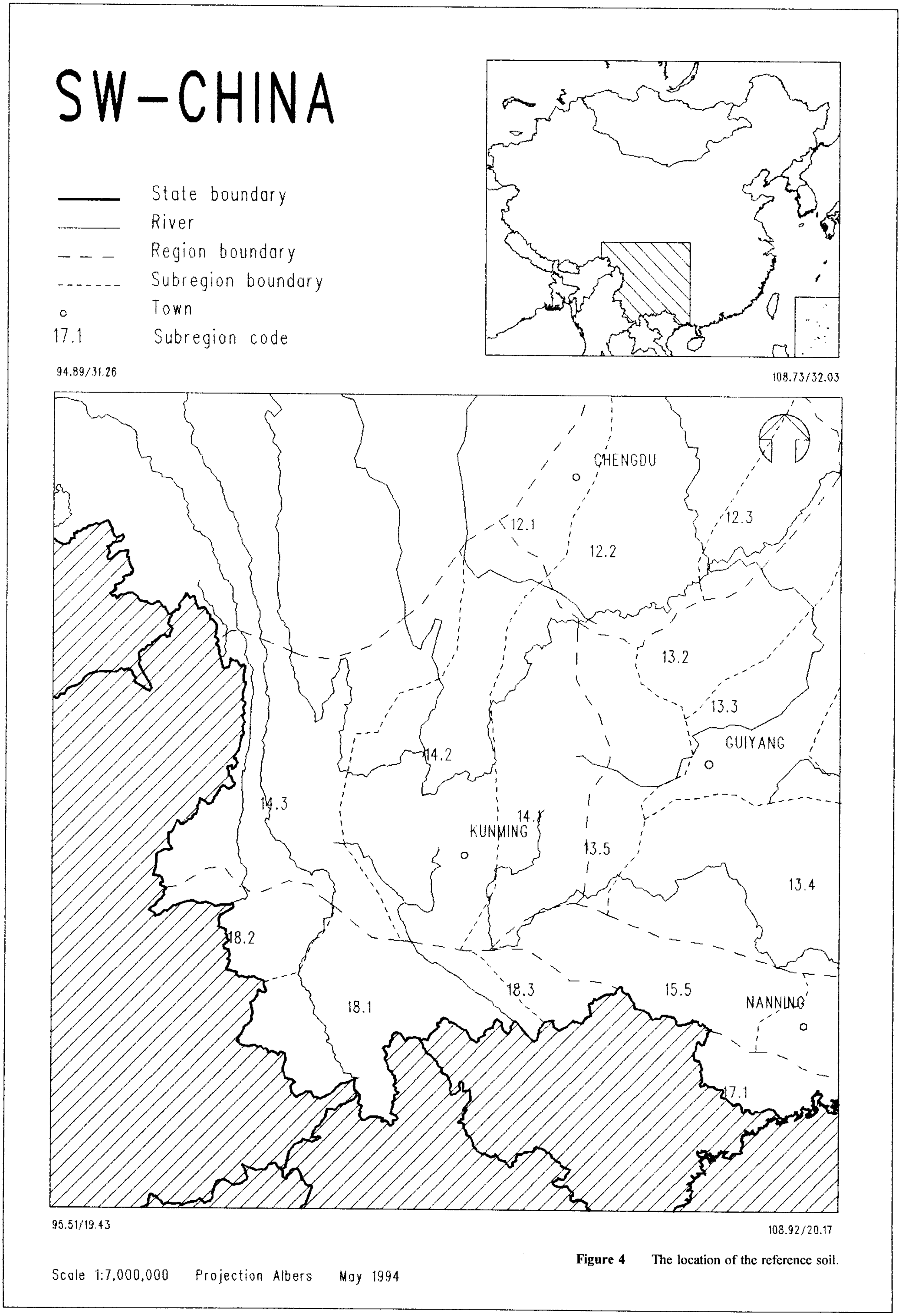

Figure 4 The location of the reference soil.

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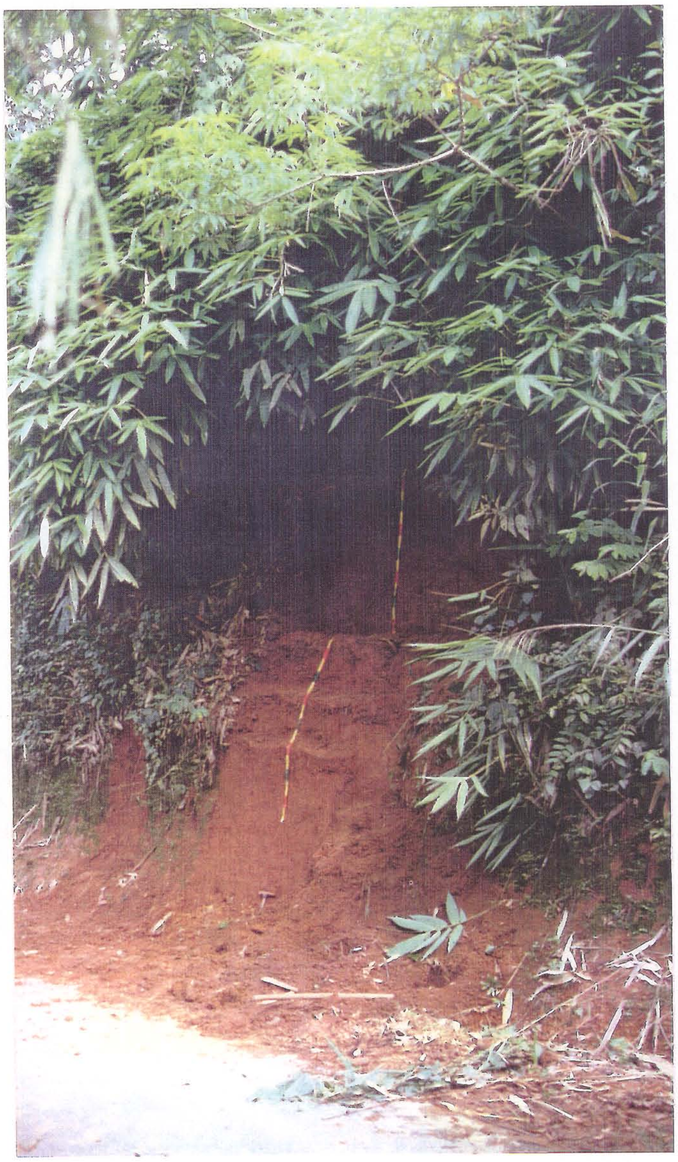

