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THESIS

PLANT DIVERSITY AND SOIL PROPERTIES IN SMALLHOLDING RUBBER-BASED AGROFORESTRY PLANTATIONS IN PHATTHALUNG AND NAKHON SI THAMMARAT PROVINCES

JAKRAPONG BUAKLA

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Jakrapong Buakla 2007: Plant Diversity and Soil Properties in Smallholding Rubber-Based Agroforestry Plantations in Phatthalung and Nakhon Si Thammarat Provinces. Master of Science (Forestry), Major Field: Silviculture, Department of Silviculture. Thesis Advisor: Associate Professor Suree Bhumibhamon, D.F. 109 pages.

The present study was conducted in Phatthalung and Nakhon Si Thammarat provinces with the objectives to assess trees and medicinal plant diversity and study the traditional uses of these plant species in the old rubber plantation. Secondly to study the difference in soil properties in the old rubber plantation and monoculture of rubber plantation. And thirdly, to study attitude of rubber smallholders toward rubber intercrop planting. Tree, medicinal plant species, and soil sample were collected from a 40x40 meter plot in each study site. The utilization of tree was investigated by interviewing farmers and parataxonomists. The attitude of rubber smallholder was done by using interview schedule.

In Phatthalung, 37 tree species including 18 species of tree, 28 species of sapling, and 7 species of seedling. Shannon-Wiener's Index of Diversity was 2.58. There were 41 species of medicinal plants with Shannon-Wiener's Index of 4.25. In Nakhon Si Thammrat, the result showed 30 tree species (19 species of tree, 16 species of sapling, and 9 species of seedling). Shannon-Wiener's Index of Diversity was 9.27. There were 49 species of medicinal plant with Shannon-Wiener's Index of 4.04.

The utilization of trees in both study sites can be presented into 2 groups; 1) production species (timber, pole, round wood, latex, fuel wood, medicinal plant, food and fodder) and 2) conservational species (soil and water conservation, shelter, shade and aesthetic).

Soil texture in the old rubber plantation and in the monoculture of rubber plantation in Phatthalung was sandy loam whereas in Nakhon Si Thammarat soil texture in the old rubber plantation was loam and clay loam. Soil in the monoculture of rubber plantation was silt loam. Bulk density of soil in the old rubber plantation of both study sites was lower than monoculture of rubber plantation whereas porosity of soil in the old rubber plantation was higher than monoculture of rubber plantation.

In term of the chemical analysis of soil including nutrients (nitrogen, phosphorus, potassium, calcium and magnesium), organic matter, CEC, and %BS in the old rubber plantation of both study sites had higher than those in monoculture of rubber plantation. In conclusion, the soil property of old rubber plantation was better than the soil of rubber monoculture as porosity caused by the accumulation of organic matter from their litter falls.

Concerning the attitude of rubber smallholders of both study sites, gender was significantly related to attitude of rubber smallholders toward rubber intercrop planting at 0.05 statistic significant level. While age, education level, secondary occupation, household income, debt, and rubber plantation area were insignificantly related to attitude of rubber smallholders toward rubber intercrop planting.

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ACKNOWLEDGMENTS

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Lastly, I thank my family for their encouragement and moral support along these years.

Jakrapong Buakla

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LIST OF ABBREVIATIONS

RRIT	=	Rubber Research Institute of Thailand
NRCT	=	The Nation Research Council of Thailand
MOAC	=	Ministry of Agriculture and Cooperative
DOA	=	Department of Agriculture
IRSG	=	International Rubber Study Group
Kc	=	Khlong Chak Series
Kkt	=	Khao Khat Series
Kh	=	Khohong Series
Nat	=	Na Thawi Series
Klt	=	Khlong Teng Series
Kkt	=	Khao Khat Series
LDD	=	Land Development Department
DBH	=	Diameter at Breast Height

PLANT DIVERSITY AND SOIL PROPERTIES IN SMALLHOLDING RUBBER-BASED AGROFORESTRY PLANTATIONS IN PHATTHALUNG AND NAKORN SI THAMMARAT PROVINCES

INTRODUCTION

Thailand has once rich in biodiversity of plants and animals. The forest divided into production and protected forests. The production forest (both terrestrial and mangrove forests) has been exploited through concession for a number of years. Additionally, over cutting and illegal cutting have been operated through out the country and this caused the over exploitation of forest resources. Factors affecting the forest resources are shifting cultivation, forest encroachment, conversion of forest area for farm practices, infrastructure development, settlement, forest fire, and natural disasters. One of the major courses affecting deforestation is the conversion of forest to cultivation of economic crops like rubber, oil palm, coffee, corn, cassava, etc. In general, the remaining forest has annual depletion rate about 300,000 - 500,000 million rai.

Rubber is an important economic crop with the total planting area of 15 million rai, a largest rubber plantation recorded of the world. In the year 2005, the country produced latex about 2.9 million ton and about 2.6 million ton of condensed latex and smoked rubber sheets were exported (RRIT, 2006). The production system of rubber is in the hand of 6 million smallholders, mostly scatterly distributed in the southern region and the eastern provinces. However, with the higher price of latex, the government has set up the policy to encourage more establishment of rubber plantation in other potential areas in the northern and the northeastern regions of Thailand. Since 2003, the target was set to be 160,000 hectare with the possible latex production of 0.5 million ton or increase was set for more latex about 10 percent (NRCT, 2004).

After the Rio Meeting, the government has emphasized more on biodiversity and sustainable development. The Ministry of Agriculture and Cooperative (MOAC)

has declared the regulation to add more biodiversity in the monoculture rubber plantation. In Thailand, agroforestry practice has been conducted in the early stage of development of rubber plantation by planting pineapple or other suitable crops between rows of rubber trees. In the later stage of plantation development, small farmer also grow *Gnetum gnemon* for young edible leave production in the older plantation. This practice would allow smallholding rubber farmers to gain more income in their old smalls rubber plantations and they can earn money even when rubber can not be tapped in the rainy day. With the MOAC regulation, about 15 percent of tree species has to be planted in the monoculture rubber plantation. Thus, there is a need of species selection of native floras to grow in the rubber plantation. In southern Thailand, list of tree species were studied in several places but these is no available data on priority species and species sites interaction in the study site in Phatthalung and Nakhon Si Thammarat provinces.

OBJECTIVES

The objectives of the present study are;

1. To study plant diversity in the old small rubber plantations in Phatthalung and Nakhon Si Thammarat
2. To study the traditional uses of native plant species in the old rubber plantation
3. To determine soil properties between the old rubber plantation and monoculture of rubber plantation
4. To study the attitude of smallholders in Phatthalung and Nakhon Si Thammarat provinces toward rubber intercrop planting
5. To apply the knowledge for practical activities in the rubber plantation

LITERATURE REVIEWS

1. Rubber Plantation

In the Family Euphorbiaceae, Para rubber tree (*Hevea brasiliensis*) is an only species planted commercially in the genus *Hevea,* which comprises 10 species. In South America, this species occurs naturally over about half the range of the genus. It mainly occupies the southern region of the Amazon, extending to the Matto Grosso and Parana areas of Brazil and into parts of Bolivia and Peru, but it is also found in the north of the Amazon to the west of Manaus as far as the extreme south of Columbia (Webster and Baulkwill, 1989).

Hevea brasiliensis was firstly introduced into Trang as an exotic species from Malaysia seed source (at present-Singapore Botanical Garden) in 1890. It was later spreaded to Chantaburi province, Eastern Thailand (Somboonsuke and Cherdchom, 2000). In addition, suitable planting area on which rubber is planted should be less than 600 m from mean sea level, less than 35 % of slope, fertile and good drainage soil (DOA, 2003). The species prefer the tropical lowland, climate with an annual rainfall higher than 2,500 mm/annual (Kermanee, 1985).

Total rubber planting area of Thailand is approximately 2.19 million hectares, which are mainly situated in the fourteen provinces in the Southern part of Thailand. This area accounts for approximately 84.17 % of total rubber holding. The balance being located in ten provinces in Eastern and Central (11.01 %), Northeastern region (4.68 %), and Northern region (0.15 %). RRIT of Thailand has separated rubber planted area into two zones i.e. traditional area (Southern and Eastern regions) and non-traditional area (Northeastern and Northern regions) (RRIT, 2004).

Growth of planted rubber tree varied with rubber clones, planting density, irrigation application, soil properties, rootstock used and tapping system (IRSG, 2005).

Difference in growth among clones relies mainly on growth during immature period (Chandrashekar *et al.*, 1998). The immaturity period of a rubber tree is about 5 to 10 years depending on the clone and the preparation of budded seedlings (IRSG, 2005).

The immature period could be reduced from 10 years to 6 years by irrigation in dry sub humid climate area (Vijayakumar *et al*., 1998), because the irrigated plants had increased growth rate in the dry season (Krishna *et al*., 1991). Thus, girth and height of rubber were higher in the irrigated tree than the rainfed tree (Devakumar *et al*., 1999). However irrigation is not a common practice in rubber due to high cost of operation. Root growth of rubber is related to competition in assimilation and to the sink strength of the difference root types, whereas root branching appeared to be promoted by leaf development (Thaler and Pages, 1996).

The stems and branches dry mass of rubber tree accounted for 80 % of total dry matter, while leaf dry mass was about 2-3 % of total dry matter (Yingjajaval and Bangjan, 2001). In addition, the vertical distribution of the shoot biomass seems to differ greatly among rubber clones (Gohet *et al*., 2001).

The yield of rubber trees at a location is dependent on genotype and on soil, atmospheric conditions and age (IRSG, 2005).

Yield change according to tree age. The maximum yield of rubber is reached around the fifth to the tenth year of tapping. *Hevea braziliensis* is productive for 20 to 40 years, where the length of productive period is largely determinated by the tapping intensity (IRSG, 2005)

Distribution of rainfall, temperature, sunshine and humidity are the major conditions contributing to yield variability in different agroclimatic zones (Rao and Vijayakumar, 1992). Rao *et al*, (1998) reported that, under humid tropical rainfed conditions, observed latex yields of rubber trees are highly variable from 19.8 to 90.5 gram per tree per tap. Seasonal variation of yield and yield component showed that

maintenance of higher soil moisture status and low vapour pressure deficit are essential to maintain optimum water relation in *Hevea* (Devakumar *et al*., 1999). Regional variations in annual rubber yields are associated with intensity and duration of moisture stress. About 40-60% of the total variation in monthly rubber production could be explained by prevailing environmental and technological factors. Rainfall exceeding 9-11 mm per rainy day is not congenial to high yield owning to difficulties in harvesting. Above 34 mm rainfall in a day may make tapping difficult (Rao *et al*., 1998).

The diurnal variations in the atmospheric vapour pressure deficit are found to be inversely related to latex yields through change in the turgor pressure in the laticifers (Paardekooper and Sookmark, 1969).

Most of the nutrient and water uptake takes place in the surface layers of the soil during the wet season and the same are absorbed from the deeper layers of the soil during dry season (Rao *et al*., 1998).

2. Colonizing Species

Variation in community assembly and abiotic conditions during succession commonly presents colonizing species with heterogeneous and often unpredictable environmental conditions. Despite the expectation that such species have characteristics adapted to colonization, environmental heterogeneity may cause optimal trait values to change between episodes or at different stages and sites of colonization (Bishop and Schemske, 1998).

Rosales *et al.* (1997) reported that basic factors directly related to colonizing ability, reproduction and recruitment include;

First factor is the natural capacity of species to colonize degraded areas. Colonizing species of degrade areas are indicators of newly created environments in degrade lands. In addition, species that tolerated stressful and highly disturbed

environments that resemble the new condition of degraded lands may also be used in restoration.

Second factor is appropriate soil treatment for ecological restoration. This implies ripping or scarification, mulch application, or draining to correct specific physical problems of the site. In addition, fertilization may be needed to solve nutrient and chemical storages. But recovering the physical and chemical properties of the soils by mean of these techniques may not be sufficient to promote a successful recruitment of native plant species in stressed natural environments.

Thirdly, the selection among native species for use in revegetation requires considerable knowledge of their patterns of reproductive biology. These species must be able to survive and reach stable populations after being planted in degraded areas.

Generally, the successful colonizing species in the degraded land as reported by Bhumibhamon (1983) show their high fitness in two ways. Firstly, the species have to adapt well under the changeable environment. Secondly, the species have to regenerate successfully under the natural condition. Moreover, species like *Imperata cylindrica* and *Leucaena leucocephala* which are the invasive species may prevent the fitness of other tree species through inhibition processes.

The successful colonizing species have to rely on species site interaction which species can adapt well under the new habitat. The excellent case study was the introduction of *Alstonia pentaphylla* from Malaysia to Sri Lanka and became the colonizing species on the hill sides (Bhumibhamon, private communication). This is also true like the case of *Leucaena leucocephala* in Thailand and elsewhere.

Lemenih *et al*. (2004) reported that forest plantation established on degraded tropical sites can serve as the nurse crops for recolonization of native woody species. Similarly, species richness, density, and growth characteristics of the colonizing woody species vary considerably between different plantation species, even among closely located stands. Some of the factors that may contributes, site factors (such as

substrate quality, altitude and radiation index), plantation age, plantation management intensity and degrees of protection from fire and other disturbances, litter mass and depth, and plantation characteristics. Hill (2001) observed that colonizing species of plant must also be able to tolerate the xeric conditions which result from sand being generally well drained with low nutrient availability.

3. Agroforestry in Thailand

The main components of agroforestry system are trees and shrubs, crops, pastures and livestocks, together with the environmental factors of climate, soils and landforms. Other components (e.g. bee, fish) occur in specialized systems.

