Agroecological comparison of „rainforestation“ farming sites on Leyte, Philippines

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Abstract

Since 1990 an innovative approach has been started in the Philippines to combine rehabilitation of degraded former rainforest areas with the necessities for subsistence income and biodiversity conservation. On more than 20 sites on the island of Leyte in the Central Visayas of the Philippine archipelago the technology of „rainforestation farming“ is continued ever since this method of using mainly indigenous trees for the reforestation of grassland areas or unproductive coconut plantations has been introduced.

Due to the rigid landscape of this island with mainly soils of volcanic or uplifted marine origin the conditions of the sites of the respective „rainforestation farms“ vary considerably. While the climatic conditions in this perhumid area of the tropics is rather uniform, the geomorphology, geology , soil conditions and nutritional input possibilities for the plants are varying on a wide scale. In addition, singularities like typhoons have a major influence on the ecosystems, both natural and anthropogenic ones.

On three sites located in different geomorphologic, geological and altitudinal places the growth behaviour of two indigenous trees (*Dracontomelon dao* and *Dipterocarpus validus*) and two exotic tropical tree species (*Pterocarpus indicus* and *Swietenia macrophylla)* were investigated. These trees are used by local farmers as part of their efforts to generate a sustainable income by using the „rainforestation“ technologies. The investigations included soil analysis, leave nutrient determination and tree growth behaviour on three different sites located at altitudes of 420 m a.s.l., 90 m a.s.l. and 52 m a.s.l. The parental material at two sites consists of basaltic/andesitic rocks while on the third site uplifted and well drained limestone forms the parental material. pH and exchangeable bases vary, so does the availability of phosphorus and potassium. The results concerning the micronutrients analysed per site and per tree revealed a very great similarity between sites and trees. The study of the vegetation structure, as expressed by the height of the tree stands of the same growth age revealed the different performance of the used reforestation trees on the various sites.

The presented data will be discussed under the aspect of optimising the efforts to rehabilitate degraded sites, re-establishment of ecological functions of erosion prone areas and generation of income for subsistence farmers on Leyte.

Keywords: Reforestation, Rainforest, Rainforestation Farming, Philippines

Introduction

Leyte island is one of the islands belonging to the Visayan group in the Philippine archipelago and covers an area of about 0.8 million ha. All the three research sites investigated and compared are located on this island. Tertiary - Quaternary volcanic activities uplifted and formed the island building the rugged central cordillera, widespread occurrence of eruptive and sedimentary rock material and uplifted coralline limestone. Due to the perhumid nature of the tropical climate with up to 2600 mm annual rainfall, no pronounced rain period and an annual average temperature of 27 ^{o}C has resulted in a geomorphologic young topography. Climatic singularities like typhoons and the El Niño Southern Oscillation phenomenon contribute to the soil formation with mainly Orthic Acrisols, Dystric Nitrosols, Glyic Cambisols, Glysols and Pellic Vertisols in the area under investigation (Barrera et al.,1954). The soil moisture regime can be classified as udic while the soil temperature regime is found to be isohyperthermic. Soils are well developed on stable old surfaces and very poor on either erosion-prone areas or in alluvial plains (Asio, 1996).

The natural vegetation cover was the Dipterocarpus-dominated tropical rainforest (Mueller-Edzard, 1996). Today’s forest records show that only about 10 % is left. The present land uses are multifold, but coconut plantations, shifting cultivation in marginal uplands and irrigated rice field cultivation are the most characteristic agricultural uses.

To find adequate technologies to combine the rehabilitation of degraded former forest areas and the generation of a sustainable income for subsistence farmers the ViSCA-GTZ Applied Tropical Ecology Project developed the so-called „Closed Canopy and High Diversity Forest Farming System“ (Rainforestation Farming). Between 1990 and 2000 the hypothesis that „ a farming system in the humid tropics is increasingly more sustainable the closer it is in its species composition to the original local rainforest“ (Milan and Margraf, 1994) was proofed to be feasible in bringing together reforestation of degraded areas, conservation and rehabilitation of biodiversity and income generation for subsistence farmers by using only indigenous natural tree species, fruit trees and other hardwood tree species for the tree - farming system called „Rainforestation Farming“ (Margarf and Milan,1996, Goeltenboth, 1999).