3

1. **Landscape CN 44**
2. **Rubber and tea intercropping on experimental station near CN 44**

3/4/5. **Profile CN 44**

5

4

Table 1 Key properties of soil CN 44

	CN 44
Texture	clay loam throughout the profile
Organic C	medium (1.6%) in the topsoil to low and very low in the subsoil
pH H_2O	extremely acid (pH-H_2O 3.9) in the topsoil to strongly acid (pH-H_2O 4.5) throughout the rest of the profile
Sum of bases	very low (<0.5 $cmol_c$ kg^{-1} soil) throughout the profile
Cation Exchange Capacity	low (6 $cmol_c$ kg^{-1} soil) throughout the profile
Exch. aluminium	extremely high (>100%) in the topsoil and high (66%) in the subsoil
Phosphorus	medium (7 mg/kg) in the topsoil to very low (0.6 mg/kg) in the subsoil
Nitrogen	low (0.15%) in the topsoil to very low (± 0.07%) in the subsoil
Clay mineralogy	kaolinite, mixed (vermiculite/chlorite)
Air capacity	high (16%) in the topsoil to medium (12%) in the subsoil
Available soil moisture	medium (12%) in the topsoil to low (6%) in the subsoil
Bulk density	medium (1.2 kg/dm^3) throughout the profile

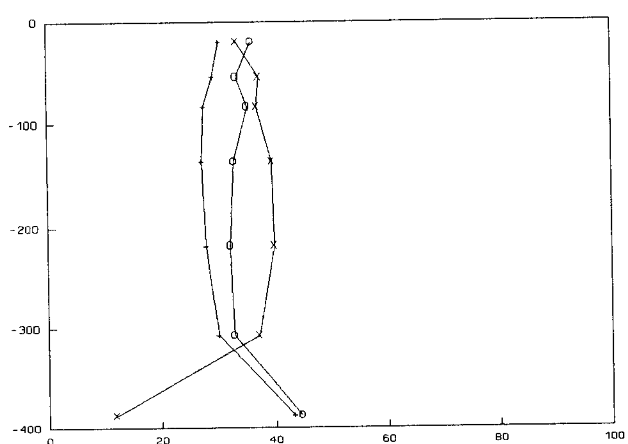

Figure 5 Percentages clay (x), silt (+) and sand (o) versus depth (cm) in profile CN 44.

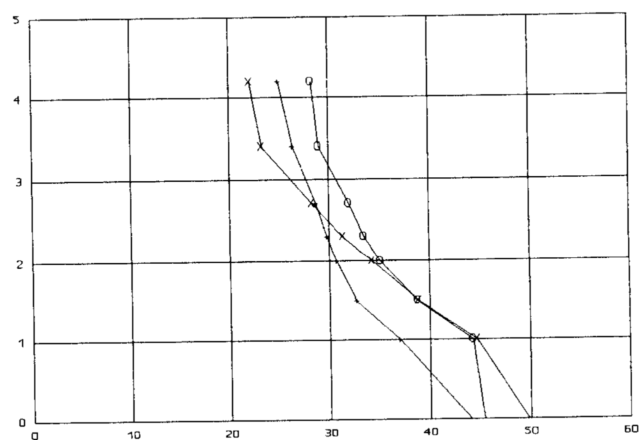

Figure 7 pF or moisture retention curves (water content in vol % versus suction) at depth 0-40 cm (x), 40-70 cm (+), 98-175 cm (o) in profile CN 44.

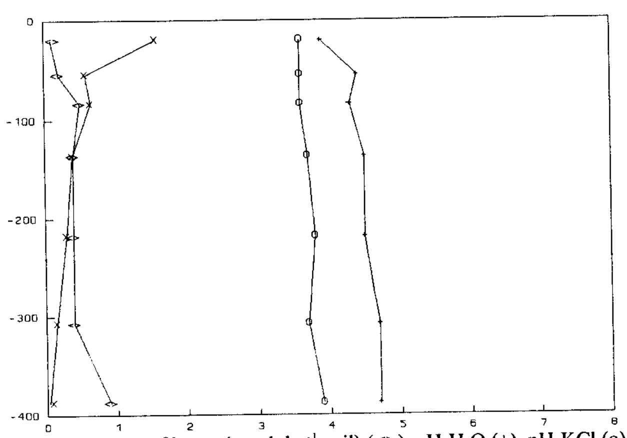

Figure 6 Sum of bases ($cmol_c$ kg^{-1} soil) (<>), pH-H_2O (+), pH-KCl (o) and organic carbon (x) versus depth (cm) in profile CN 44.

<u>USDA Soil Taxonomy (1992)</u>

At first sight, the soil gives the impression that it has an oxic horizon that has its upper boundary within 150 cm of the mineral soil surface. The thickness of the B horizon is ≥ 30 cm, it has a low content of weatherable minerals, a low CEC (< 16 $cmol_c$ kg^{-1} clay) and the upper particle size boundary is diffuse (< 20% within a vertical distance of 15 cm). The ECEC of the B horizon is however > 12 $cmol_c$ kg^{-1} clay and therefore it keys out as a cambic horizon and not as an oxic one.