Young (1997) classified the agroforestry system based on three levels, as follows;

At the highest level, the classification is based on the components present:

Agrosylvicultural system:	Trees with crops
Sylvopastoral system:	Trees with pastures and livestock
Trees predominant system:	Forestry with other components subordinate
Special component system:	Trees with insects or fish

The second level is based on the arrangement of component in space and time. In rotation systems, the association between trees and crops (or pastures) takes place primarily over time, although there may also be some degree of overlapping. In spatial systems, the association is a primarily zone of trees and crops growing together on the same land management unit. In spatial mixed arrangements, the trees and other component are grown as intimate mixtures, with the trees distributed over more or less the whole of the land area. In spatial zoned arrangements, the trees are either planted in some systematic arrangement, such as rows, or are grown on some element in the farm, like field boundaries or soil conservation structures.

The third and lowest level of classification is empirical, employing tree density, detailed spatial arrangement, functions and management as criteria. A criterion of open versus dense trees (crowns separated or touching) can be applied to the spatial mixed classes; thus, trees on cropland and multistrara systems are respectively open and dense variants of the spatial mixed arrangement.

Rubber tree has been generally planted as intensive monocrop cultivation and this has been reported to be uneconomical to smallholdings particularly those area with less than 2 hectare. In order to increase productivity some farmers cultivate short term crops such as vegetables, maize, pineapple, groundnut and banana between rubber tree rows. However, although the return is good, such agroforestry practices will last only for 2.5 to 3 years. Once the rubber tree canopy closed such planting is no more economical.

Agroforestry researchers are also paying increasingly attention to the role of smallholder cultivation (sometimes called 'jungle rubber agroforestry') as an alternative to certain types of unsustainable food crop-based shifting cultivation systems. Jungle rubber agroforestry is widely practiced in Indonesia (Sumatra and Kalimantan) and Southern Thailand; similar approaches are being introduced in Vietnam and are being considered in Myanmar.

In Thailand, the government's efforts to improve the livelihood of rubber farmers and mitigate environmental impacts. The Rubber Intercropping Research Project was set up by the Rubber Replanting Fund. Under this project, replanting loans are granted even when intercropping is practiced. Intercrops include longgong (*Aglaia dookoo*), mangosteen (*Garcinia mangostana*), tiem (*Azadirachta excelsa*), stink bean (*Parkia speciosa*), bamboo, jampada (*Artocarpus integer*), durian (*Durio zibethinus*), riang (*Parkia timoriana*) and *Gnetum gnemon* var. *gnemon*. So far, the lessons learnt from diversifying rubber tree-based agroforestry systems can be concluded that agroforestry techniques are more labors intensive and therefore will face difficulties in family-run plantations (IRSG, 2005).

4. Effect of Colonizing Species on Soil Property

Soil physical alteration can occur depending on the type of management even through the period of intercropping may be short-term (Krishnapillay *et al*., 2003). Watson *et al*., (1964) observed the beneficial effect of creeping legumes on growth of rubber. Apart from its higher nutrient returns, a leguminous cover has also been shown to improve physical properties compare with the effect of other plants. Su and Zhao (2003) found that shrub establishment and development improved soil water holding capacity, enhanced organic carbon and total nitrogen accumulation, and decreased pH and bulk density. Keersmaeker (2003) found that, in afforestation area, the soil moisture, carbon, total nitrogen and phosphorus content of the soil, were correlated with forest age.

Vegetation influences soil pH because it produces organic matter and caused leaching. The addition of decomposable organic matter to a soil results in the formation of organic acids. These acids add to the cation-exchange capacity, but the present base saturation and pH are lower. Bases released from the organic matter and from accelerated weathering of the soil minerals may or may not be enough to prevent the soil from becoming acid (Thompson and Troeh, 1973).

The presence of ion exchangeable in the soil is of great importance both in pedegenesis and in the soil-plant nutritional relationship. Most metallic elements which are taken up by growing plants are absorbed as action but the exist in three forms in the soil: (1) sparingly soluble components of mineral or organic material; (2) absorbed onto the cation exchange complex and (3) in small quantities in soil solution. Under high rainfall condition, which maintain a steady supply of nutrients to the plant cover without becoming rapidly depleted of nutrients by the reaching process. The plant also act as bio-circlers in this relationship, the root systems extracting nutrients from deeper horizons and thence returning to the soil surface in litter. As decomposition proceeded the liberated cation return the exchange complex of the surface layer (Etherington, 1975).

Research on the ecological impact of rubber plantations on soils degraded by shifting cultivation in Northeast India has demonstrated an improvement of soil properties after the establishment of *Hevea*. Rubber plantations adopting proper agroforestry management practices (including terracing; silt pitting and bunding; and the growth of leguminous cover plants between the rows to assist with nitrogen fixation) were found to help in the enrichment of organic matter, which consequently improved soil physical properties, such as bulk density, soil porosity, moisture retention and infiltration. An increase in organic matter was also observed. (FAO, 2000). Similarly, a review of Malaysian research argued that all the agroforestry cropping systems rubber plantations approximate closest to the rainforest system, in terms of canopy, leaf litter and in nutrient cycling (IRSG, 2005). Fertilizer inputs are considered very low and soil surrounding rubber trees appears to be enriched by abundant leaf falls.

5. Attitude of Smallholding Farmers

Attitude is the mental and neural state of readiness organized through experience, exerting a directive or dynamic influence upon the individual response to all object and situation with which it is related (Maneekul, 1998).

The understanding of attitudes is one of the central concern in social life and is vital for bringing desired change in the behavior. Social actions of people are directed by their attitudes. By knowing the attitudes, it may be possible to do something about the prediction and control of their behavior, which may be ultimately useful for the more successful implementation (Rishi, 2006).

5.1 Concept of media

Media are windows that enable us to see beyond our immediate surrounding, interpreters that help people make sense of experience, platforms or carriers that convey information, interactive communication that includes audience

feedback, signposts that provide us with instructions and directions, filter that screen out parts of experience and focuses on other, mirrors the truth.

There is no precise or agree definition of what to include or exclude as the main focus of media studies, but is generally accepted that the fallowing comprise the core areas: television, radio, cinema, newspaper, magazine, advertising and popular music. They all share ability to large publish audiences via the increasingly advanced technologies of print, video, sound, etc. Panichpan (2005) grouped mass media into two broad categories with certain attributes in common but with unlike physical characteristics, as follows:

Print: newspapers, magazines, and books, their words make images in the mind as well as convey information.

Electronic and Film: radio, recordings, television, still and motion pictures, and video. These media produce their messages through visual and audio impact on the senses, sometimes with great emotional flow.

Primarily, newspaper, magazines, brochures and direct mail dominate on the travel industry. The outdoor posters also include transit poster, taxi sign, bench sign and other variation. With poster you can location selectivity, large size, repetitive, impact, decent color, and all things considered a reasonable price.

Mass media are a pervasive part of our lives. Just how pervasive might become clear if we need to realize that different media have different primary uses. Not everything that happens in the world on any given day can be included in the newspaper, magazines, radio, television, etc. Mass media was used to disseminate to encourage public support for development programs and generally to inform and persuade people to adopt modern technologies. Each of the experiences put people in contact with medium or channel of communication radio, records and types, newspaper, magazines, billboard, book, movies, television, advertising-all of these are mass media because they reach people in one time. Mass media has enormous

impact. They have become so important, in fact, that they are often called simply “the media”.

The mass media are more than just a mean of communication. They also contribute to our economy, influence social conventions and shape our political debates. The media serve as important source of information of a wide range of topics, especially politics and public affairs. The mass media also plays an important role in transmission of attitudes, perceptions and beliefs.

In case of rubber plantation owner, information and practices on rubber management system have been intensively guided through mass media.

5.2 Related researches

Herath and Takeya (2003) found that the variables related to farmers’ awareness and attitudes towards intercropping of immature rubber (*Hevea brasiliensis*) stand, extension contacts, education level, and experience with farming other crops are positively associated with the probability of adoption. Higher levels of off-farm income are associated with reduced intercropping in immature rubber stand. Farmers who are sole owners of the land and engaged in full or part-time rubber farming showed lower adoption rates than other land ownership groups.

Rishi (2006) studied on joint forest management in India: an attitudinal analysis of stakeholders. The results indicated that both forest officers and rural communities were in the process of developing positive attitudes toward each other and a significant improvement in the interrelationship between the two was found. Rural communities were unable to express clear attitude towards functioning of forest committee and role of women. However, they had a clear positive attitude towards forest protection and management. Forest officers were also not clearly positive in their attitude towards forest institutions in terms of freedom working and participatory approach as they wanted more freedom in their work environment with limited external pressure.

Chaisalee (2002) studied on attitudinal of villagers on Khaoson Community Forest, Tambol Khaokrapuk, Amphoe Tayang, Changwat Petchaburi. Results showed that, attitude of villager on Khaoson Community Forest significantly related with 7 factors (education level, length of settle, household member, ownership area, household income, village club member and participations in community forest development) but the gender, age, secondary occupation and meeting with the officer are non significant.

METERIALS AND METHODS

1. Study Areas

The present study was conducted at two sites, in Phatthalung and in Nakhon Si Thammarat provinces.

The study site in Phatthalung province is located at 68 meter above mean sea level in the Sub Watershed Area of Songkhla Lake, next the Kao Hua Chang Community Forest. The site locates on the other side of the mountain ridge which comprises of old rubber plantation, monoculture of new rubber plantation, secondary forest, homegarden, and paddy field with the total area of 37 rai (Figure 1). The study site is owned by Mr. Witoon Noosen, a citizen of Moo 9 village, Tamot Subdistrict, Tamot District, Phatthalung Province.

The old rubber plantation was about 40 years old and the total area was 4.2 rai. This plantation was found to have succession by native species during the last 12 years. The 16 years old rubber plantation about 14 rai was used to study soil properties. In this plantation rubber tree was grown as monoculture and weeding was done several times a year.

The climatic condition in Phatthalung is controlled by two monsoons (Southwest and Northeast Monsoons) and thus gives more rain than in the other parts of the country. Dry season is more pronounced, occurring during February to July. Mean annual rainfall is 2,140 mm (Figure 2). The temperature is ranged between 26-29 ˚C (Figure 3). The relative humidity is 76.82 % (Figure 4).

The study site in Nakhon Si Thammarat province is located at Na Moh Boon Village, about 97 m above mean sea level in the Sub Area of Pak Panang Watershed. The study area is relatively flat land in adjacent to the foothill which comprise old rubber plantation and monoculture of rubber plantation (Figure 1). The hill is almost covered with various aged rubber plantations. In the present study, the old rubber

plantation and monoculture of rubber plantation unit are owned by Mr. Aadoon Anurak, the citizen of Moo 6 village, Na Moh Boon Subdistrict, Chulabhorn District, Nakorn Si Thammarat Province.

The old rubber plantation was 25 years old with the total area of 4.3 rai. The native species distributed into the old rubber plantation during the last 6 years. The monoculture rubber plantation was conducted to study soil properties. The planation age was 25 years old and covering the area of 4 rai.

The climatic condition in Nakhon Si Thammarat is controlled by two monsoons (Southwest and Northeast Monsoons) and thus gives more rain than in the other parts of the country. Dry season is more pronounced occurring during February to July with mean annual rainfall of 2,532 mm (Figure 2). The temperature is ranged between 25-28 ˚C (Figure 3) and the relative humidity is 81.58 % (Figure 4).

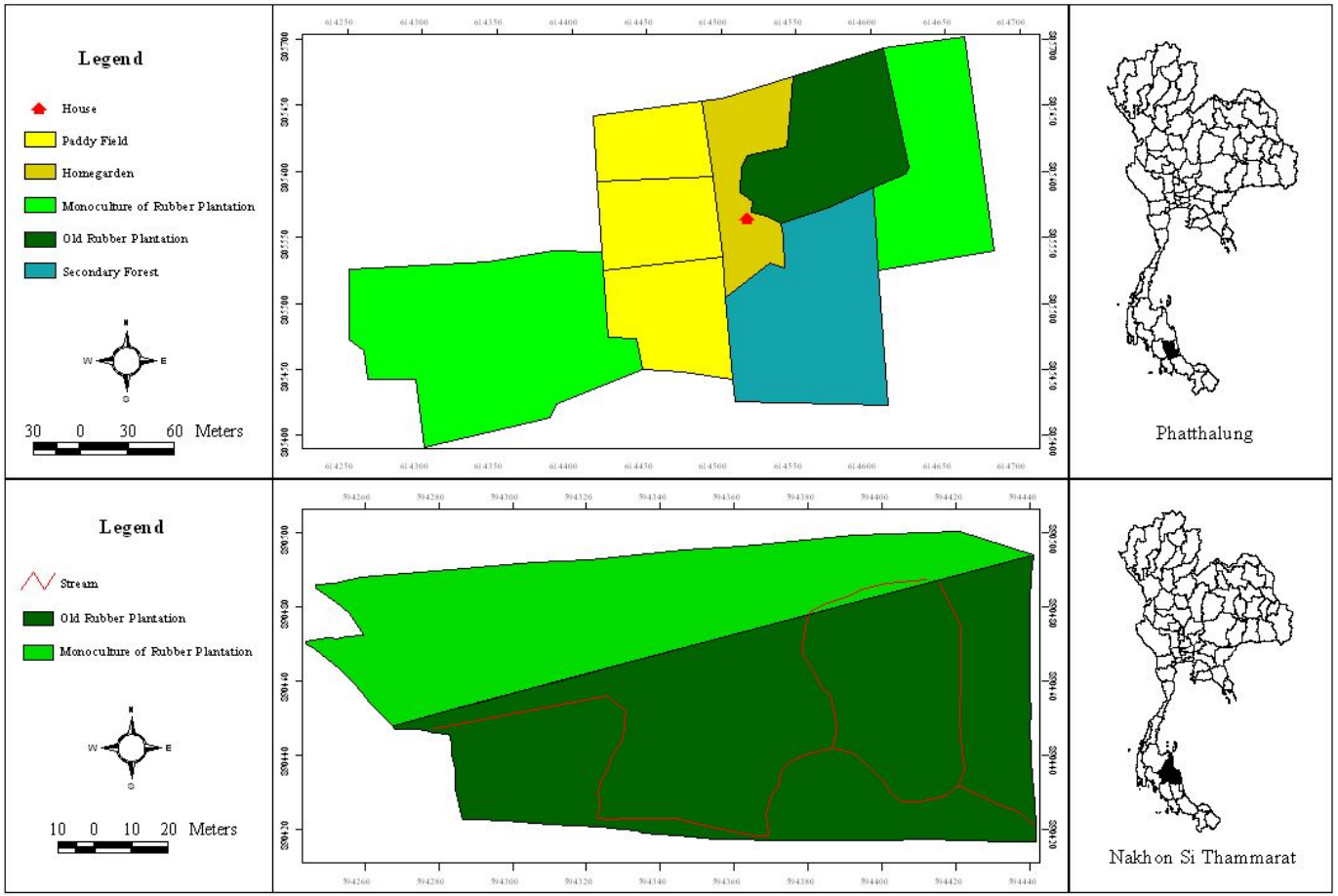

Figure 1 Study sites at Tamot Sub District, Tamot District, Phatthalung Province and at Na Mor Boon Sub District, Chulabhon District, Nakhon Si Thammarat Province.