Material and Methods

Selected investigation sites

Visayas State College of Agriculture „ Closed Canopy“- Demonstration Farm(RF-Farm): Located on the foothills of Mt. Pangasugan between 80 - 90 m a.s.l.
The reforested area is about 4 ha wide with trees planted in 1993-1994(Fig.1).
Reforestation took place in a former *Iperata cylindrica* - invested slopy area with exposure to the South, 5-10% sloping and parental material being andesitic and basaltic rocks of Pleistocene age.

Upland Mailhi Subsistence Farmer Area: Located along the roadside at about 420 - 500 m a.s.l. with South-West exposure (Fig. 2).

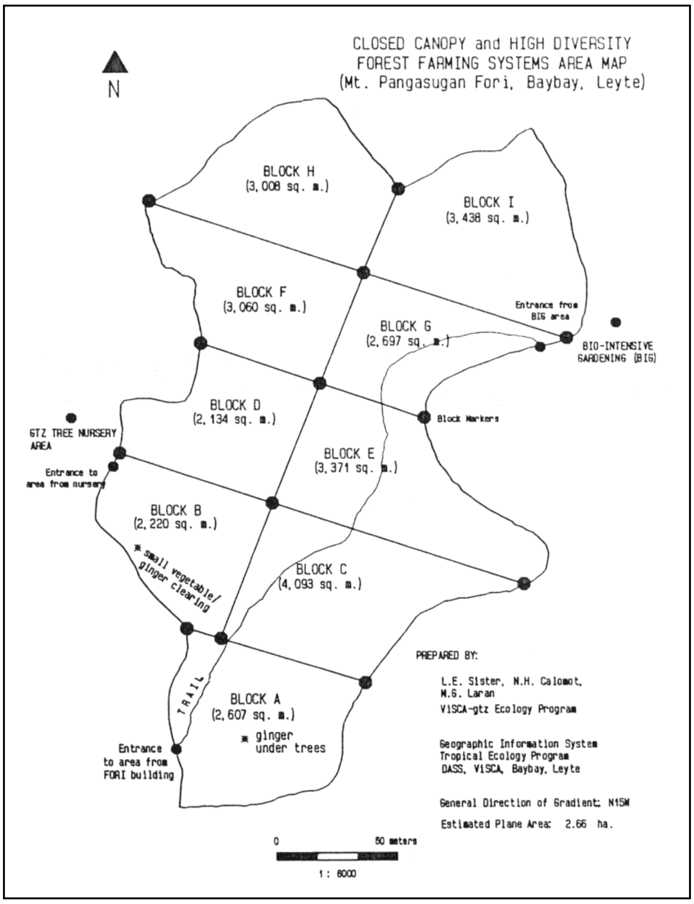

Figure 1. Area of the 4ha of Closed Canopy „Rainforestation“ Farm at ViSCA on former grassland.

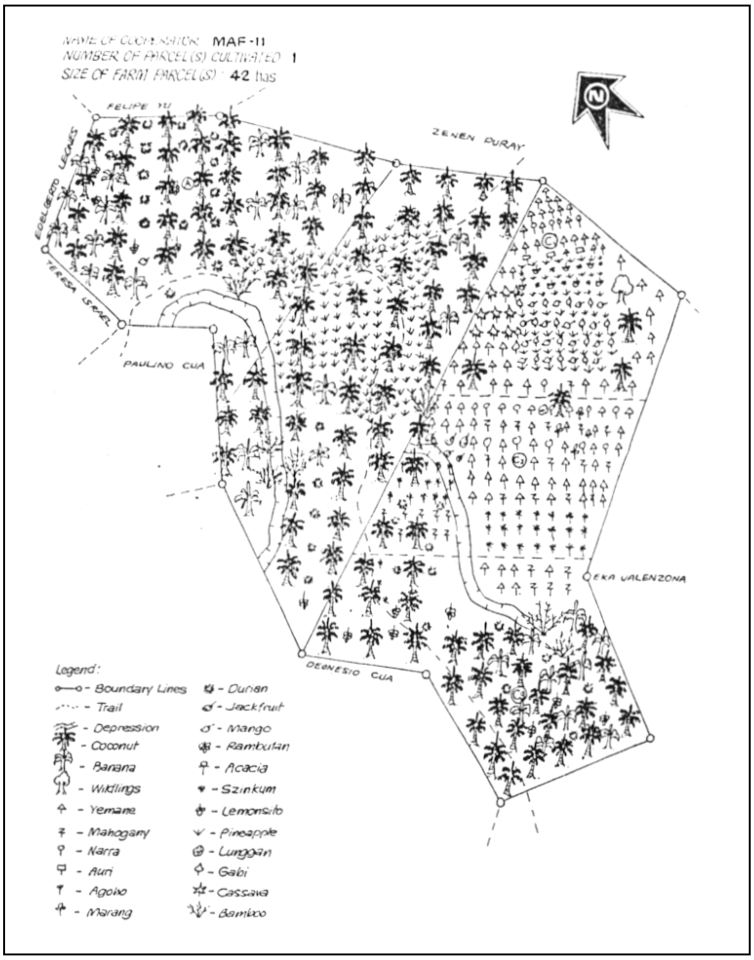

Figure 2. Area of the Mailhi Subsistence Farmer „Rainforestation „ Farm established under old coconut stands.