The soil has an ochric epipedon and at a depth of 125 cm below the mineral soil surface the organic carbon content is ≥ 0.2%. The slope is < 25% and the Ap horizon has a colour value of ≤ 3. Therefore the soil keys out as a Fluventic Umbric Dystrochrept.

Chinese Soil Classification System (Soil Taxonomic Classification Research Group, 1993)
The soil belongs to the suborder of the Udic Ferrallisols. It has an umbrihumic epipedon, a base saturation of < 35%, lacks redoxic features and humic properties, and does not show an argic horizon or argillic horizon whose upper boundary is within 125 cm of the surface. The soil keys out as a Haplic Latosol.

3.5 Soil suitability

A qualitative evaluation of relevant land qualities according to the Framework for Land Evaluation (FAO, 1983) was carried out. In this methodology an evaluation is made for different land use types. In this Soil Brief, the evaluation was only made for rubber, a native of tropical rain forests. For many years China had to import rubber, but nowadays it is self supporting in its rubber requirements. It is therefore a cash crop of great economic and strategic importance.
Soil and climatic requirements for rubber were taken from Purseglove (1968), ILACO (1981) and Landon (1991). The results of the evaluation are presented in a list of soil/land qualities in Annex 2.

3.5.1 Requirements and limitations for rubber

Rubber (*Hevea brasiliensis*) needs about 2000 mm of precipitation well distributed through the year with no month with less than 100 mm rain. Daily temperatures must be between 26°C and 30°C (range 10- 25°C); big changes in temperature are unfavourable. Both excessive amounts of rain and pronounced dry seasons reduce the yields. The crop is frost sensitive, and strong winds can be very harmful for the trees.
Rubber is a deep rooting (maximum rooting depth 3- 4 m) crop which has an extensive rooting pattern (shallow lateral roots can extend > 20 m). The main nutrients/ water uptake of the roots takes place in the upper 2 m. It is a low nutrient demanding crop (excess of nitrogen can cause trunk breakage when the tree is young; surface pH range for satisfactory yield 3.8- 8.0; optimal pH 5-6; CEC > 15 $cmol_c$ kg^{-1}; Organic Carbon topsoil > 1%). Nutrients are recycled with the falling leaves. At maturity stage, erosion under rubber is low. An imperfect drainage and short periods with water saturation of the soil are well tolerated. However, the drought resistance is low. The soil, preferably of medium to coarse texture (sandy clay loam or clay loam) must be well drained and permeable.

3.5.2 Evaluation of CN 44

The region has sufficient solar energy, abundant heat and ample rainfall, although it suffers from conditions that are unfavourable for rubber growth such as the occurrence of typhoons, droughts and especially low temperatures in certain moments of the year (Lu Xing-zheng, 1988). The amount of water stored in the soil is moderately high (Available Water Capacity is 66 mm/70 cm soil).
Rooting conditions and oxygen availability are optimal, as the soil is very deep and well drained. It is low in nutrients, which is partly compensated by the leaves of the rubber trees. Close to villages, manure is applied and in areas where intercropping with tea is practised, NPK fertilizers are applied.
The acidity of the soil is a little bit too high for a good rubber yield and is directly related to the high amount of exchangeable aluminium. However, high exchangeable aluminium is tolerated by rubber, but certainly affects other sensitive crops.

3.6 Intercropping of rubber and tea

The demand for land is in this part of Yunnan Province is not very high. The population density is low, and farmers are only interested in certain tree species for construction purposes, furniture and firewood. The selling of timberwood is strictly regulated by the Chinese Government. The area with forest can be subdivided in Natural Reserves, State owned forests close to the border and areas occupied by the farmers which are ecologically seen, the most fragile.
For those parts which are taken into agricultural use the principle of eco-farming is of vital importance. This includes the maintenance of the soil nutrient status, the conservation of soil and water and the control of biological forces. The latter includes intercropping with leguminous crops that are adopted to local environment with other crops, or introduction in a rotation scheme in order to improve fertility, the reduction of fallow time, and the control of weeds (Li Lianfang, 1991; Wang Huihai *et al.*, 1991).
The fertility of the soil is to a great extent influenced by the natural vegetation. Tropical soils may be poor in organic matter due to an intensive activity of microorganisms under influence of the hot and humid climate. However, under natural rain forest the soils may have an organic matter content of 8 to 10%, with a greyish brown surface soil of 15 to 25 cm, or even 30 cm and a litter layer of 2 to 3 cm on the soil surface. After the soils have been cleared for cultivation, the organic matter content may decrease rapidly below 2%. However, the fertility can be maintained, even increased, by reasonable intercropping, mulching and fertilization.

It is striking that rubber can be cultivated at such a high latitude. The Xishuangbanna area is located more northwards than Hainan island, where 80% of the Chinese rubber production takes place. The total production of rubber in China is 300000 tons/year. On only 20000 has. rubber is intercropped with tea, of which only a very small area can be found in Yunnan province.

The variety of tea is the so called broad leaf (large-leaved) tea, yielding higher and gives a higher price because leaves can already be harvested in January and not in March which is the case with normal tea.