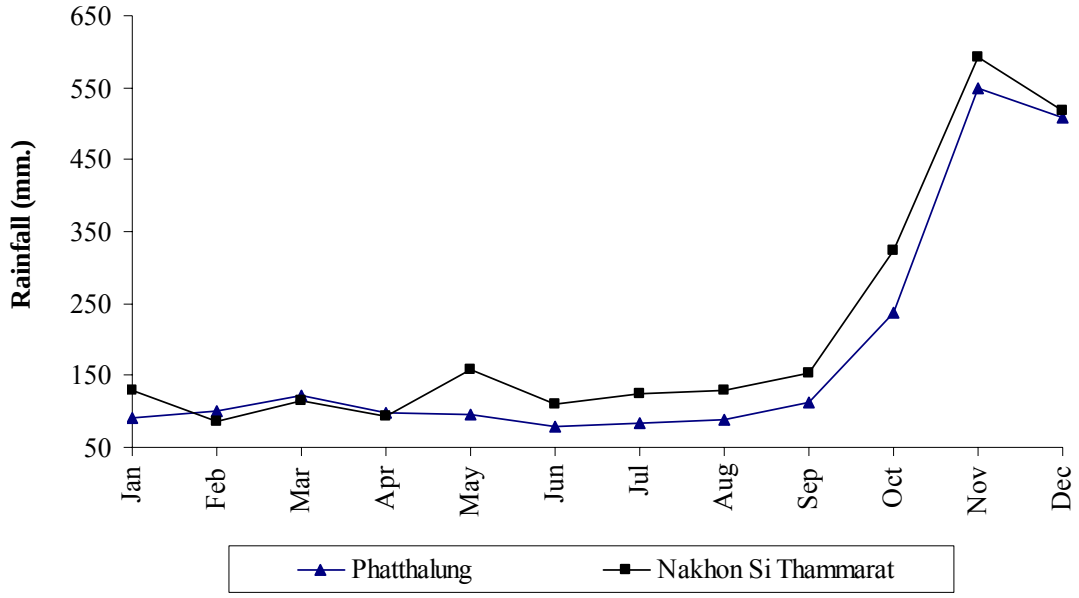

Figure 2 Average Rainfall at Phatthalung Agromet and Nakhon Si Thammarat Stations (1990-2005).

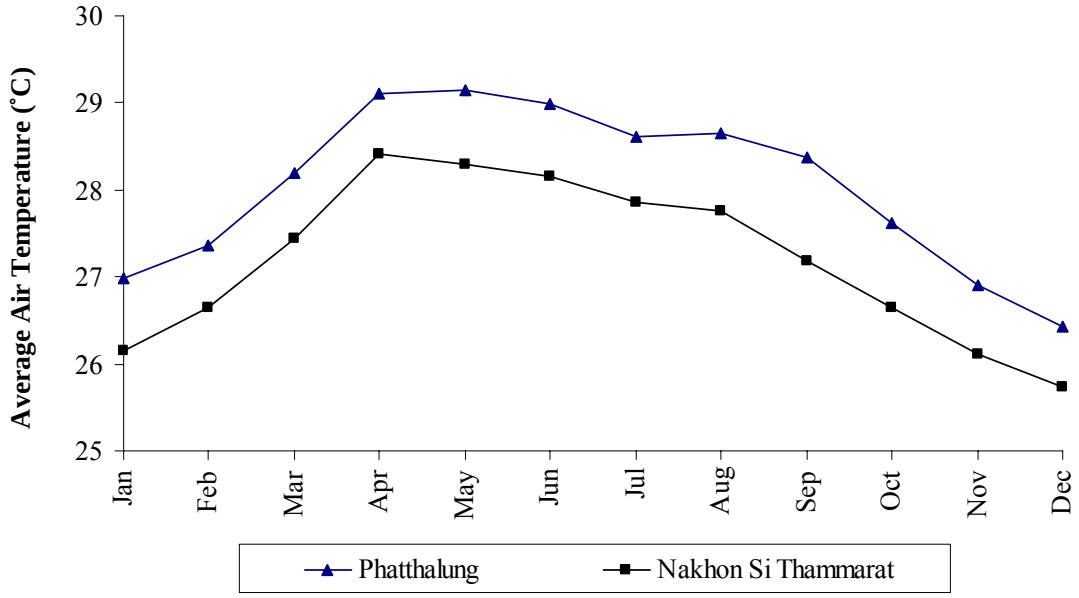

Figure 3 Average Air Temperature at Phatthalung Agromet and Nakhon Si Thammarat Stations (1990-2005).

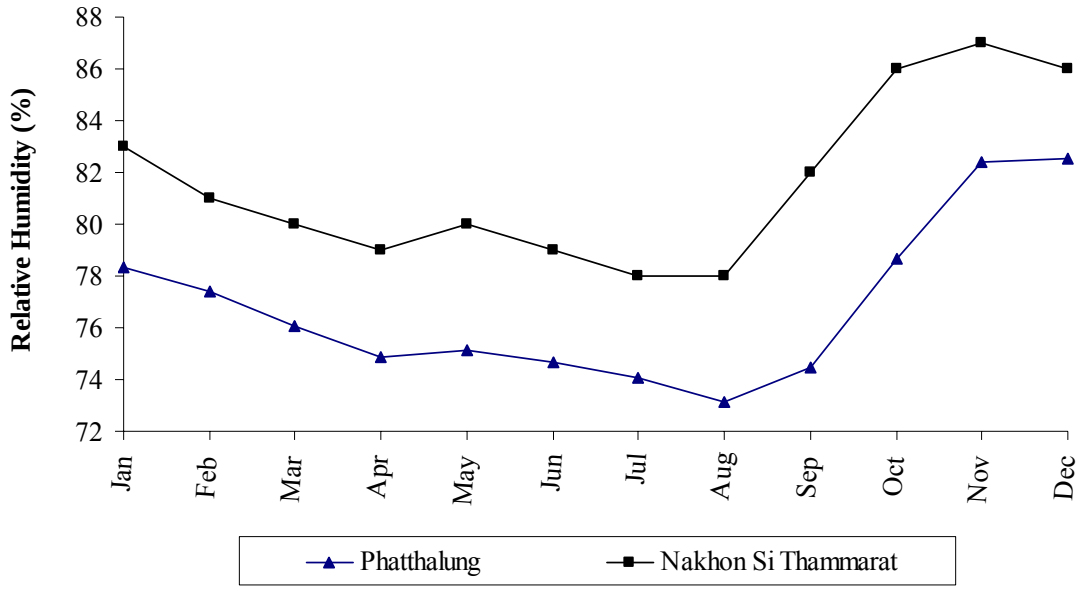

Figure 4 Average Relative Humidity at Phatthalung Agromet and Nakhon Si Thammarat Stations (1990-2005).

2. Plant Diversity

2.1 Field data collection

The sample plot of 40 x 40 m^2 was established in the old small rubber plantation in both study sites (Figure 5). The study was done by using Relevé Method (Mueller-Dombois and Ellenburg, 1974).

The area was divided into 16 quadrats (10 x 10 m^2) for tree studies. In each quadrat, every trees having DBH over 4.5 cm. and higher than 1.30 m was identified and measured. Height of trees was measured by using Haga Altimeter while DBH was measured with the diameter tape. In this study, the analysis of Important Value Index exclude rubber tree because the rubber tree was planted before and rich in number.

Plot of 10 x 40 m^2 was established in plot 40 x 40 m^2 for vertical stratification study.

Plots of 10 x 10 m^2 were established in each corner for medicinal plant study. Name of medicinal plants and the number of medicinal plants were recorded.

Plot of 4 x 4 m^2 were established in each corners for sapling study of plants higher than 1.3 m. and 4.5 cm. DBH of these trees were identified and recorded the total height.

Plot of 1 x 1 m^2 were also established in each corner for seedling study. Name of seedling and the number of seedlings were recorded.

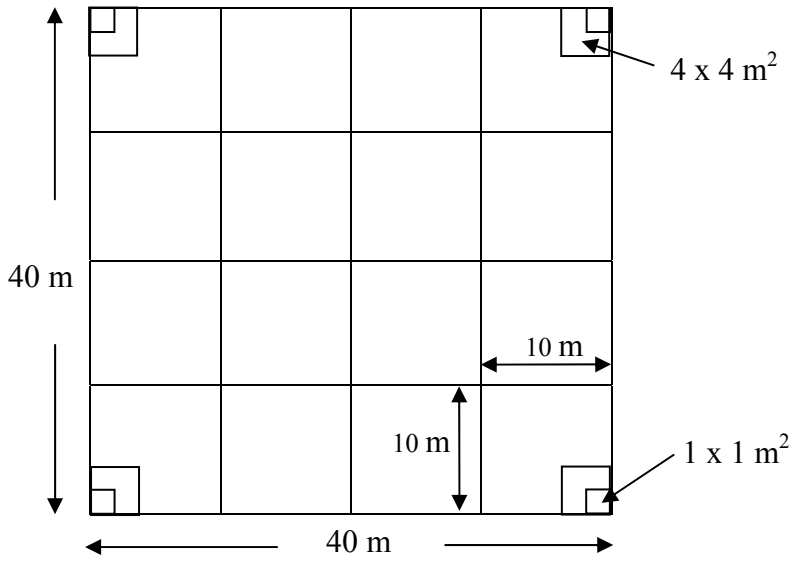

Figure 5 Layout of sample plot in the study site of old rubber plantation.

2.2 Species identify

The species were identified in the field while unknown samples in each sample plots were identified with specimens at Princess Sirindhorn Plant Herbarium Building (Bangkok Herbarium).

2.3 Data analysis

2.3.1 Important Value Index (IVI)

The Importance Value Index (IVI) of a plot was determined as:

IVI = Relative Density + Relative Frequency + Relative Dominance

Where,

$$\text{Relative Density} = \frac{\text{Density of species I}}{\text{Total density of all species}} \times 100$$

$$\text{Relative Frequency} = \frac{\text{Frequency of species I}}{\text{Total frequency of all species}} \times 100$$

$$\text{Relative Dominance} = \frac{\text{Total basal area of species I}}{\text{Total basal area of all species}} \times 100$$

2.3.2 Diversity Index

Richness Index (R_1) was calculated by based on Margalef (1958)'s formula.

$$R1 = \frac{S - 1}{\ln(n)}$$

Where, S = The total number of species in a community

n = Total number of individuals observed

Shannon-Wiener's Index (H′) was calculated by based on Shannon-Wiener function (Shannon and Weaver, 1949) in log2 formula.

$$H' = -\sum_{i=1}^{S} (p_i \log_2 p_i)$$

Where, H' = Shannon-Wiener's Index

S = The number of species

p_i = Proportion of number of individuals of species I to the total number of individuals of all species

Similarity Index assess by Sorensen function (Kutintara, 2541).

$$Isj = \frac{2W}{(A+B)} \times 100$$

Where, W = Number of species present in community A and B

A = Number of species present in community A

B = Number of species present in community B

Evenness Index (E_1) was calculated by based on Hill's Diversity Number E_1 (Hill, 1973).

$$E_1 = \frac{H'}{\ln(S)} = \frac{\ln(N_1)}{\ln(N_0)}$$

Where, H' = Shannon-Wiener's Index

N_1 = The number of abundant species in the sample

N_0 = The number of all species

3. Interviewing the Traditional Uses of Tree Species

The traditional uses of tree species in a plot were surveyed by interviewing the parataxonomists and farmers. The report was present in descriptive form.

4. Soil Properties

4.1 Data collection

Soil samples of the old rubber plantation and monoculture of rubber plantation were collected in August 2005. Both locations, a composite soil sample from two soil depths (0-15 and 15-30 cm.) were collected from four sampling plots by undisturbed and disturbed methods for the analysis of physical and chemical soil properties.

4.2 Data analysis

Physical and chemical properties of soil samples were analyzed at the Forest Soil Laboratory of Department of Silviculture, Kasetsart University, as follows;

4.2.1 Physical properties

Soil texture was analyzed by using Hydrometer Method.

Analysis of Bulk Density, Particle Density and Porosity were implemented by Three Phase Meter, using the formula, as shown below;

$$\text{Bulk Density} = W_{ods} / V_t$$

Where, W_{ods} = Weight of oven dry soil

V_t = Volume of solid dry soil

$$\text{Particle Density} = W_{ods} / V_s$$

Where, V_s = Volume of solid particle

$$\text{Porosity (\%)} = (1 - D_b / D_p) \times 100$$

Where, D_b = The bulk density of the soils

D_p = The average particle density

4.2.2 Chemical properties

Soil pH was determined by 1:1 soil water suspension with pH meter

Soil organic matter was analyzed by using Walkley and Black Method.

Cation Exchange Capacity (CEC) was analyzed by leaching cation with 1N NH_4OAc at pH 7.0 and replace ammonium ion with sodium chloride solution (10%) in acid condition. Then extracted solution is used for analyzing ammonium ion and calculated CEC of soil.