The sloping is 10-15% in the lower and 30-60% in the upper part of this former coconut plantation site. Severe erosion problems did occur before the tree planting , started in 1994 . The parental material is andesitic and basaltic rock covered with dystric Cambisol on this 1.63 ha wide area.

Lowland Punta Co-operative Farmer Area (Fig. 3): Located in the coastal area at about 50- 60 m a.s.l. The 3.5 ha area is exposed to South-West with 10-15% sloping. This former *Imperata cylindrica* area with some coconut trees was planted with the technology of the rainforestation farming system in 1993. The parental material is uplifted coralline limestone and the soil can be classified as calceric Phaeozem.

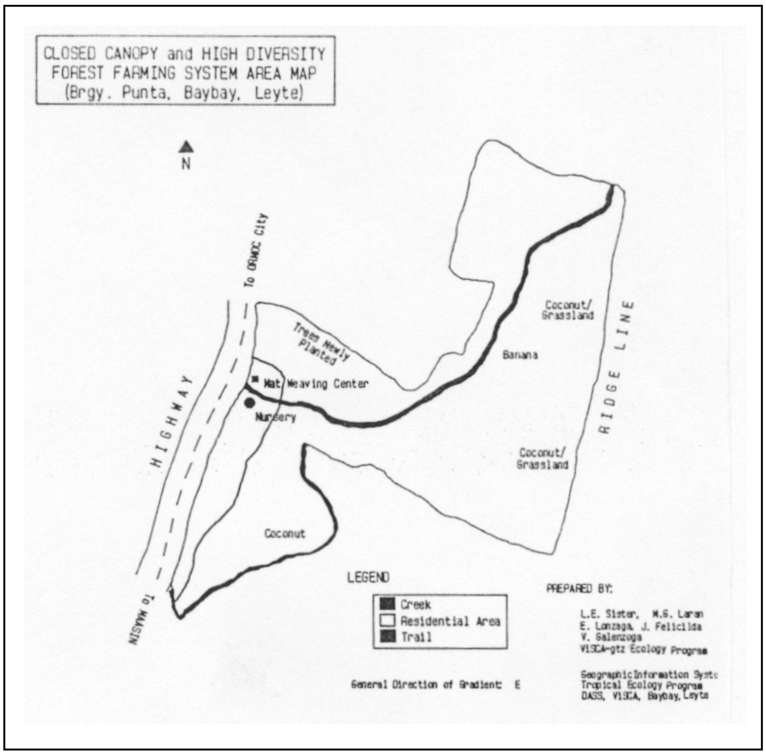

Figure 3. Location of the „ Rainforestation“ farming area in the coastal lowlands near Punta under an old stand of coconuts and on grassland.

Selected tree species

Dracontomelon dao ,Family: Anacardiaceae. Local name: Dao

Widely distributed throughout the South and South East Asia including the Philippines. Low altitude tree on well to poorly drained soils, demanding high rainfall and half shade locations. Good furniture timber (Schulte, 2000)

Dipterocarpus validus, Family: Dipterocarpaceae. Local name: Apitong
Widely distributed throughout South East Asia. Rainforest tree on low altitudes. Sun and shade tolerant with no specific soil preferences. Mainly used for heavy construction purposes (Schulte, 2000) .

Pterocarpus indicus, Family: Leguminosae. Local name: Narra
Widely distributed in South and South East Asia and declared National Tree in the Philippines. In seasonal and evergreen forest. Used in many anthropogenic surroundings and habitats as decorative element. Nitrogen-fixing, sun- and half -shade tolerating tree. Timber is used for heavy constructions and interior finish (Schulte, 2000) .

Swietenia macrophylla, Family: Meliaceae. Local name: Mahagony
Originating from South America it has been planted all over the Philippines particularly along road sides. Sun demanding tree with timber used for veneers (Payer, 1998).