Ma Youxin's (1991) analysis of the ecological and economic benefits of rubber (*Hevea brasiliensis*) and tea (*Camellia sinensis*) intercropping revealed the following facts:

* The wind speed is reduced by 67% compared to plantations with only tea.
* The winter is warm and the summer cool, and a reduction in the amplitude of annual temperatures takes place. Daily and annual fluctuations of air temperature are reduced with 1.6°C and 0.7°C, respectively, in comparison with pure tea plantations, which is beneficial to growth and development of tea shrubs. Also the air temperature in the coldest month is about 0.5°C more than that of pure rubber plantations. This is favourable for the survival of rubber trees in winter because roots of the rubber trees are better protected by a dense tea cover close to the soil surface.
* A better use is made of water stored in the deeper layers, while competition for water between rubber and tea is avoided because respiration peaks occur at different times (Long Biyun, 1991).
* The litter-fall increases, run-off and soil erosion are reduced, and soil fertility is improved (higher organic matter content; 0.1 to 0.2% more than plantations with only tea or only rubber; water content of the surface soil layer (0-50 cm) is increased compared to pure tea plantations).
* The reproduction of natural enemies of pests and plant diseases is induced.
* The rubber can produce 1 to 2 years earlier and tea even 4 to 5 years earlier, while yields of tea increase by 30 to 40%, compared to plantations with only tea.

REFERENCES

Brunt, J. and J.H. Kauffman, 1995. *SOLGRAPH: a soil and climatic data presentation and assessment program.* Technical Paper 25. ISRIC, Wageningen.

FAO-Unesco, 1978. *FAO-Unesco Soil map of the world 1: 5,000,000.* Volume VIII North and Central Asia. Unesco, Paris.

FAO, 1977. *Guidelines for soil profile description* (2nd edition). FAO, Rome.

FAO, 1983. *Guidelines: land evaluation for rainfed agriculture.* FAO Soils Bulletin 52. FAO, Rome.

FAO, 1988. *FAO-Unesco Soil Map of the World, revised Legend.* World Resources Report 60. FAO, Rome. Reprinted as Technical Paper 20, 1989. ISRIC, Wageningen.

ILACO, 1981. *Agricultural compendium for rural development in the tropics and subtropics.* Elsevier, Amsterdam, The Netherlands.

ISRIC (in prep). *STRESS: a qualitative model for assessment of agricultural suitability of reference soils.* Working Paper & Preprint. ISRIC, Wageningen.

Landon, J.R. (Ed.), 1991. *Booker tropical soil manual. A handbook for soil survey and agricultural land evaluation in the tropics and subtropics.* Longman Scientific and Technical and John Wiley, New York. (paperback ed.).

Li Lianfang, 1991. *On the traditional agriculture and sustainable utilization of land resources in Xishuangbanna.* International symposium on made-made community, integral land-use and biodiversity in the tropics. October 1991. Abstracts. Xishuangbanna.

Long Biyun, 1991. *Dynamic of soil water in mad-made rubber-tea community.* International symposium on made-made community, integral land-use and biodiversity in the tropics. October 1991. Abstracts. Xishuangbanna.

Loveland, P.J. and W.R. Whalley, 1991. Particle size analysis. In: Smith, K.A. and C.E. Mullins (Eds.). *Soil Analysis: Physical Methods.* Books in Soils, Plants, and the Environment Series. Marcel Dekker, New York.

Lu Xing-zheng, 1988. Soil management in China's rubber plantations. In: *Proceedings of the international conference on the management and fertilization of upland soils in the tropics and subtropics.* September 7- 11, 1986. Nanjing.

Ma Youxin, 1991. *Analysis of the ecological and economic benefits of multistorey tea plantation in China.* International symposium on made-made community, integral land-use and biodiversity in the tropics. October 1991. Abstracts. Xishuangbanna.

Purseglove, J.W., 1968. *Tropical crops. Dicotyledons.* Longman, London.

Soil Survey Staff, 1992. *Keys to Soil Taxonomy, fifth edn.* SMSS Technical Monograph No. 19. Pacohontas Press, Blacksburg.

Soil Taxonomic Classification Research Group, 1993. *Chinese soil taxonomic classification system. First Proposal.* Manuscript and translation of the original Chinese version. Institute of Soil Science - Academia Sinica, Nanjing. Science Press, Beijing.

Van Reeuwijk, L.P., 1992. *Procedures for soil analysis.* Technical Paper 9 (3rd edition). ISRIC, Wageningen.

Van Waveren, E.J. and A.B. Bos, 1988a. *Guidelines for the description and coding of soil data.* Revised edition. Technical Paper no. 14. ISRIC, Wageningen.

Van Waveren, E.J. and A.B. Bos, 1988b. *ISRIC Soil Information System, user manual and technical manual.* Technical Paper no. 15. ISRIC, Wageningen.

Wang Huihai, Li Dehou and Wang Pinghua, 1991. *New ways to utilize and manage the rainfed uplands in tropical South Yunnan, China.* International symposium on made-made community, integral land-use and biodiversity in the tropics. October 1991. Abstracts. Xishuangbanna.

Xu Yue, Jing Kuifeng and Xie Kejing, 1991. *Dynamics of soil organic matter in tropical rain forest after being burnt.* International symposium on made-made community, integral land-use and biodiversity in the tropics. October 1991. Abstracts. Xishuangbanna.

Zhang Keying, 1991. *The influence of deforestation of tropical rainforest on local climate and disaster in Xishuangbanna region of China.* International symposium on made-made community, integral land-use and biodiversity in the tropics. October 1991. Abstracts. Xishuangbanna.

Zhao Qiguo, Gong Zitong, Hou Chuanqing and Zou Guochu, 1990. Tropical soils. In: Institute of Soil Science Academia Sinica (Ed.). *Soils of China.* Science Press, Beijing.

Zhao Songqiao, 1986. *Physical geography of China.* Science Press, Beijing, China.