The Total Nitrogen was determined using C/N Analyzer.

Available Phosphorus was extracted using Bray No 2 procedure, analyzed by Spectrophotometer and calculated from the formula below

$$\%\ P = \frac{\text{ppm P from standard x } 8 \text{ x } 10^{-4}}{\text{Weight of sample (g) x ml of aliquot (3 ml)}} \text{ x } 100$$

Exchangeable Cation of Potassium (K), calcium (Ca) and magnesium (Mg) were analyzed by using Atomic Absorption Spectrophotometer and calculated from the formula below

$$\%K = \frac{\text{mg } KL^{-1} \text{ from standard x } 10^{-4}}{\text{Weight of sample (g) x } 0.039} \text{ x } 100$$

$$\%Ca = \frac{\text{mg } CaL^{-1} \text{ from standard x } 10^{-4}}{\text{Weight of sample (g) x } 0.02} \text{ x } 100$$

$$\%Mg = \frac{\text{mg } MgL^{-1} \text{ from standard x } 10^{-4}}{\text{Weight of sample (g) x } 0.012} \text{ x } 100$$

Base Saturation Percentage (%BS) was calculated from the sum of Exchangeable Cation of potassium (K), calcium (Ca), magnesium (Mg) and sodium (Na).

5. Study on the Attitude of Rubber Smallholder toward Rubber Intercrop Planting

5.1 Conceptual framework

The conceptual framework of this study is relied on attitude of rubber smallholder and is the key to success of implementation rubber intercrop planting program. In this study, it is hypothesized that rubber smallholder attitude toward rubber intercrop planting (Dependent variable, Y) is dependent with 7 independent variable (X) and that independent variable is related to gender, age, education level, secondary occupation, annual year income, debt, and rubber plantation area. The conceptual framework chart is shown below:

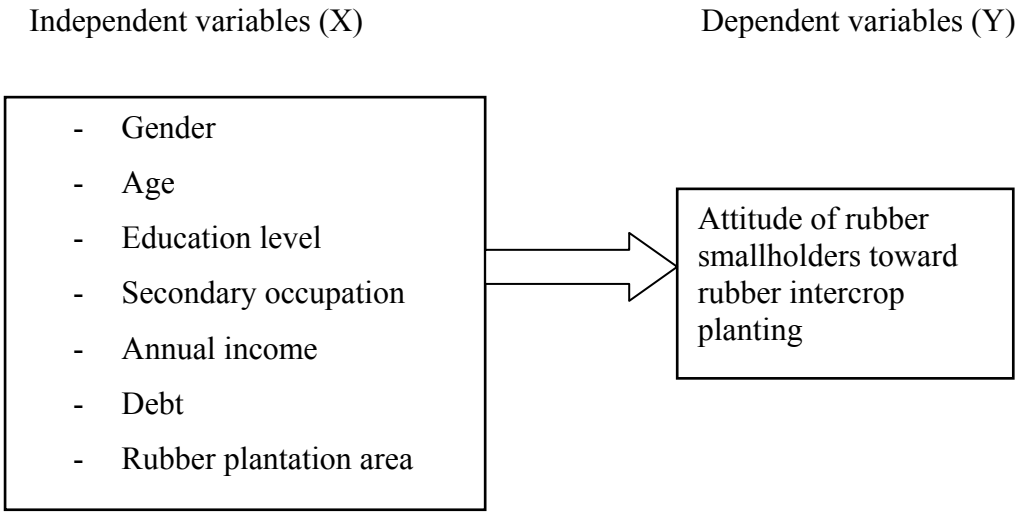

Figure 6 The conceptual framework of study on attitude of rubber smallholder toward rubber intercrop planting.

5.2 Research hypothesis

Based on the conceptual framework, the hypotheses are developed as follows:

1. Gender is relating to attitude of rubber smallholders toward rubber intercrop planting.

2. Age is relating to attitude of rubber smallholders toward rubber intercrop planting.

3. Education level is relating to attitude of rubber smallholders toward rubber intercrop planting.

4. Secondary occupation is relating to attitude of rubber smallholders toward rubber intercrop planting.

5. Household income is relating to attitude of rubber smallholders toward rubber intercrop planting.

6. Debt is relating to attitude of rubber smallholders toward rubber intercrop planting.

7. Rubber plantation area is relating to attitude of rubber smallholders toward rubber intercrop planting.

5.3 Preliminary survey

During the preliminary survey, visit to the village was done to get idea about the general picture of the village in terms of culture and daily living activities as well as present rubber plantation. The researcher discussed with the village head, former village head, member of village committee and parataxonomist. The details from the discussion were used in improving the questionnaire for final data collection.

5.4 Population and samples

The entire population of rubber smallholding in the study was 301 and 1118 families in Tamot and Na Mor Boon villages. Based on these data, 174 and 303 samples were selected for data collection. The random of sample size estimation was done by using Yamane Random Sampling Method (Yamane, 1973) and used Subongkoch's Law (Chameekorn, 1983) for random sample in each village (Moo). The compute of law was shown below;

$$n = N / (1 + Ne^2)$$

Where; e = Error of confident interval (0.05)
n = Number of sample size
N = Number of population

$$n_i = n (Ni / N)$$

Where; n_i = Sample size in group i
n = Sample size
Ni = Total population in group i
N = Total population

5.5 Data collection of interview schedule

Study on the attitude of villager toward rubber intercrop planting was carried out by using the Interviewing Method with smallholding farmers in Phatthalung (nearby Kao Hua Chang Community Forest) and Nakhon Si Thammarat (Na Mor Boon village).

5.6 Data analysis

Quantitative data was analyzed by statistical program. Descriptive statistics included frequency, percent, and Chi-square Test was employed to determine the relationship between factors and attitude of rubber smallholder toward rubber intercrop planting.

RESULTS AND DISSCUSSION

1. Plant Diversity

Concerning the study on Plants diversity in old rubber plantation of smallholder in Phatthalung and Nakhon Si Thammarat, IVI, tree and medicinal plant diversity, vertical stratification, and the traditional uses of tree species are presented below;

1.1 Important Value Index (IVI)

1.1.1 Old rubber plantation in Phatthalung

18 tree species in this small plantation were found, as present in Table 1. Plant with highest density and dominance was Nuan (*Garcinia eugeniaefolia*). The highest frequencies of tree were Nuan and Thung Fa (*Alstonia macrophylla*). The first six species on IVI were Nuan, Thung Fa, Khi Tai (*Syzygium zeylanicum*), Mahad (*Artocarpus lakoocha*), Thang (*Litsea grandis*) and Mao (*Eugenia grandis*) with the IVI values of 142.07, 55.33, 24.55, 14.49, 13.40, and 12.5, respectively.

28 sapling species were recorded (Table 2). Nuan had the highest density and dominance in the sapling stage. Plant with highest frequencies were detected in Nuan, Kra Duk Kai (*Prismatomeris tetrandra*) and Taew (*Cratoxylum maingayi*). The first six main species on IVI were Nuan, Kra Duk Kai, Thung Fa, Taew, Mahad and Mao with the IVI values of 142.92, 21.19, 15.98, 14.34, 7.93, and 7.40, respectively.

Result showed 7 seedling species (Table 3) in old rubber plantation at Phatthalung site. The highest density and frequency is Khem Pa (*Ixora javanica*). The first three species on IVI were Khem Pa, Mui (*Micromelum minutum*) and Yangpara (*Hevea brasiliensis*) with the IVI values of 78.57, 31.79, and 24.29, respectively.

Trees, saplings, and seedlings in old rubber plantation in Phatthalung can be presented in three groups, as shown in Figure 7.

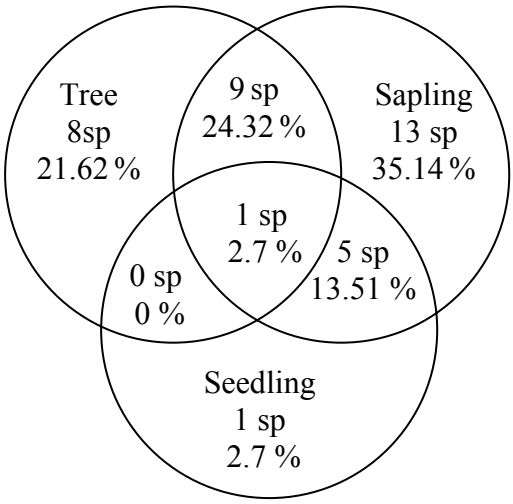

Figure 7 Tree diversity separated by size in old rubber plantation in Phatthalung.

1.1.2 Old rubber plantation in Nakhon Si Thammarat

19 tree species were found (Table 4) in Nakhon Si Thammarat site. The highest density and frequency of Sae (*Millettia atropurpurea*) was detected. The highest dominance tree species was Taew (*Cratoxylum maingayi*). The first five common species based on IVI were Sae, Taew, Thang (*Litsea grandis*), San (*Dillenia obovata*), and Maduea (*Ficus spp.*) with the IVI values of 48.57, 39.57, 32.61, 26.06, and 19.68, respectively.

There were 16 sapling species recorded (Table 5) in Nakhon Si Thammarat site. Species with highest density were Moa (*Eugenia grandis*) and Ching (*Ficus fistulosa*). The first four species on IVI values were Sae, Mao, Noknon and Ching with the IVI values of 63.80, 53.62, 30.67, and 23.55, respectively.

There were only 9 seedling species recorded (Table 6) in Nakhon Si Thammarat site. The highest density and frequency was detected in Yai chung lan

(*Phyllanthus oxyphyllus*). The first four species with high IVI values were Yai chung lan, Yangpara (*Hevea brasiliensis*), Moa and, Mui with the IVI of 70.38, 32.88, 22.88, and 22.88, respectively.

The study of trees, saplings, and seedlings in the old rubber plantation in Nakhon Si Thammarat was shown in Figure 8.

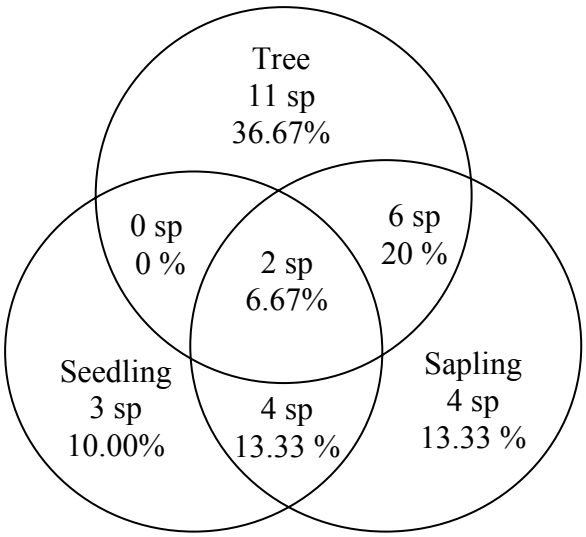

Figure 8 Tree diversity separated by DBH size in the old rubber plantation in Nakhon Si Thammarat

IVI is a representation of each tree in the side of relationship with other species (Kutintara, 1998). It defined as the sum of relative dominance, relative density and relative frequency (Curtis and McIntosh, 1951) which was shown density, frequency, and growth in basal area of the species in plant community. In Phatthalung, Nuan was a highest representative species (IVI) in tree and sapling groups, while in the group of seedling, Khem Pa was a highest representative species. So the representative tree in the next generation of old rubber plantation will be Nuan because the highest representative sapling was Nuan. Khem Pa is possible to be highest representative seedling because its habit is shrubby plants, and can regenerate by rhizome. Moreover it is growing well under the shade of trees. The other species seedling stage can grow up as tree depended on the growth factor. The representative

tree and sapling in the old rubber plantation in Nakhon Si Thammarat, the tree with highest IVI in the future should be Sae because it showed highest IVI in the group of sapling. The IVI of sapling in the future is possible to be Yangpara.

Because of, IVI shown density, frequency, and growth in basal area of the species in plant community. For future, silvicultural practice by thinning and enrichment planting should be used for management in the old rubber plantation. The production species such as Nuan which highest IVI should be thinned so as to reduce the density. The edible plant such as Phak Miang, Yo Ban, fruit tree (Mangosteen, Longkong) should be planted for consumption in household.