Vegetation description

The planting scheme was recorded along a 100 m long and 16 m wide transect line recording all trees with their height.

Tree data acquisition

Height, stem diameter at breast height (dbh), vitality, insect infections, light conditions and microhabitat were recorded.

Leaf sampling and chemical analysis

Leaf samples were taken from middle branches and oven dried at 100 ^oC. 150 mg of dried material were treated with 1 ml of conc. HNO_3 at 170 ^oC for 6 hours. The cooled , filtered and diluted solutions were analysed for their nutrient contents with the ICP-OES ISA Yvon JY 70 Plus spectrometer.

Soil sampling and analysis

From various plots (1-7 plots per investigated site according to necessities)

subdivided into four sections, five samples each were collected from 0-25 cm and 25-50 cm depth. Samples of one subplot were mixed and dried, sorted, sieved and the dry air contents measured. Stone content was estimated by weighing procedure described elsewhere. Oven dried fine soil samples were analysed for pH with 0.01 M $CaCl_2$ (Schlichting et al., 1995), available phosphorus using the Bray No.2 method (Jackson, 1958), available potassium using the flame emission spectrometer Eppendorf ELEX 6361 (Houba et al., 1989), exchangeable bases (K,Ca,Mg,Na) with the ICP-OES (Blakemore et al., 1981) exchangeable acidity and aluminium using the method described by Rowell (1997), reducible manganese treated and extracted according to the method described by Houba et al.(1989) and measured with the ICP-OES.

Results and Discussion

Soil Profiles

The comparison of the underlying soil revealed the following facts (Tab.1).

The pH in soils is influenced by the exchangeable cations which are in strongly acidic soils H- and Al-ions, in lower to alkaline soils Ca- and Mg-ions. These exchangeable ions are easy to mobilise by plants. In general the exchangeable ions Ca^{2+}, Mg^{2+}, K^+ and Na^+ were found to be higher in the A-horizon with the exception of two plots in the calceric region of Punta. Al^{3+}-ions were highest in Mailhi with a measurable increase in the second horizon. In the ViSCA-RF Farm the second horizon showed highest amounts. All the various measurements indicate that no major leaching effect do exist (Fig.4).

Table 1. Comparison of soil profiles

Location	Mailhi	RF/Farm ViSCA	Punta
Elevation (m a.s.l.)	420	90	52
Position	valley	backslope	valley
Exposition	SW	S	N
Parent material	basaltic/andesitic	basaltic	limestone
Drainage	well	well	good
Slope (%)	10-15	5-10	10-15
Classification	Dystric Cambisol	Haplic Alisol	Calceric Phaeozem
pH	4-4.3	4.8-5.5	6.6-6.8
A-horizon (cm)	0-10	0-20	0-25
B-horizon (cm)	10-60	20-100	25-50
Vegetation	Planted trees under coconuts	Planted trees	Planted trees under coconuts

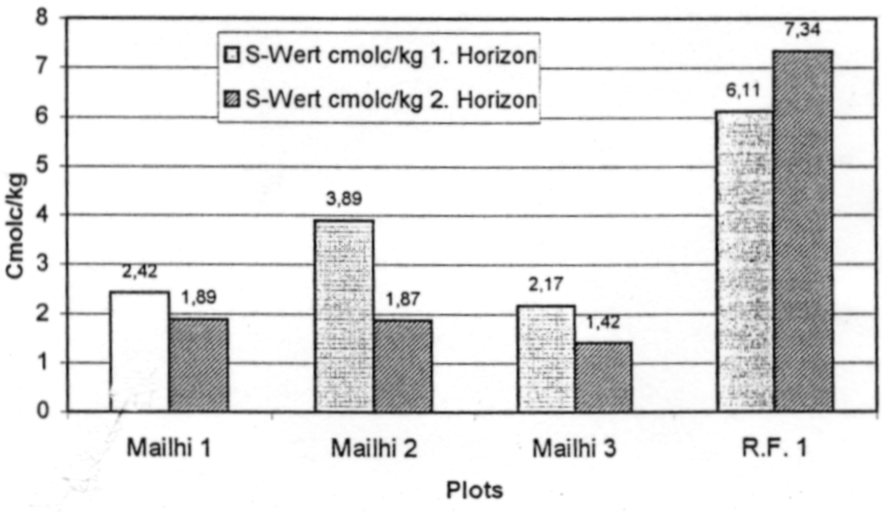

Figure 4. Comparison of the sum of exchangeable cations (S-values) for Mailhi and the ViSCA Rainforestation Farm (R.F.). Punta is not included due to the high natural Ca^{2+} contents (> 60 cmolc/kg).