Annex 1 ISIS Data Sheet CN 44

ISIS 4.0 data sheet of monolith CN 44 Country : PEOPLE'S REPUBLIC OF CHINA Print date (dd/mm/yy) : 27/05/94

FAO/UNESCO (1988) : Alumi-Ferralic Cambisol (Chromic) (1974 : Ferralic Cambisol)
USDA/SCS SOIL TAXONOMY (1992) : Fluventic Umbric Dystrochrept, fine, kaolinitic, hyperthermic
(1975) : Fluventic Umbric Dystrochrept
CSTC (1991) : Haplic latosol

DIAGNOSTIC CRITERIA FAO (1988) : ochric A, cambic B horizon
USDA/SCS (1992) : ochric epipedon, cambic horizon
Soil moisture regime : udic

LOCATION : Menglun, roadcut along entrance road to Tropical Ecological Station
Latitude : 21°55' 0'' N Longitude : 101°14' 0'' E Altitude : 580 m a.s.l.
AUTHOR(S) : Vogel, A.W., Wang Mingzhu, Huang Xiaqing Date (mm/yy) : 7/93

GENERAL LANDFORM : valley Topography : hilly
PHYSIOGRAPHIC UNIT : upper slope of river valley
SLOPE Gradient : 16% Aspect : S Form : convex
POSITION OF SITE : upper slope
MICRO RELIEF Kind :
SURFACE CHAR. Rock outcrop : nil Stoniness : nil
Cracking : nil Slaking/crusting : nil
Salt : nil Alkali : nil
SLOPE PROCESSES Soil erosion : nil
Slope stability : locally unstable

PARENT MATERIAL 1 : stony alluvium derived from sandstone
Weathering degree : partial or moderate
2 : sandy limestone/sandstone
Weathering degree : partial or moderate Resistance : moderate
Depth lithological boundary : 400 cm
Remarks : 1 deposited on 2

EFFECTIVE SOIL DEPTH : 370 cm

WATER TABLE : no watertable observed
DRAINAGE : well
PERMEABILITY : no slowly permeable layer(s)
FLOODING Frequency : nil Run off : rapid
MOISTURE CONDITIONS PROFILE : 0 - 370 cm moist

LAND USE : woodland, grazed; crops : rubber
VEGETATION Type : evergreen woodland Status : modified
Landuse/vegetation remarks : Semi-natural vegetation grazed by cattle

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ADDITIONAL REMARKS :
Parent material: the parent material at a depth of 370 cm consists of a 50 cm thick layer of gravel deposited by a side branch of the Lancang Jiang River (Me Kong). The river, at a distance of 100 m from the roadcut where the profile was described, has formed a deep valley and runs actually 50 m lower than the profile is situated. Under the alluvial deposits another type of parent material is found, limestone/sandstone.

CLIMATE : Köppen: Am
Station: MENGLA 21 29 N/101 34 E 632 m a.s.l. 59 km SE of site Relevance: poor

	No. years of record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
pan evaporation mm	24	103	129	170	188	192	145	133	133	139	129	106	92	1660
relative humidity %	24	87	81	79	79	82	87	89	90	88	88	88	89	86
precipitation mm	24	29	22	40	95	172	234	308	309	150	100	48	32	1540
no. of raindays	24	6	5	6	13	19	24	25	25	17	13	9	8	172
tot.glob.rad. MJ/m2		10.6	13.0	15.1	16.8	17.7	14.5	13.4	13.7	14.7	12.8	11.0	9.8	0.0
T mean °C	24	15.2	16.6	19.6	22.6	24.3	24.7	24.5	24.2	23.6	21.8	18.8	15.8	21.0
T max °C	24	24.5	26.9	30.3	32.1	31.7	30.4	29.7	29.6	30.0	28.6	26.4	24.1	28.7
T min °C	24	11.0	11.2	13.5	17.2	20.2	21.9	22.0	21.8	20.8	18.7	15.4	12.3	17.2
windspeed(at 2m) m/s	24	0.6	0.7	0.7	0.8	0.8	0.7	0.7	0.6	0.6	0.6	0.5	0.5	0.6
bright sunshine h/d	24	5.2	6.0	6.3	6.3	6.2	4.3	3.8	4.0	5.1	5.0	4.9	4.6	5.1
bright sunshine %	24	47	52	52	50	48	33	29	32	42	43	44	43	43

PROFILE DESCRIPTION :

Very deep, well drained, reddish brown to red clay loam developed from alluvial deposits derived from sandstone.

Ah	0 - 40 cm	Dark reddish brown (5YR 3/4, moist) clay loam; leaves, moderately decomposed; moderate to strong fine granular structure; friable; common very fine exped-inped tubular pores; moderately porous; many fine and medium roots throughout; very frequent termite channels; gradual wavy boundary to
AB1	40 - 70 cm	Reddish brown (5YR 4/4, moist) clay loam; moderate fine granular and moderate fine subangular blocky structure; friable; common very fine exped-inped tubular pores; moderately porous; common fine roots throughout; very frequent termite channels; gradual wavy boundary to
AB2	70 - 98 cm	Reddish brown (5YR 4/4, moist) clay loam; moderate fine granular and moderate fine subangular blocky structure; friable; common very fine exped-inped tubular pores; moderately porous; common coarse roots throughout; gradual wavy boundary to
Bw	98 - 260 cm	Red (2.5YR 4/6, moist) clay loam; weak to moderate fine to medium subangular blocky medium subangular blocky structure; friable; few very fine exped-inped tubular pores; slightly porous; few fine roots throughout; gradual wavy boundary to
BC	260 - 370 cm	Red (2.5YR 4/6, moist) clay loam; moderate to strong medium wedge-shaped angular blocky structure; firm; abrupt smooth boundary to
C1	370 - 420 cm	gravelly loam; abrupt smooth boundary to
C2	420 cm +	stones

ANALYTICAL DATA :