Table 1 Relative Density (RD), Relative Frequency (RF), Relative Dominance (RDo) and Important Value Index (IVI) of trees in an old rubber plantation in Phatthalung

Local names	**Scientific names**	**RD (%)**	**RF (%)**	**RDo (%)**	**IVI**
Nuan	*Garcinia eugeniaefolia*	61.93	22.86	51.20	135.99
Thungfa	*Alstonia macrophylla*	15.60	22.86	17.35	55.80
Khi tai	*Syzygium zeylanicum*	5.50	12.86	6.65	25.01
Mahat	*Artocarpus lakcucha*	3.21	8.57	2.10	13.88
Thang	*Litsea grandis*	3.67	5.71	4.28	13.66
Mao	*Eugenia grandis*	2.75	7.14	2.28	12.17
Taew	*Cratoxylum maingayi*	1.38	4.29	0.77	6.43
Kho haeng	*Rinorea lanceolata*	0.92	1.43	1.87	4.22
Han	*Knema laurina*	0.46	1.43	4.99	6.88
Sae	*Millettia atropurpurea*	0.92	1.43	1.14	3.49
Kam pla chon	*Emilia sonchifolia*	0.46	1.43	1.80	3.69
Yo	*Morinda citrifolia*	0.46	1.43	1.37	3.26
Phantan	*Schima wallichii*	0.46	1.43	1.26	3.15
Sathon rok	*Elaeocarpus robustus*	0.46	1.43	1.19	3.07
Dang khao	*Chaetocarpus castanocarpus*	0.46	1.43	0.60	2.49
Khoi	*Streblus asper*	0.46	1.43	0.56	2.45
Fat	*Eugenia longiflora*	0.46	1.43	0.32	2.20
Phlapphla	*Microcos tomentosa*	0.46	1.43	0.28	2.17
Total		**100.00**	**100.00**	**100.00**	**300.00**

Table 2 Relative Density (RD), Relative Frequency (RF), Relative Dominance (RDo) and Important Value Index (IVI) of saplings in an old rubber plantation in Phatthalung

Local names	Scientific names	RD (%)	RF (%)	RDo (%)	IVI
Nuan	*Garcinia eugeniaefolia*	67.11	8.16	73.30	148.57
Kraduk kai	*Prismatomeris tetrandra*	8.88	8.16	1.82	18.87
Thungfa	*Alstonia macrophylla*	4.61	6.12	5.80	16.52
Taew	*Cratoxylum maingayi*	2.96	2.04	4.02	9.02
Mahat	*Artocarpus lakoocha*	0.99	6.12	1.13	8.24
Mao	*Eugenia grandis*	1.64	4.08	1.68	7.40
Nam Khi raet	*Streblus ilicifolius*	1.64	4.08	0.59	6.31
Tang hon	*Calophyllum curtissii*	0.99	4.08	1.05	6.11
Khi tai	*Syzygium zeylanicum*	0.99	4.08	1.23	6.30
Mui	*Micromelum minutum*	1.32	4.08	0.30	5.70
Yangpara	*Hevea brasiliensis*	1.32	4.08	0.20	5.60
Tin ped	*Alstonia scholaris*	0.66	4.08	1.43	6.17
Phlapphla	*Microcos tomentosa*	0.66	4.08	1.33	6.07
Mi ra	*Symplocos cochinchinensis*	0.99	4.08	0.33	5.40
Yo	*Morinda citrifolia*	0.66	4.08	1.16	5.89
Khem pa	*Pavetta wallichiana*	0.66	4.08	0.14	4.88
San	*Dillenia obovata*	0.33	2.04	1.09	3.46
Thang	*Litsea grandis*	0.33	2.04	0.73	3.10
Mai	*Diospyros tahanensis*	0.33	2.04	0.51	2.88
Phantan (Mangtan)	*Schima wallichii*	0.33	2.04	0.72	3.09
Ian	*Litsea sp.*	0.33	2.04	0.28	2.65
Khat khao	*Oxyceros horridus*	0.33	2.04	0.28	2.65
Sok	*Saraca pierreana*	0.33	2.04	0.24	2.61
Khanun	*Artocarpus heterophyllus*	0.33	2.04	0.20	2.57
Phawa	*Garcinia speciosa*	0.33	2.04	0.20	2.57
Ma huat	*Lepisanthes rubiginosa*	0.33	2.04	0.16	2.53
Ta pet ta kai	*Ardisia crenata*	0.33	2.04	0.07	2.44
Mueai	*Cryptolepid buchanani*	0.33	2.04	0.02	2.39
	Total	**100.00**	**100.00**	**100.00**	**300.00**

Table 3 Relative Density (RD), Relative Frequency (RF) and Important Value Index (IVI) of seedlings in an old rubber plantation in Phatthalung

Local names	**Scientific names**	**RD (%)**	**RF (%)**	**IVI**
Khem pa	*Ixora javanica*	50.00	28.57	78.57
Kraduk kai	*Prismatomeris tetrandra*	7.50	14.29	21.79
Thang	*Litsea grandis*	2.50	7.14	9.64
Yangpara	*Hevea brasiliensis*	10.00	14.29	24.29
Sa lao	*Goniothalamus undulatus*	5.00	7.14	12.14
Nam khi raet	*Streblus ilicifolius*	7.50	14.29	21.79
Mui	*Micromelum minutum*	17.50	14.29	31.79
	Total	**100.00**	**100.00**	**200.00**

Table 4 Relative Density (RD), Relative Frequency (RF), Relative Dominance (RDo) and Important Value Index (IVI) of trees in an old rubber plantation in Nakhon Si Thammarat

Local names	**Scientific names**	**RD (%)**	**RF (%)**	**RDo (%)**	**IVI**
Sae	*Millettia atropurpurea*	17.86	17.07	13.64	48.57
Taew	*Cratoxylum maingayi*	14.29	4.88	20.81	39.97
Thang	*Litsea grandis*	12.50	9.76	10.36	32.61
San	*Dillenia obovata*	8.93	9.76	7.38	26.06
Ma duea	*Ficus spp.*	7.14	7.32	5.22	19.68
Mangtan	*Schima wallichii*	5.36	7.32	4.83	17.51
Sadaochang	*Azadirachta excelsa*	5.36	7.32	4.52	17.19
Sato	*Parkia speciosa*	1.79	2.44	9.57	13.80
Yo pa	*Morinda coreia*	3.57	4.88	4.62	13.07
Kho haeng	*Rinorea lanceolata*	3.57	4.88	4.13	12.58
Non	*Vitex pinnata*	3.57	4.88	2.32	10.77
Ching	*Ficus fistulosa*	3.57	2.44	2.00	8.01
Khan laen	*Canthium glabrum*	1.79	2.44	2.11	6.34
Somset	*Glochidion rubrum*	1.79	2.44	1.78	6.00
Sathon rok	*Elaeocarpus robustus*	1.79	2.44	1.71	5.93
Khoi	*Streblus asper*	1.79	2.44	1.33	5.56
Chiang phra nang ae	*Carallia brachiata*	1.79	2.44	1.27	5.49
Mamao	*Antidesma ghaesembilla*	1.79	2.44	1.21	5.44
Chick nom	*Barringtonia macrostachya*	1.79	2.44	1.20	5.42
	Total	**100.00**	**100.00**	**100.00**	**300.00**

Table 5 Relative Density (RD), Relative Frequency (RF), Relative Dominance (RDo) and Important Value Index (IVI) of saplings in an old rubber plantation in Nakhon Si Thammarat

Local names	**Scientific names**	**RD (%)**	**RF (%)**	**RDo (%)**	**IVI**
Sae	*Millettia atropurpurea*	28.36	9.09	26.35	63.80
Mao	*Eugenia grandis*	20.90	13.64	19.09	53.62
Nok non	*Cleistanthus sp.*	13.43	4.55	12.70	30.67
Ching	*Ficus fistulosa*	4.48	13.64	5.43	23.55
Uk2	Unidentified	7.46	4.55	5.12	17.13
San	*Dillenia obovata*	2.99	4.55	8.34	15.87
Phlapphla	*Microcos tomentosa*	2.99	9.09	2.33	14.41
Mamao	*Antidesma ghaesembilla*	2.99	4.55	4.45	11.98
Taeo	*Cratoxylum maingayi*	2.99	4.55	3.52	11.05
Mui	*Micromelum minutum*	2.99	4.55	3.39	10.93
Non	*Vitex pinnata*	2.99	4.55	2.18	9.71
Somset	*Glochidion rubrum*	1.49	4.55	2.21	8.25
Wa hin	*Syzygium pyrifolium*	1.49	4.55	1.83	7.86
Krai	*Xylopia malayana*	1.49	4.55	1.40	7.44
Thang	*Litsea grandis*	1.49	4.55	0.89	6.93
Yo thuean	*Morinda elliptica*	1.49	4.55	0.77	6.81
	Total	**100.00**	**100.00**	**100.00**	**300.00**

Table 6 Relative Density (RD), Relative Frequency (RF) and Important Value Index (IVI) of seedlings in an old rubber plantation in Nakhon Si Thammarat

Local names	**Scientific names**	**RD (%)**	**RF (%)**	**IVI**
Yai chung lan	*Phyllanthus oxyphyllus*	55.00	15.38	70.38
Yangpara	*Hevea brasiliensis*	17.50	15.38	32.88
Mao	*Eugenia grandis*	7.50	15.38	22.88
Mui	*Micromelum minutum*	7.50	15.38	22.88
Khem pa	*Ixora javanica*	2.50	7.69	10.19
Ching	*Ficus fistulosa*	2.50	7.69	10.19
Nok non	*Cleistanthus sp.*	2.50	7.69	10.19
Non	*Vitex pinnata*	2.50	7.69	10.19
Phlapphla	*Microcos tomentosa*	2.50	7.69	10.19
Total		**100.00**	**100.00**	**200.00**

1.2 Tree diversity

Diversity of tree in the sample plot of the old rubber plantation in Phatthalung and Nakhon Si Thammarat were calculated the Evenness Index, Richness Index, and Shannon-Wiener Index (Table 7). The result found that tree community of an old rubber plantation in Nakhon Si Thammarat had higher Evenness Index and Shannon-Wiener Index than an old rubber plantation in Phatthalung, while Richness Index was similarly. Otherwise, on the similarity of Sorensen to evaluate similarity of tree community between the old rubber plantation in Phatthalung and Nakhon Si Thammarat was 30.64 %.

Table 7 Evenness Index, Richness Index, Shannon-Wiener's Index and Similarity of Sorensen

Diversity Index	Old rubber plantation in Phatthalung	Old rubber plantation in Nakhon Si Thammarat
Richness Index	5.69	5.69
Evenness Index	0.49	1.89
Shannon Wiener's Index	2.58	9.27
Similarity of Sorensen (%)	30.64	

Evenness index of old rubber plantation in Nakhon Si Thammarat had higher value than old rubber plantation in Phatthalung because the species abundances in old rubber plantation in Nakhon Si Thammarat was equally abundance than Phatthalung. Ludwig and Reynolds (1988) observed, Evenness Index refers to how the species abundances are distributed among the species. Thus, evenness is maximum when all species in a sample are equally abundant and decrease toward to zero as the relative abundances of the species diverge away from evenness.

The Shannon-Wiener Index (H') has two properties that have made it a popular measure of species diversity: (1) $H' = 0$ if and only if there is one species in the sample, and (2) H' is maximum only when all S species are represented by the same number of individuals, that is, a perfectly even distribution of abundances (Ludwig and Reynolds, 1988). Thus the H' of trees of Nakhon Si Thammarat had higher than Phatthalung, because the total species of trees in old rubber plantation at Nakhon Si Thammarat has the same number of individual while the total species and number of individual of trees in old rubber plantation at Phatthalung was difference.

Neeranathpibul (2002) studied on plant species diversity in different Teak plot ages of Maehad plantation, Prae province found that plant species diversity (including tree, sapling, and undergrowth species) decrease with increasing ages of teak plots. The 13, 18, 23, and 43 years old plot had 77, 72, 72, and 69 species respectively. The Shannon-Wiener Index of 13 years old of teak plantation was 2.12. When

comparison with the 12 years old of old rubber plantation in Phatthalung and 6 years old of old rubber plantation in Nakhon Si Thammarat found that tree diversity (including tree, sapling, and seedling) was not decrease with increasing ages of colonization and old rubber plantation of both sites had higher Shannon-Wiener Index than 13 years old of teak plantation.

1.3 Medicinal plant diversity

Medicinal plant was surveyed in 10x10 m^2 in the old rubber plantation in Phatthalung and Nakhon Si Thammarat. At Phatthalung site, medicinal plant was comprised of 41 species (Table 8). The top five species based on IVI values were Mui (*Micromelum minutum*), Pod (*Stephania japonica*), Kra Duk Kai (*Justicia gendarussa*), Nam Khi Rat (*Streblus ilicifolius*) and Supparod Pa (*Ananas comosus*). The relative density and number of medicinal plants were 16.78, 12.59, 11.89, 9.79, and 6.99%, and 288, 216, 204, 168, and 120 trees per hectare. The value of Shannon-Weiner Index was 4.25.

In Nakhon Si Thammarat, medicinal plant was found to comprise of 49 species (Table 9). The top five species based on IVI values were Do mai ru lom (*Elephantopus scaber*), Yai klang (*Jastica sp.*), Noknon (*Cleistanthus sp.*), Mui (*Micromelium minutum*), and Yanpod (*Tetracera loureiri*), The value of Shannon-Weiner Index was 4.04.