For the nutrition of plants the inorganic form of phosphorus , potassium, reducible manganese, organic matter and organic carbon are important. Their availability is a limiting factor for the plant growth. The highest and lowest values found are given in Table 2.

Table 2. Comparison of availability of phosphorus, potassium, reducible manganese, organic matter and organic carbon on three sites

	Maximum	Minimum
Phosphorus (mg/kg)	Mailhi: 26	RF/Farm:1
Potassium (mg/kg)	Mailhi: 510	Punta: 130
Manganese (mg/kg)	Mailhi: 70.9	Mailhi: 206.1
Organic Matter (%)	Punta: 13.4	RF/Farm: 2.7
Organic carbon (%)	Punta: 7.7	Mailhi: 0.2
Nitrogen (%)	Punta: 0.4	RF/Farm: 0.1

In most applied analytical soil investigations the C/N ratio is the indicator of highest value for proposing the degree of humification in the soil. Narrow C/N ratios indicate rapid decomposition processes (Scheffer and Schachtschnabel, 1992).

In general, Mailhi, the RF/Farm and most of the Punta plots do show narrow
C/N ratios, but two exceptions are clearly detectable (Fig.5).

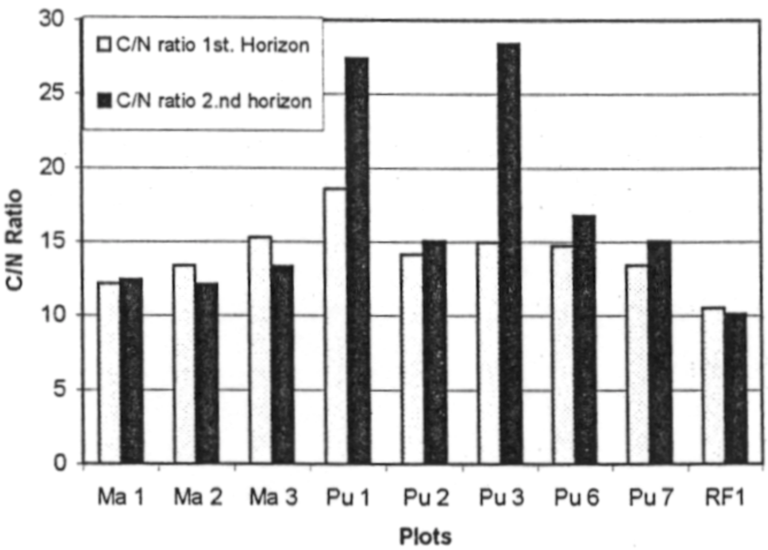

Figure 5. Comparison of C/N ratios in various plots of the three investigaton sites.
Ma Mailhi
Pu Punta
RF Rainforestation Farm ViSCA

Leaf Nutrients

Six most essential micronutrient in form of the trace elements Mo, Zn, B, Mn, Fe and Cu were extracted from fresh leaves from the investigated trees and analysed per tree (Tab.3).

Table 3. Comparison of micronutrient contents in leaves of the four investigated tree species (in mg/kg).
1 *Dracontomelan dao* 2 *Dipterocarpus validus* 3 *Swietenia macrophylla* 4 *Pterocarpus indicus*

	Mo mg/kg	*Zn mg/kg*	*B mg/kg*	*Mn mg/kg*	*Fe mg/kg*	*Cu mg/kg*
1	0.08	14.8	22.6	173.8	85.7	5.6
2	0.13	19.9	24.0	508.7	63.4	10.1
3	0.24	13.8	22.1	20.8	56.4	10.8
4	0.09	19.1	24.9	88.8	94.0	13.1

The greatest differences were found in Mn contents both between trees and sites.
Further the contents of K, Mg, P and Ca was investigated (Fig. 5) and the C/N ratio determined (Fig. 6).