Hor. no.	Top - Bot	>2 mm	2000 1000	1000 500	500 250	250 100	100 50	TOT SAND	50 20	20 2	TOT SILT	<2 µm	DISP	BULK DENS	pF- 0.0	1.0	1.5	2.0	2.3	2.7	3.4	4.2
1	0 - 40	-	0	1	3	14	18	36	16	14	31	34	10.2	1.12	50	45	39	34	31	28	23	22
2	40 - 70	-	1	1	3	14	15	33	14	15	29	37	17.7	1.21	44	37	33	31	30	29	26	25
3	70 - 98	-	0	1	3	12	19	35	13	15	28	37	16.7	-	-	-	-	-	-	-	-	-
4	98 - 175	-	0	0	2	14	16	33	12	16	27	40	13.7	1.36	45	44	39	35	34	32	29	28
5	175 - 260	-	0	1	2	11	18	32	13	15	28	40	5.4	-	-	-	-	-	-	-	-	-
6	260 - 355	-	0	1	2	13	16	33	17	13	30	37	2.5	-	-	-	-	-	-	-	-	-
7	355 - 420	-	0	2	8	23	12	45	8	35	43	12	0.0	-	-	-	-	-	-	-	-	-

Hor. no.	pH- H2O	KCl	CaCO3 %	ORG-C %	MAT. N %	EXCH CAT. Ca	Mg	K	Na	sum	EXCH AC. H+Al	Al	CEC soil	clay	OrgC	ECEC	BASE SAT %	Al SAT %	EC 2.5 mS/cm
						cmol$_c$ kg^{-1}													
1	3.9	3.6	-	1.57	0.15	0.0	0.0	0.1	0.0	0.1	8.2	7.9	8.0	24	5.5	8.3	1	99	0.11
2	4.4	3.6	-	0.58	0.08	0.2	0.0	0.0	0.0	0.2	8.2	7.3	5.3	14	2.0	8.4	4	138	0.03
3	4.3	3.6	-	0.65	0.08	0.4	0.0	0.0	0.1	0.5	8.1	7.3	6.6	18	2.3	8.6	8	111	0.04
4	4.5	3.7	-	0.39	0.07	0.2	0.0	0.0	0.2	0.4	6.3	5.9	4.3	11	1.4	6.7	9	137	0.02
5	4.5	3.8	-	0.30	0.06	0.4	0.0	0.0	0.0	0.4	6.0	5.2	8.3	21	1.1	6.4	5	63	0.02
6	4.7	3.7	-	0.15	0.04	0.2	0.0	0.0	0.2	0.4	6.0	5.4	8.2	22	0.5	6.4	5	66	0.01
7	4.7	3.9	-	0.04	0.03	0.2	0.0	0.1	0.6	0.9	3.3	2.9	4.2	35	0.1	4.2	21	69	0.02

CLAY MINERALOGY (1 very weak, ..., 8 very strong) / AVAILABLE P (Bray & Olsen)

Hor. no.	MICA /ILL	CHLO	SMEC	KAOL	MIX	QUAR	FELD	GOET	AVAIL. P mg/kg Bray	Olsen
1	2	2	-	7	6	1	1	2	2.1	6.8
2	2	2	-	7	6	1	1	2	0.7	0.6
3	2	2	-	7	7	1	1	2	0.7	0.6
4	2	2	-	7	7	1	1	2	0.7	0.6
5	2	2	-	7	7	1	-	2	0.7	2.4
6	2	2	-	6	6	-	-	2	0.0	2.4
7	4	-	2	5	-	2	2	2	0.7	0.6

Annex 2 Evaluation of Soil/Land Qualities

LAND QUALITY Availability (1)

Hazard/Limitation (2)

vh	h	m	l	vl
n	w	m	s	vs

vh = very high, h = high, m = moderate, l = low, vl = very low

n = not present, w = weak, m = moderate, s = serious, vs = very serious

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↓

CLIMATE			vh / n	h / w	m / m	l / s	vl / vs
Radiation regime	- total radiation	1	■				
	- day length	1	■				
Temperature regime		1	■				
Climatic hazards (hailstorm, wind, frost)		2		■			
Conditions for ripening		1					
Length growing season		1	■				
Drought hazard during growing season		2	■				

SOIL			vh / n	h / w	m / m	l / s	vl / vs
Potential total soil moisture		1		■			
Oxygen availability		1	■				
Nutrient availability		1			■		
Nutrient retention capacity		1				■	
Rooting conditions		1	■				
Conditions affecting germination		1	■				
Excess of salts	- salinity	2	■				
	- sodicity	2	■				
Soil toxicities (e.g. high Al sat.)		2		■			

LAND MANAGEMENT			vh / n	h / w	m / m	l / s	vl / vs
Initial land preparation		2	■				
Workability		1					
Potential for mechanization		1					
Accessibility	- existing	1					
	- potential	1					
Erosion hazard	- wind	2	■				
	- water	2	■				
Flood hazard		2	■				
Pests and diseases		2	■				