Table 8 Relative Density (RD), Relative Frequency (RF) and Important Value Index (IVI) of medicinal plants in an old rubber plantation in Phatthalung

Local names	Scientific names	RD (%)	RF (%)	IVI
Mui	*Micromelum minutum*	16.78	4.40	21.18
Pod	*Stephania japonica*	12.59	4.40	16.98
Kraduk kai	*Justicia gendarussa*	11.89	4.40	16.28
Nam khi raet	*Streblus ilicifolius*	9.79	4.40	14.19
Sabparod pa	*Ananas comosus*	6.99	1.10	8.09
Tin tuk kae	*Tridax procumbens*	4.66	3.30	7.96
Thungfa	*Alstonia macrophylla*	3.03	4.40	7.43
Kra por	*Licala spinosa*	3.50	3.30	6.79
Phlapphla	*Microcos paniculata*	2.10	4.40	6.49
Yo pa	*Morinda coreia*	1.40	4.40	5.79
Kluay moo sang	*Uvaria leptopoda*	2.10	3.30	5.39
Mak mok	*Lepionurus sylvestris*	2.10	3.30	5.39
Toei noo	*Pandanus humilis*	1.63	3.30	4.93
Kamlang hanuman	*Dracaena conferta*	3.73	1.10	4.83
Kon ti ma	*Ancistrocladus tectorius*	1.40	3.30	4.70
Taeo	*Cratoxylum maingayi*	0.93	3.30	4.23
Ta pet ta kai	*Ardisia crenata*	0.70	3.30	4.00
Yan pla mee	Unidentified	0.70	3.30	4.00
Mang re	*Melastoma villosum*	1.40	2.20	3.60
Yanlipao	*Lygodium flexuosum*	1.40	2.20	3.60
Kha pa	*Catimbium malaccense*	1.17	2.20	3.36
Phai sam kong	Unidentified	0.93	2.20	3.13
Khem pa	*Pavetta wallichiana*	0.70	2.20	2.90
Chiad	*Cinnamomum iners*	0.70	2.20	2.90
Chamao	*Eugenia blate*	0.70	2.20	2.90
Thang	*Litsea grandis*	0.70	2.20	2.90
Mahat	*Artocarpus lakoocha*	0.70	2.20	2.90
Wai Khring	*Calamus palustis*	0.70	2.20	2.90
San	*Dillenia sp*	0.47	2.20	2.66
Mak prao nok kum	*Molineria latifolia*	0.93	1.10	2.03
Yai Krang	Unidentified	0.70	1.10	1.80
Tin ped	*Alstonia scholaris*	0.47	1.10	1.57
Pud	*Achasma megalocheilos*	0.47	1.10	1.57
Mahuat	*Lepisanthes rubiginosa*	0.23	1.10	1.33

Table 8 (Continued)

Local names	Scientific names	RD (%)	RF (%)	IVI
Kha min khao	*Globba schomburgkii*	0.23	1.10	1.33
Oi chang	*Albizia myriophylla*	0.23	1.10	1.33
Krang	Unidentified	0.23	1.10	1.33
Tanbid	*Schizaea digitata*	0.23	1.10	1.33
Non	*Vitex pinnata*	0.23	1.10	1.33
Pla lai phueak	*Eurycoma longifolia*	0.23	1.10	1.33
Yannod	Unidentified	0.23	1.10	1.33
	Total	**100.00**	**100.00**	**200.00**

Table 9 Relative density (RD), relative frequency (RF) and Important Value Index (IVI) of medicinal plants in an old rubber plantation in Nakhon Si Thammarat

Local names	**Scientific names**	**RD (%)**	**RF (%)**	**IVI**
Do mai ru lom	*Elephantopus scaber*	21.60	1.16	22.76
Yai klang	*Justicia sp.*	13.61	4.65	18.26
Mui	*Micromelum minutum*	9.50	4.65	14.15
Noknon	*Cleistanthus sp.*	12.53	1.16	13.69
Yanpod	*Tetracera loureiri*	8.86	4.65	13.51
Mang re	*Melastoma malaBahtricum*	3.67	4.65	8.32
Khem dok kao	*Ixora javanica*	2.38	4.65	7.03
Kamlang khwai thuek	*Smilax perfoliata*	3.02	3.49	6.51
Thong pling	*Vanilla aphylla*	3.02	3.49	6.51
Makrudpee	Unidentified	2.16	2.33	4.49
Kra duk kai	*Prismatomeris tetrandra*	0.86	3.49	4.35
Tang dok	*Mussaenda sp*	0.65	3.49	4.14
Tiem	*Azadirachda excelsa*	0.65	3.49	4.14
Kombang	*Scleria sp*	1.08	2.33	3.41
Deua bid	*Anganosma marginata*	1.08	2.33	3.41
Sap seua	*Chromolaena odoratum*	2.16	1.16	3.32
Ching dok diew	*Polyalthia bullata*	0.86	2.33	3.19
Yo pa	*Morinda coreia*	0.86	2.33	3.19
Lipao	*Lygodium sp*	0.65	2.33	2.97
Mak mok	*Lepionurus sylvestris*	0.65	2.33	2.97
Ueang pa	*Costus speciosus*	0.65	2.33	2.97
Khem dok dang	*Ixora javanica*	0.43	2.33	2.76
Ta ped ta kai	*Ardisia crenata*	0.43	2.33	2.76
Som set	*Glochidion rubrum*	0.43	2.33	2.76
Ai	*Briddelia tomentosa*	0.43	2.33	2.76
Toei nu	*Pandanus sp.*	0.86	1.16	2.03
Som wai	*Schizaea digitata*	0.86	1.16	2.03
Phak kood	*Diplazium esculentum*	0.65	1.16	1.81
San	*Dillenia obovata*	0.65	1.16	1.81
Koi	*Streblus asper*	0.43	1.16	1.59
Phak wan nok	*Sauropus sp.*	0.43	1.16	1.59
Ka-uam	*Arconychia pedunculata*	0.22	1.16	1.38
Kluai mu sang	*Uvaria leptopoda*	0.22	1.16	1.38

Table 9 (Continued)

Local names	Scientific names	RD (%)	RF (%)	IVI
Kloom	*Donax grandis*	0.22	1.16	1.38
Kun tee din	Unidentified	0.22	1.16	1.38
Chik nom	*Barringtonia macrostachya*	0.22	1.16	1.38
Chiang phra nang ae	*Carallia brachiata*	0.22	1.16	1.38
Dee ngoo	*Sterculia sp.*	0.22	1.16	1.38
Tao rang	*Caryota sp*	0.22	1.16	1.38
Thang	*Litsea grandis*	0.22	1.16	1.38
Non	*Vitex pinnata*	0.22	1.16	1.38
Nomkhwai	Unidentified	0.22	1.16	1.38
Phappla	*Microcos tomentosa*	0.22	1.16	1.38
Chamao	*Eugenia grandis*	0.22	1.16	1.38
Reu si som ton	*Diospyros wallichii*	0.22	1.16	1.38
Som	*Crypteronia paniculata*	0.22	1.16	1.38
Sa ton rok	*Elaeocarpus robustus*	0.22	1.16	1.38
Salao	*Dasymachalon blumei*	0.22	1.16	1.38
Mak prao nok kum	*Molineria latifolia*	0.22	1.16	1.38
Total		**100.00**	**100.00**	**200.00**

1.4 Vertical stratification

Structural diversity of trees in the old rubber plantation may be characterized by vertical stratification.

The present study showed the differences in vertical arrangement between the old rubber plantation in Phatthalung and Nakhon Si Thammarat (see Figures 9 and 10).

In Phatthalung, vertical stratification showed 10 species and had 2 canopy layers, as illustrated in Table 10. The top canopy (H = 17-20 m.) was continuous canopy of *Hevea brasiliensis*. The secondary layer (H = 7-13.5) was canopy of colonizing species in plantation, including *Garcinia merguensis*, *Alstonia macrophylla*, *Millettia atropurpurea* (Figure 9).

In Nakhon Si Thammarat result showed 13 species (Table 11) that stratified into 2 layers. The top canopy (H > 16 m.) was continuous canopy of *Hevea brasiliensis*. The secondary layer (H = 7-12 m.) was canopy of colonizing species in plantation, including *Cratoxylum maingayi*, *Litsea grandis*, *Barringtonia macrostachya*, etc. (Figure 10).

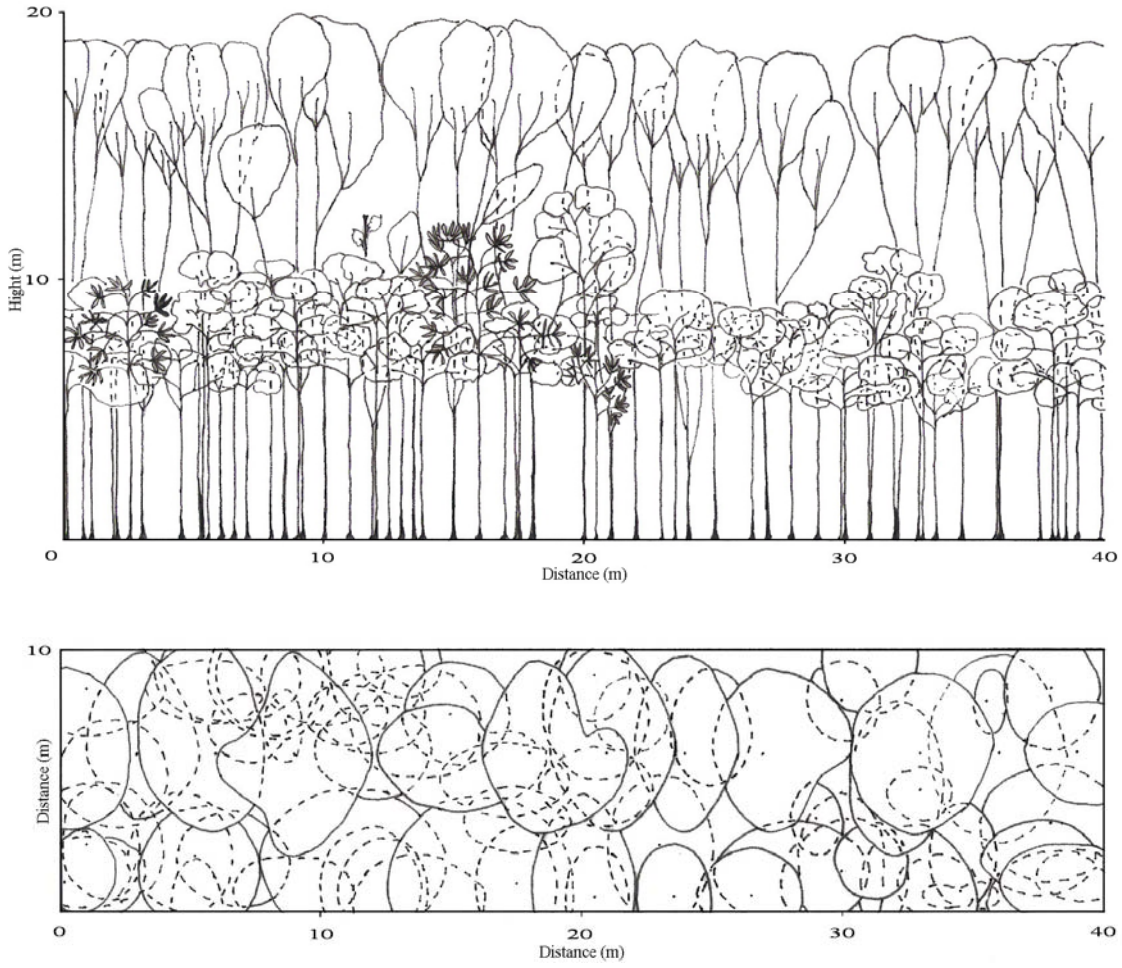

Figure 9 Profile diagram of trees with DBH larger than 4.5 cm along 10x40 m^2 in an old rubber plantation in Phatthalung.

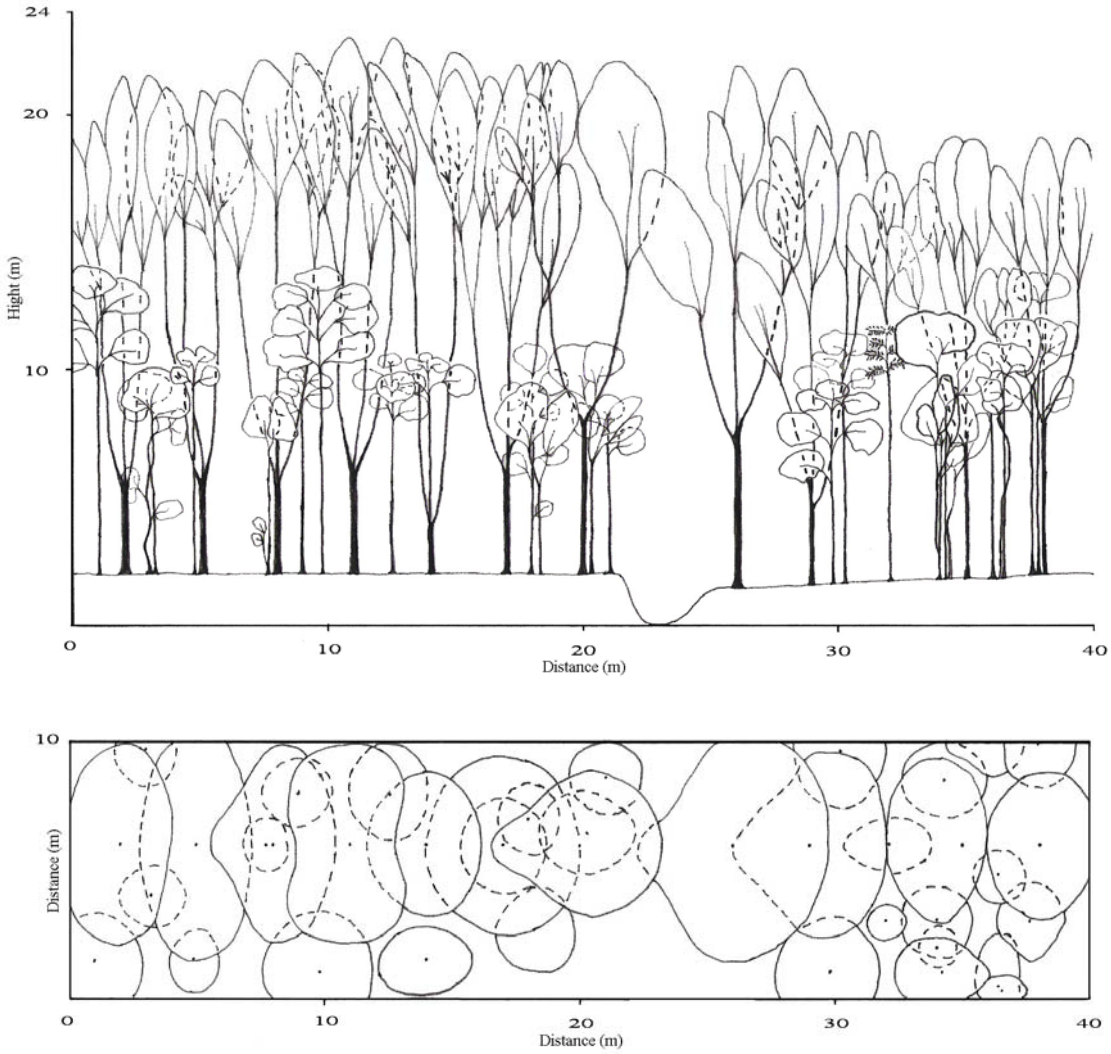

Figure 10 Profile diagram of trees with DBH larger than 4.5 cm along 10x40 m^2 in an old rubber plantation in Nakhon Si Thammarat.