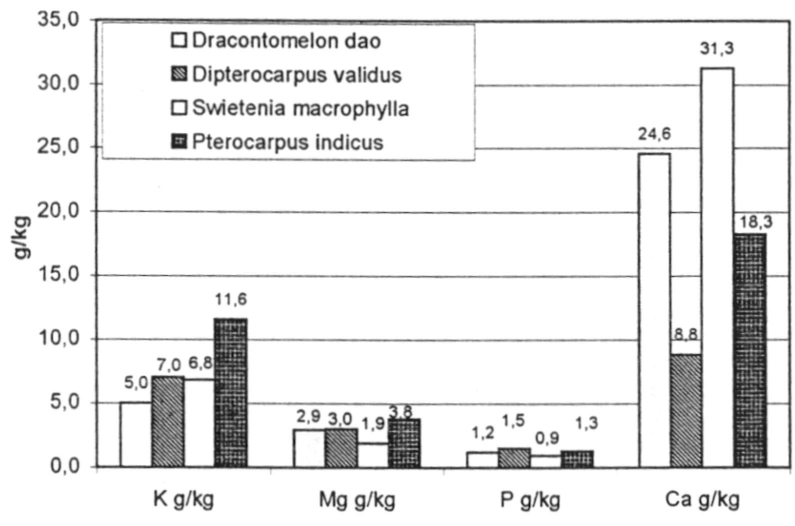

Figure 6. Comparison of K, Mg, P and Ca contents in leaves of the inve stigated tree species (in g/kg).

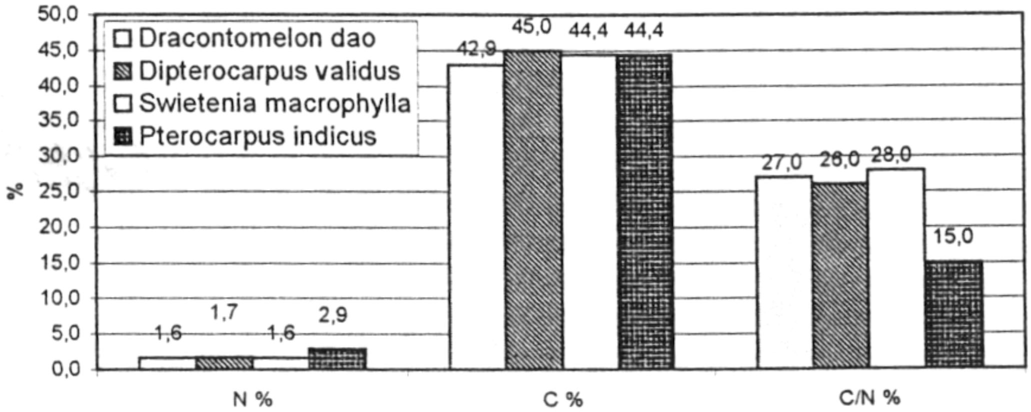

Figure 7. Comparison of the C/N ratio in the leaves of the four investigated trees and the mean values per site (in %).

No exceptional differences could be observed in the contents of micronutrients in the leaves on any of the tree species at any of the investigated sites.

Vegetation structure and Performance of planted Tree species

At the Punta site the most dominant tree species are the two exotic species *Swietenia macrophylla* and *Gmelina arborea*, planted before the beginning of the enrichment planting with indigenous tree species. Only *Pterocarpus indicus* and *Dracontomelon dao* performed relatively well at this site. *D. dao* performed best at this site in comparison with all the other sites, while *P. indicus* showed the poorest growth performance with only 0.5 cm rel. height/year. Insect infestation was in both cases medium to light and vitality
could be classified as category 2 i.e. 10-30% discoloured leaves.
At the site in Mailhi a broader variety of trees was planted under old coconut trees in a very slopy area partly prone to landslides. The landslide area was mainly planted with *Casuarina* sp. while the investigated trees (*Swietenia macrophylla, Dipterocarpus validus* , *Pterocarpus indicus* and *Dracontomelon dao*) performed different with poorest performance shown by *S. macrophylla* and *D. dao.*
Insect infestation and vitality were similar to the site at Punta for all investigated tree species.

The Rainforestation Farm at ViSCA (RF-Farm) is dominated by *Dipterocarpus validus*. The species diversity is much higher than on the other sites with about 100 different species planted in a randomised manner. Three of the investigated tree species (*S. macrophylla, D. validus, P. indicus)* performed on this site best in comparison with the other sites. However, *D. dao* showed poorest growth performance.
No striking or highly significant differences in soil composition and mineral contents of the two sites at the RF Farm at ViSCA and Mailhi could be recorded and therefore also the micronutrients in the leaves of the various trees are not very different, resulting in relatively unanimous growth performances in most species. Punta is different in both, the soil composition and therefore also the growth performance of the planted tree species. Adequate selection of indigenous tree species to receive optimal growth performance needs further investigations, but the data revealed from the RF-Farm show clearly that the nearer the planting scheme copies the natural forest setting the better is the growth performance of the majority of the investigated tree species.

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