COMMENTS

Annex 3 Methods of Soil Analysis

Preparation	Each sample is air-dried, cleaned, crushed (not ground), passed through 2 mm sieve, homogenized. Moisture content is determined at 105^0 C.
pH H_2O	(1:2.5): 20 g of soil is shaken with 50 ml of deionised water for 2 hours, electrode in upper part of suspension.
pH-KCl	likewise but shaken with 1 *M* KCl.
EC	(1:2.5): Conductivity of pH-H_2O suspension.
Particle-size distribution	Soil is treated with 15% hydrogen peroxide overnight in the cold, then on waterbath at about 80°C. Then boiled on hot plate for 1 hour. Washings until dispersion. Dispersing agent is added (20 ml solution of 4% Na-hexametaphosphate and 1% soda) and suspension shaken overnight. Suspension sieved through 50 μm sieve. Sand fraction remaining on sieve dried and weighed. Clay and silt determined by pipetting from sedimentation cylinder.
Exchangeable bases and CEC	Percolation with 1*M* ammonium acetate pH7 using automatic extractor. (If EC>0.5mS pre-leaching with ethanol 80%). Cations are determined in the leachate by AAS. CEC: saturation with sodium acetate 1*M* pH7; washed with ethanol 80% and then leached with ammonium acetate 1*M* pH7. Na determined by FES.
Exchangeable acidity and Aluminium	The sample is extracted with *1 M* KCl solution and the exchange acidity (H+Al) titrated with NaOH. Al is measured by AAS.
Carbonate	Piper's procedure. Sample is treated with dilute acidand the residual acid is titrated.
Organic carbon	Walkley-Black procedure. The sample is treated with a mixture of potassium dichromate and sulphuric acid at about 125°C. The residual dichromate is titrated with ferrous sulphate. The result expressed in % carbon (because of incomplete oxidation a correction factor of 1.3 is applied).
Total nitrogen	Micro-Kjeldahl. Digested in H_2SO_4 with Se as catalyst. Then ammonia is distilled, trapped in boric acid and titrated with standard acid.
Extractable Iron, Aluminium, Manganese and Silicon	All determinations by AAS. 1 "Free" (Fe, Al, Mn): Holmgren Shaken with sodium citrate (17%) + sodium dithionite (1.7%) solution for 16 hours. 2 "Active" (Fe, Al, Si): Shaken with acid ammonium acetate 0.2 *M* pH 3 for 4 hours in the dark. 3 "Organically bound" (Fe, Al): Shaken with sodium pyrophosphate 0.1 *M* for 16 hours.
Clay mineralogy	Clay is separated as indicated for particle-size analysis. about 10-20 mg of clay is brought on porous ceramic tile by suction and analyzed using a Philips diffractometer.
Soluble salts	Measuring pH, EC, cations and anions in water extracts. 1 1:5 extract. Shaking 30 g of fine earth + 150 ml of water for 2 hours. 2 saturation extract. Adding to 200-1000 g fine earth just enough water to saturate the sample. Standing overnight. After filtration Ca, Mg, Na, K are measured by AAS. Cl with the Chlorocounter and SO_4 turbidimetrically.
Gypsum	To 10 g of fine earth 100 ml of water is added, shaken overnight and centrifuged. Precipitation by adding acetone. Precipitate redissolved in water and determination of Ca by AAS.
Elemental composition	The fine earth is dried, ignited and fused with lithium tetraborate. The formed bead is analyzed by X-ray fluorescence spectroscopy.
Moisture retention	Moisture determinations on undisturbed core samples in silt box (pF1.0;1.5;2.0) and kaolinite box (pF2.3;2.7) respectivily and on disturbed samples in high pressure pan (pF3.4;4.2). Bulk density obtained from dry weight of core sample.

Annex 4 Units, Glossary, Classes and Acronyms

UNITS

Chinese weights and measures	SI equivalent
1 mu	0.067 ha
1 jin	0.5 kg
1 jin/mu	0.133 kg ha^{-1}

Other units

$cmol_c\ kg^{-1}$	centimol charge per kilogram (formerly meq/100 g; 1 meq/100 g = 1 $cmol_c\ kg^{-1}$)
μm	micro-metre: 1/1000th of a millimetre.
mg kg^{-1}	milligram per kilogram (formerly parts per million (ppm))
mS cm^{-1}	milliSiemens per cm at 25°C (formerly mmho cm^{-1})
MJ	Megajoules (formerly kcal; 1 MJ = 4186.8 kcal)

GLOSSARY

Air capacity	Amount of pore space filled with air 2 or 3 days after soil has been wetted. It is calculated from the difference between amount of water under almost saturated conditions (pF 0.0) and moisture retained at "field capacity" (pF 2.0), and expressed as volume percentage.
Al saturation	Ratio of exchangeable aluminium to the CEC, expressed as percentage.
Available soil moisture	Amount of moisture retained between "field capacity" (pF 2.0) and "wilting point" (pF 4.2), expressed as volume percentage (also called "available water capacity"). It is indicative of the amount of moisture available for plant growth.
Base saturation	Ratio of the sum of bases to the CEC, expressed as percentage.
Bulk density	Weight of an undisturbed soil sample divided by its volume.
CEC	Cation exchange capacity, indicative of the potential nutrient retention capacity of the soil.
Clay mineralogy	Type of clay-sized (< 2μm) particles.
kaolinite	Clay mineral with a low nutrient retention capacity, common in soils from (sub)tropical regions.
smectite	Silica-rich clay mineral with a high nutrient retention capacity and the ability to absorb water, resulting in swelling of the clay particles.
illite	Potassium-rich clay mineral with a moderately high nutrient retention capacity, common in soils from temperate regions and in alluvial soils.
vermiculite	Clay mineral with a high nutrient retention capacity and strong potassium-fixation.
chlorite	Aluminium-rich clay mineral with a moderately high nutrient retention capacity, occurring in variable quantities in soils rich in aluminium.
halloysite	Clay mineral with a moderately high nutrient retention capacity, common in soils derived from volcanic ashes.
quartz	Residual silica, resistant to weathering.
feldspar	Residual primary mineral, unstable in soil environments and, if present, indicative of a slight to moderate degree of weathering.
hematite	Reddish coloured iron oxide, common in well drained soils of tropical regions.
goethite	Yellowish coloured hydrated iron oxide, common in soils of temperate regions.
gibbsite	Aluminium hydroxide, indicative of a high degree of weathering.
Consistence	Refers to the degree and kind of cohesion and adhesion of the soil material, or to the resistance to deformation or rupture.
ECEC	Effective cation exchange capacity. It is calculated by addition of the sum of bases and exchangeable acidity, and reflects the actual nutrient retention capacity of the soil.
ESP	Exchangeable sodium percentage, ratio of exchangeable sodium to the CEC, expressed as percentage.
Exchangeable acidity	Sum of exchangeable hydrogen and aluminium.
Fine earth fraction	Part of the soil material with a particle-size of 2 mm or less (nearly all analyses are carried out on this soil fraction).
Horizon	Layer of soil or soil material approximately parallel to the earth's surface.
Land characteristic	Measurable property of land (e.g. texture).
Land quality	Set of interacting land characteristics which has a distinct influence on land suitability for a specified use (e.g. erosion hazard, which is a.o. influenced by slope, rainfall intensity, soil cover, infiltration rate, soil surface characteristics, texture).
Leaching	Downward or lateral movement of soil materials in solution or suspension.
Mottle	Spot or blotch differing in colour from its surroundings, usually indicative of poor soil drainage.