Table 10 H class distribution of trees in an old rubber plantation in Phatthalung

Local names	Scientific names	No. of trees in different H classes (m)			Total
		7-13.5	13.5-17	17-20	
Mao	*Eugenia grandis*	1	-	-	1
Khi tai	*Syzygium zeylanicum*	2	-	-	2
Mahad	*Artocarpus lakoocha*	2	-	-	2
Nuan	*Garcinia eugeniaefolia*	45	-	-	45
Pantan (mangtan)	*Schima wallichii*	1	-	-	1
Sae	*Millettia atropurpurea*	3	-	-	3
Satonrok	*Elaeocarpus robustus*	1	-	-	1
Thang	*Litsea grandis*	1	-	-	1
Thung Fa	*Alstonia macrophylla*	7	-	-	7
Yangpara	*Hevea brasiliensi*	1	-	12	13
Total		64	0	12	76

Table 11 H class distribution of trees in an old rubber plantation in Nakhon Si Thammarat

Local names	Scientific names	No. of trees in different H classes (m)			Total
		7-12	12-16	>16	
Yangpara	*Hevea brasiliensis*		-	12	12
Chiang Pra Nang Ae	*Carallia brachiata*	2	-	-	2
Chignom	*Barringtonia macrostachya*	1	-	-	1
Ching	*Ficus fistulosa*	3	-	-	3
Kanlan	Unidetified	1	-	-	1
Mangtan	*Schima wallichii*	1	-	-	1
Mao	*Eugenia grandis*	1	-	-	1
Non	*Vitex pinnata*	1	-	-	1
Sae	*Millettia atropurpurea*	1	-	-	1
Taeo	*Cratoxylum maingayi*	8	-	-	8
Thang	*Litsea grandis*	5	-	-	5
Tiem	*Azadirachta excelsa*	1	-	-	1
Yo thuan	*Morinda elliptica*	1	-	-	1
Total		26	0	12	38

1.5 The traditional uses of tree species

The study on traditional uses of tree species in the old rubber plantations in Phatthalung and Nakhon Si Thammarat were done by interviewing the parataxonomists and farmers in Tamot and Na Mor Boon villages. The utilization can be classified into seven types (Table 12), comprising of, timber, pole, fuel wood, latex and resin, medicines, food, fodder, shelter belt, soil, and water conservation and aesthetic.

Concerning the utilization of all species in Phatthalung, it was found that 24 species (64.86 %) used as timber, 14 species (37.84 %) used as pole, 13 species (35.14 %) used as fuel wood, 17 species (45.95 %) was used as medicinal plant, 20 species (54.05 %) was used as the edible plant, 14 species (37.84 %) was fodder tree, 5 species (13.51 %) planted as shelterbelt, 12 species (32.43 %) planted for aesthetic, and only 2 species (5.41 %) was latex produce. It was suggested that almost all species can be planted for soil and water conservation.

27 out of 30 species in Nakhon Si Thammarat study site showed 13 species (48.15 %) used as timber, 2 species (7.41 %) used as pole, 11 species (40.74 %) used as fuel wood, 14 species (51.85 %) used as medicinal plant, 7 species (25.93 %) use as edible plants, 11 species (40.74 %) use as fodder trees. 8 species (29.63 %) used as shelterbelt, 6 species (22.22 %) used for soil and water conservation, 11 species (40.74 %) used for aesthetic, and only 1 species used for latex produce.

In the present study, a species can be classified for traditional uses into 2 types, including the production (Timber, fuel wood, resin and latex, medicinal plant and fodder tree) and soil and water conservation, shelterbelt and aesthetic value (Tables 13 and 14).

Table 12 Type and number of species for utilization of colonizing species in the old rubber plantation in Phatthalung and Nakhon Si Thammarat

Type of utilization	**Phatthalung**	**Nakhon Si Thammarat**
	Number of species	**Number of species**
Timber	24	13
Pole	14	2
Fuel wood	13	11
Latex or resin	2	1
Medicines	17	14
Food	20	7
Fodder	14	11
Shelterbelt	5	8
Soil and water conservation	37	6
Aesthetic	12	11
Total number of species	**37**	**27**

Table 13 The traditional uses of tree species in an old rubber plantation in Phatthalung

Local names	Scientific names	Production							Conservation		
		ti	po	wo	l	md	fo	fd	sh	co	am
Khem pa	*Ixora javanica*	-	-	-	-	✓	-	✓	-	✓	✓
Mao	*Eugenia grandis*	✓	✓	-	-	-	✓	✓	✓	✓	✓
Ian	*Persea menbranacea*	✓	✓	✓	-	✓	✓	✓	✓	✓	✓
Kam pla chon	*Emilia sonchifolia*	-	✓	✓	-	-	✓	-	-	✓	-
Sae	*Millettia atropurpurea*	✓	-	✓	-	✓	✓	✓	-	✓	✓
Taew	*Cratoxylum maingayi*	✓	✓	✓	-	✓	✓	-	-	✓	✓
Sok	*Saraca pierreana*	-	-	✓	-	-	-	-	✓	✓	✓
Mai	*Diospyros tahanensis*	✓	✓	✓	-	-	✓	✓	✓	✓	✓
Han	*Knema laurina*	✓	-	-	-	✓	✓	-	-	✓	-
Kraduk kai	*Justicia gendarussa*	-	✓	✓	-	✓	-	-	-	✓	✓
Khanun	*Artocarpus heterophyllus*	-	-	-	✓	✓	✓	✓	✓	✓	-
Khoi	*Streblus asper*	-	-	✓	-	✓	✓	✓	-	✓	✓
Khi tai	*Syzygium zeylanicum*	✓	✓	✓	-	✓	✓	✓	-	✓	-
Kho haeng	*Rinorea lanceolata*	✓	✓	-	-	-	✓	✓	-	✓	-
Dang khao	*Chaetocarpus castanocarpus*	✓	-	✓	-	-	✓	-	-	✓	-
Tang hon	*Calophyllum curtissii*	✓	-	-	-	✓	-	-	-	✓	-
Khat khao	*Oxyceros Horridus*	✓	-	-	-	-	-	-	-	✓	-

Table 13 (Continued)

Local names	Scientific names	Production							Conservation		
		ti	po	wo	l	md	fo	fd	sh	co	am
Ta pet ta kai	*Ardisia crenata*	-	-	-	-	✓	-	✓	-	✓	✓
Tin ped	*Alstonia scholaris*	✓	✓	✓	-	✓	-	-	✓	✓	✓
Thang	*Litsea grandis*	✓	-	✓	-	-	-	✓	✓	✓	✓
Thungfa	*Alstonia macrophylla*	✓	✓	✓	-	✓	-	-	✓	✓	✓
Nuan	*Garcinia merguensis*	✓	✓	-	-	-	-	-	-	✓	-
Fat	*Eugenia longiflora*	✓	✓	✓	-	-	-	-	-	✓	-
Phlapphla	*Microcos tomentosa*	-	-	✓	-	-	✓	✓	-	✓	-
Phawa	*Garcinia speciosa*	✓	-	-	-	-	✓	✓	-	✓	-
Phantan (Mangan)	*Schima wallichii*	✓	-	-	-	-	✓	-	-	✓	-
Mueai	*Cryptolepid buchanani*	-	-	✓	-	✓	-	-	✓	✓	✓
Ma huat	*Lepisanthes rubiginosa*	✓	-	-	-	-	✓	-	-	✓	-
Mahat	*Artocarpus lakcucha*	✓	-	-	-	-	✓	-	-	✓	-
Mi ra	*Symplocos cochinchinensis*	-	-	-	-	-	-	✓	-	✓	-
Yo	*Morinda citrifolia*	✓	-	-	-	✓	✓	✓	-	✓	-
Yangpara	*Hevea brasiliensis*	✓	✓	✓	✓	-	-	-	-	✓	-
Sathon rok	*Elaeocarpus robustus*	✓	✓	-	-	-	✓	-	-	✓	-
San	*Dillenia obovata*	✓	-	-	-	-	-	-	-	✓	-

Table 13 (Continued)

Local names	Scientific names	Production							Conservation		
		ti	po	wo	l	md	fo	fd	sh	co	am
Sa lao	*Goniothalamus undulatus*	-	-	-	-	✓	-	-	-	✓	✓
Nam Khi raet	*Streblus ilicifolius*	-	-	-	-	-	✓	-	-	✓	-
Mui	*Micromelum minutum*	-	-	-	-	✓	✓	-	-	✓	-

Note: ti = Timber, po = Pole, wo = Fuel wood, l = Latex or Resin, md = Medicines, fo = food, fd = Fodder, sh = Shelter belt, co = Soil and Water Conservation, am = Aesthetic

Table 14 The traditional uses of tree species in an old rubber plantation in Nakhon Si Thammarat

Local names	Scientific names	Production							Conservation		
		ti	po	wo	l	md	fo	fd	sh	co	am
Khem pa	*Ixora javanica*	✓	-	✓	-	✓	-	-	-	-	-
Chiang phra nang ae	*Carallia brachiata*	-	-	✓	-	✓	-	✓	-	-	✓
Sae	*Millettia atropurpurea*	✓	-	✓	-	-	✓	✓	-	-	✓
Taew	*Cratoxylum maingayi*	-	-	✓	-	-	-	-	✓	-	✓
Khoi	*Streblus asper*	✓	-	-	-	✓	-	✓	-	-	✓
Kho haeng	*Rinorea lanceolata*	✓	✓	-	-	-	✓	✓	-	✓	-
Khan laen	*Canthium glabrum*	-	-	✓	-	-	-	-	-	-	✓
Chick nom	*Barringtonia macrostachya*	-	-	✓	-	✓	-	-	-	-	-
Chomao	*Eugenia grandis*	✓	✓	-	-	-	✓	✓	✓	✓	✓
Ching	*Ficus fistulosa*	-	-	-	-	-	✓	✓	-	✓	-
Non	*Vitex pinnata*	✓	-	-	-	-	-	-	✓	-	-
Thang	*Litsea grandis*	✓	-	-	-	✓	-	-	-	-	-
Nok non	*Cleistanthus sp.*	-	-	-	-	✓	-	-	-	-	-
Fat	*Syzygium pyrifolium*	-	-	-	-	-	-	-	✓	✓	-
Phlapphla	*Microcos toemntosa*	-	-	✓	-	✓	-	✓	✓	-	-
Ma duea	*Ficus sp.*	-	-	-	-	-	✓	✓	-	✓	-
Mao khai pla	*Antidesma ghaesembilla*	-	-	✓	-	✓	-	✓	-	-	-
Mangtan	*Schima wallichii*	✓	-	✓	-	✓	-	-	✓	-	-

Table 14 (Continued)

Local names	Scientific names	Production							Conservation		
		ti	po	wo	l	md	fo	fd	sh	co	am
Yo thuan	*Morinda elliptica*	✓	-	✓	-	✓	-	-	-	-	✓
Yo pa	*Morinda coreia*	-	-	✓	-	✓	-	✓	✓	-	✓
Yangpara	*Hevea brasiliensis*	✓	-	✓	✓	-	-	-	✓	-	✓
Somset	*Glochidion rubrum*	-	-	-	-	✓	-	-	-	-	
Sadao chang	*Azadirachta excelsa*	✓	-	-	-	-	-	-	-	-	✓
Sato	*Parkia speciosa*	✓	-	-	-	✓	✓	-	-	-	-
Sathon rok	*Elaeocarpus robustus*	✓	-	-	-	-	-	-	-	-	-
San	*Dillenia obovata*	-	-	-	-	-	-	✓	-	-	✓
Mui	*Micromelum minutum*	-	-	-	-	✓	✓	-	-	✓	-

Note: ti = Timber, po = Pole, wo = Fuel wood, l = Latex or Resin, md = Medicines, fo = food, fd = Fodder, sh = Shelter belt, co = Soil and Water Conservation, am = Aesthetic

2. Soil Properties

Soil characteristics are directly controlled by relief parent materials, climate, and timing. Sub soil series in Phatthalung are soil series Nos. 32 and 34.

In soil series No. 32 (Khlong Chak Series (Kc) – family clayey skeletal kaolinitic, Typic Paleudults mixed with Khao Khat Series (Kkt) – family clayey skeletal kaolinitic, Oxic Plinthudults). The soil depth in both series are shallow with good drainage. Soil color is mixed between brown or reddish brown and grayish brown, with pH ranging between 5.5-7.0 and 4.0–5.5 respectively. The soil textures of Kc Series are sandy loam and loam while soil texture of Kkt Series are sandy loam (LDD, 1987).

As regards soil series No.34 (Khohong Series (Kh). It is belonging to family Corse loamy, siliceous, Typic Paleudults mixed with Na Thawi Series (Nat) – family coarse loamy, siliceous, Typic Paleudults). The soil depth in both series are also shallow with good drainage. Soil color is mixed between dark brown or grayish brown, with pH ranging between 4.5–5.0 in both series. The soil textures of Kh Series and Nat series are sandy loam (LDD, 1987).

In Nakorn Si Thammarat soil types are series 45. In soil series No. 45 included Khlong Teng Series (Klt) – family fine-loamy mixed, dytropeptic tropudults mixed with Khao Khat Series (Kkt) – family clayey skeletal kaolinitic, Oxic Plinthudults. The soil depth in Klt series is moderately depth and Kkt is shallow. In both series is good drainage. Soil color is mixed between brown and grayish brown, with pH ranging between 4.0-5.5 and 4.5–6.0 respectively. The soil textures of Klt Series are silt loam and loam while soil texture of Kkt Series are loam and sandy loam (LDD, 1987).