Organic carbon	Content of organic carbon as determined in the laboratory (% org. C x 1.72 = % org. matter)
Parent material	The unconsolidated mineral or organic material from which the soil is presumed to have been developed by pedogenetic processes.
pF value	Measure for soil moisture tension.
SAR	Sodium adsorption ratio of the soil solution, indicative of sodication hazard.
Soil reaction (pH)	Expression of the degree of acidity or alkalinity of the soil.
Soil structure	Aggregates of primary soil particles (sand, silt, clay) called peds, described according to grade, size and type.
Sum of bases	Total of exchangeable calcium (Ca^{++}), magnesium (Mg^{++}), potassium (K^+) and sodium (Na^+).
Texture	Refers to the particle-size distribution in a soil mass. The field description gives an estimate of the textural class (e.g. sandy loam, silty clay loam, clay); the analytical data represent the percentages sand, silt and clay measured in the laboratory.
Water soluble salts	Salts more soluble in water than gypsum.

CLASSES OF SOME ANALYTICAL SOIL PROPERTIES

Organic Carbon - C (%)

< 0.3	very low
0.3 - 1.0	low
1.0 - 2.0	medium
2.0 - 5.0	high
> 5.0	very high

Acidity pH-H_2O

< 4.0	extremely acid
4.0 - 5.0	strongly acid
5.0 - 5.5	acid
5.5 - 6.0	slightly acid
6.0 - 7.5	neutral
7.5 - 8.0	slightly alkaline
8.0 - 9.0	alkaline
> 9.0	strongly alkaline

Available phosphorus (mg kg^{-1})	Olsen	Bray
low	< 5	< 15
medium	5 - 15	15 - 50
high	> 15	> 50

CEC [pH7] ($cmol_c$ kg^{-1} soil)

< 4	very low
04 - 10	low
10 - 20	medium
20 - 40	high
> 40	very high

Sum of bases ($cmol_c$ kg^{-1} soil)

< 1	very low
1 - 4	low
4 - 8	medium
08 - 16	high
> 16	very high

Base saturation - BS [CEC pH7] (%)

< 10	very low
10 - 20	low
20 - 50	medium
50 - 80	high
> 80	very high

Aluminium saturation (%)

< 5	very low
05 - 30	low
30 - 60	moderate
60 - 85	high
> 85	very high

Exchangeable sodium percentage - ESP (%)

Soil structure		*Crops*
< 5	very low	< 2
05 - 10	low	02 - 20
10 - 15	medium	20 - 40
15 - 25	high	40 - 60
> 25	very high	> 60

Bulk density (kg dm^{-3})

< 0.9	very low
0.9 - 1.1	low
1.1 - 1.5	medium
1.5 - 1.7	high
> 1.7	very high

ACRONYMS

FAO	Food and Agricultural Organization of the United Nations
ISIS	ISRIC Soil Information System
ISRIC	International Soil Reference and Information Centre
ISSAS	Institute of Soil Science - Academia Sinica
SCS	Soil Conservation Service
UNESCO	United Nations Educational, Scientific and Cultural Organization
USDA	United States Department of Agriculture

Soil Briefs of China

(ISSN: 1381-6950)

No.	Title	No. of soils*
China 1	Red reference soils of the subtropical Yunnan Province	3
China 2	Reference soil ("Latosol") of tropical southern Yunnan Province	1
China 3	Yellow/brown reference soils of subtropical Guizhou Province	3
China 4	Purple upland and lowland reference soils of subtropical Sichuan Province	2
China 5	Reference soils of the subtropical mountains of Jiangxi Province	3
China 6	Reference soils of the subtropical mountains of Guangdong Province	3
China 7	Reference soils of tropical China (Hainan Island)	4
China 8	Reference soils of the Red Basins of Jiangxi Province	5
China 9	Reference soil of Chaoyang County, typical of the formerly wooded hilly areas in the SW of Liaoning Province	1
China 10	Reference soils of the Liaohe plain, Liaoning Province	2
China 11	Reference soil of the Changbai Mountains, Jilin Province	1
China 12	Reference soils of the Songnen plain, Heilongjiang Province	4
China 13	Reference soil of the Wudalianchi volcanic area, Heilongjiang Province	1
China 14	Reference paddy soils of the eastern alluvial lowlands of China (in prep.)	3

Country Reports

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1	Cuba	22
2	P.R. of China	51
3	Turkey	15
4	Côte d'Ivoire	7
5	Thailand	13
6	Colombia	18
7	Indonesia	48
8	Ecuador	in prep.
9	Brazil	28
10	Peru	21
11	Nicaragua	11
12	Costa Rica	12
13	Zambia	11
14	Uruguay	10

No.	Country	No. of soils*
15	Gabon	6
16	Ghana	in prep.
17	Philippines	6
18	Zimbabwe	13
19	Spain	20
20	Italy	17
21	Greece	in prep.
22	India	in prep.
23	Kenya	in prep.
24	Mali	in prep.
25	Nigeria	in prep.
26	Mozambique	in prep.
27	Botswana	in prep.

* State of reference collections as of January 1995