Study on soil properties was done in the old rubber plantation and monoculture of rubber plantation at the depths of 0-15 cm and 15–30 cm in Phatthalung and Nakhon Si Thammarat. The results were shown as follows;

2.1 Physical properties

In Phatthalung site, the soil physical property at a depth of 0-15 cm and 15-30 cm in the old rubber plantation and monoculture rubber plantation was shown in Table 15. Soil texture in the two plantations and two levels of soil depth was sandy loam. The bulk density, particle density, and porosity in old rubber plantation at the depth of 0-15 cm were 1.37 g/cm^3, 2.69 g/cm^3, and 49.15 % and the value at the depth of 15-30 cm were 1.47 g/cm^3, 2.71 g/cm^3 and 45.5 %. In monoculture rubber plantation, the bulk density, particle density and porosity at the depth of 0-15 cm were 1.45 g/cm^3, 2.75 g/cm^3, and 47.03 % whereas at the depth of 15-30 cm were 1.56 g/cm^3, 2.67 g/cm^3 and 41.56 %. The bulk density at the depth of 0-15 cm was lower than at the depth of 15-30 cm in both old rubber plantation and monoculture rubber plantation. However, the porosity at the depth of 0-15 cm showed value higher than at the depth of 15-30 centimeter. The comparison between an old rubber plantation and a monoculture of rubber plantation in each level of soil depth showed that the old rubber plantation had more bulk density and porosity, while the particle density of the old rubber plantation and monoculture rubber plantation was similar (2.67-2.72 g/cm^3). The comparison of bulk density from analysis with standard value of LDD (2004), it was found that the bulk density was similar.

As regards Nakhon Si Thammarat site, the result of soil physical property at the depth of 0-15 cm and 15-30 cm in the old rubber plantation and monoculture rubber plantation was shown in Table 16. The soil texture in the old rubber plantation in a depth 0-15 cm was sandy loam, while in a depth of 15-30 cm was clay loam. In monoculture of rubber plantation, silt loam was identified at both levels of soil depth. The bulk density at a depth of 0-15 cm of old rubber plantation and monoculture of rubber plantation were 1.31 and 1.32 g/cm^3 and had lower value than at the depth of 15-30 cm of old rubber plantation and monoculture of rubber plantation (1.47 g/cm^3). The soil porosity at the depths of 0-15 and 15-30 cm in the old rubber plantation were 49.25 and 48.24 %, while the values in the monoculture of rubber plantation were 44.38 and 43.28 %, respectively. The particle density of the old rubber plantation and

monoculture of rubber plantation was 2.56-2.60 g/cm^3. When comparing bulk density with the standard value of LDD (2004), it was found that the bulk density was similar.

At the depth of 0-15 cm, bulk density was found to be lower value than at the depth of 15-30 cm. This was caused by the accumulation of organic matters in the top soil. The particle density depends on the soil particle ratio (Soils Division Staff, 1976) which was the same in most cases. At the depth of 0-15 cm, more porosity was found than at the deeper level. The old rubber plantation had more soil porosity than monoculture of rubber plantation as caused by the decomposition of litterfall. Plant root distribution is improving soil structure and increased soil porosity (Soils Division Staff, 2001). Species diversity in the old rubber plantation has also effected to root distribution and influence on bulk density and porosity.

When comparing soil texture in Phatthalung (sandy loam) and Nakhon Si Thammarat (loam and silt loam) with standard value (LDD, 1987), it was found to be similar. The succession of the old rubber plantation did not change soil texture but improved bulk density and porosity. Thus, rubber plantation-based agroforestry system should be practiced. It can be maintained soil moisture content and reduced affect of soil erosion, so in watershed area.

Table 15 Physical property of soil in an old rubber plantation and monoculture of rubber plantation in Phatthalung

Study areas	Soil depth (cm)	Soil texture	Bulk density (g/cm^3)	Particle density (g/cm^3)	Soil porosity (%)
Old rubber plantation	0-15	Sandy loam	1.37	2.69	49.15
	15-30	Sandy loam	1.47	2.71	45.51
Monoculture of rubber plantation	0-15	Sandy loam	1.45	2.75	47.03
	15-30	Sandy loam	1.56	2.67	41.56

Table 16 Physical property of soil in an old rubber plantation and monoculture of rubber plantation in Nakhon Si Thammarat

Study areas	Soil depth (cm)	Soil texture	Bulk density (g/cm^3)	Particle density (g/cm^3)	Soil porosity (%)
Old rubber plantation	0-15	Loam	1.31	2.57	49.25
	15-30	Clay loam	1.47	2.65	44.38
Monoculture of rubber plantation	0-15	Silt loam	1.32	2.56	48.24
	15-30	Silt loam	1.47	2.60	43.28

2.2 Chemical properties

Tables 17 and18 showed the result of chemical analysis of Phatthalung and Nakhon Si Thammarat soil samples.

In Phatthalung soil sample, the total nitrogen content, available phosphorous, exchangeable potassium, exchangeable calcium and exchangeable magnesium at the depth of 0-15 cm of old rubber plantation were 0.125 %, 1.90 mg/kg, 0.66 cmol/kg, 10.80 cmol/kg, and 0.57 cmol/kg, respectively, whereas, those of the monoculture of rubber plantation were 0.093 %, 2.93 mg/kg, 1.61 cmol/kg, 9.95 cmol/kg, and 0.41 cmol/kg, respectively. At a depth of 15-30 cm of old rubber plantation and monoculture of rubber plantation, result showed the total nitrogen content (0.095 and 0.048 %), available phosphorous (1.42 and 1.57 mg/kg), exchangeable potassium (0.18 and 0.45 cmol/kg), exchangeable calcium (2.14 and 9.63 cmol/kg), and exchangeable magnesium (0.12 and 0.17 cmol/kg). Generally, top soil had more nutrients content than the sub-soil. In comparison between old rubber plantation and monoculture of rubber plantation at soil depth of 0-15 cm and 15-30 cm, it was found that the available phosphorous and exchangeable potassium in monoculture of rubber plantation had more content than in the old rubber plantation. Additionally, the total nitrogen content in the old rubber plantation had higher value than the monoculture of rubber plantation.

The available phosphorous and exchangeable potassium in the monoculture of rubber plantation at Phatthalung site had more value than in the old rubber plantation, as caused by the chemical fertilizer application twice a year. The total nitrogen content in the old rubber plantation had more value than the monoculture of rubber plantation which was mainly caused by the decomposition of litterfalls.

Concerning to Nakhon Si Thammarat soil sample, the total nitrogen in the old rubber plantation at the depth 0-15 and 15-30 cm were 0.10 and 0.09 % respectively. Others were available phosphorous (1.6 and 1.5 mg/ per kg),

exchangeable potassium (0.01, 0.01 cmol/kg), calcium (0.9, 0.2 cmol/kg), and magnesium (0.8, 0.5 cmol/kg). In monoculture of rubber plantation at the depth of 0-15 and 15-30 cm, the total nitrogen was 0.08 and 0.07 % and available phosphorous was found to be 1.4 and 1.3 mg/kg. The investigation also recorded the value of exchangeable potassium, calcium, and magnesium to be 0.01, 0.01, 0.2, 0.1, 0.2 and 0.2 cmol/kg. At the depth of 0-15 and 15-30 cm of both areas the nutrients content was not statistically difference.

Soil pH of old rubber plantation and monoculture of rubber plantation in Phatthalung study site were extremely acid (ranging between 4.17-4.38) but these pH values were still suitable for planting rubber tree (RRIT, 2005).

In Nakhon Si Thammarat, soil pH in an old rubber plantation at a depth of 0-15 cm was 4.6 (extremely acid). It turned to be very strong acid (4.3) at the depth of15-30 cm. In monoculture of rubber plantation, soil pH in the depth of 0-15 and 15-30 cm were 4.4 and 4.3 or extremely acid.

Concerning organic matters of Phatthalung site, it was found that percent of organic matters at the depth of 0-15 cm of old rubber plantation and monoculture of rubber plantation were 2.94 and 1.68 %, whereas at the depth 15-30 cm, there were 1.86 and 0.45 %. It was also found that old rubber plantation has higher percentages of organic matters at both soil depth when comparing to the monoculture rubber plantation.

In Nakhon Si Thammarat, soil organic matters at the depth of 0-15 and 15-30 cm in old rubber plantation was 1.7 and 1.1 %, They were moderately and slightly value when compared with standard value which determined by USDA (LDD, 2004). In monoculture of rubber plantation the organic matter at the depth of 0-15 and 15-30 cm were 1.2 and 0.8 % and they were slightly and low value when compare with standard value which determined by USDA (LDD, 2004). Similarly, monoculture rubber plantation has less organic matter when comparing to the old rubber plantation at all soil depths.

Concerning the analysis of Cation Exchange Capacity (CEC) at Phatthalung site, it was found that the CEC increased with soil depth. The CEC at the depth of 0-15 and 15-30 cm of old rubber plantation was ranging between 3.8-5.5 cmol/kg and the value at the monoculture of rubber plantation was ranging between 4.25-4.50 cmol/kg. The comparison with standard value which determined by USDA (LDD, 2004) showed that CEC in the old rubber plantation at the depth of 0-15 cm was low, whereas CEC at the depth of 15-30 cm was moderately to low. In monoculture of rubber plantation CEC at the depth of 0-15 cm and 15-30 cm was low.

In Nakhon Si Thammarat site, CEC at the depth of 0-15 and 15-30 cm in old rubber plantation were 7.2 and 10.1 cmol/kg and they were slightly and moderately value when compared with standard value which determined by USDA (LDD, 2004). In monoculture of rubber plantation, CEC at the depth of 0-15 and 15-30 cm were 4.5 and 6.9 cmol/kg and they were low and slightly when compared with standard value which determined by USDA (LDD, 2004).

As regards the analysis of Base Saturation Percentage (%BS) at Phatthalung site, it was found that the %BS in old rubber plantation at the depth of 0-15 and 15-30 cm were 35.73 and 5.04 %, whereas %BS in monoculture of rubber plantation were 30.96 and 26.23 %.

In Nakhon Si Thammarat, it was found that %BS at the depth of 0-15 and 15-30 cm in the old rubber plantation were 27.73 and 7.20 % whereas in monoculture of rubber plantation were 11.0 and 6.78 %.

In both study sites, %BS at the depth of 0-15 cm had higher value than at the depth of 15-30 cm and percent base saturation decreased with soil depth.

The comparison of three macronutrients (nitrogen, phosphorous, and potassium) and organic matters with standard value which determined by Land Development Department (LDD, 2004) showed that at Phatthalung site the three macronutrient content in the old rubber plantation and monoculture of rubber

plantation were slightly difference. The organic matters in old rubber plantation at the depth of 0-15 cm was moderately to high value while those at the depth of 15-30 cm the macronutrients was moderately. In monoculture of rubber plantation at the depth of 0-15 cm was moderately but those at the depth of 15-30 cm was lower value.

The comparison of three macronutrient (nitrogen, phosphorous, and potassium) at Nakhon Si Thammarat site with standard value which determined by USDA (LDD, 2004) result showed that at the depth of 0-15 and 15-30 cm in the old rubber plantation, available phosphorous, exchangeable potassium, calcium, and magnesium were lower, low, lower and low values, respectively. In monoculture of rubber plantation they were lower, low, lower and lower values, respectively.

Table 17 Soil nutrient content, pH, percent organic matters, cation exchange capacity, and percent base saturation between the old rubber plantation and monoculture of rubber plantation at Phatthalung site

Chemical properties	Soil depth			
	0-15 cm.		15-30 cm.	
	Old rubber plantation	Monoculture of rubber plantation	Old rubber plantation	Monoculture of rubber plantation
Total nitrogen (%)	0.125	0.093	0.095	0.048
Phosphorous (mg/kg)	1.90	2.93	1.42	1.57
Potassium (cmol/kg)	0.66	1.61	0.18	0.45
Calcium (cmol/kg)	10.80	9.95	2.14	9.63
Magnesium (cmol/kg)	0.57	0.41	0.12	0.17
pH	4.19	4.29	4.17	4.38
Organic matters (%)	2.94	1.68	1.86	0.45
Cation exchange capacity (cmol/kg)	3.88	4.25	5.50	4.50
Base saturation percentage	35.73	30.96	5.04	26.23

Table 18 Soil nutrient content, pH, percent organic matter, cation exchange capacity, and percent base saturation between the old rubber plantation and monoculture of rubber plantation at Nakhon Si Thammarat site

Chemical properties	Soil depth			
	0-15 cm.		15-30 cm.	
	Old rubber plantation	Monoculture of rubber plantation	Old rubber plantation	Monoculture of rubber plantation
Total nitrogen %)	0.10	0.08	0.09	0.07
Phosphorus (mg/kg.)	1.6	1.4	1.5	1.3
Potassium (cmol/kg)	0.01	0.01	0.01	0.01
Calcium (cmol/kg)	0.9	0.2	0.2	0.1
Magnesium (cmol/kg)	0.8	0.2	0.5	0.2
pH	4.6	4.4	4.3	4.3
Organic matters (%)	1.7	1.2	1.1	0.8
Cation exchange capacity (cmol/kg)	7.2	4.5	10.1	6.9
Base saturation percentage	27.7	11.0	7.2	6.9

3. Attitude of Rubber Smallholder toward Rubber Intercrop Planting

Smallholders are the majority of the latex production system. The agroforestry practices in small rubber plantation will directly involve in their livelihood. So as to develop the potential system for future application, it is thus important to study the attitude of smallholders of rubber plantation. Several studies related to the attitude in the present study are socio-economic data of population, rubber planting data and the relationship of various variables on their attitude. Results of these findings were presented below;

3.1 Socio-economic data of population

3.1.1 Gender

In Phatthalung, male respondent was 52.3 % whereas female respondent was 47.7 %. In Nakhon Si Thammarat, 66.3 % of the respondents were male and 33.7 % were female. Results showed that respondent in Phatthalung were more female as male have to take a rest after long hours of latex tapping in early morning. Therefore female have more participation in data collection. In Nakhon Si Thammarat, male take a lead in the family and female played more role as housewife.

3.1.2 Age

In Phatthalung, age of the respondents ranged from 18 to 80 years old with a mean age of 44 years. Most of the respondents (52.9%) belong to the age group of 40-60 years old, followed by those belonging to the age classes of 20-39 years old (36.8 %) and older than 60 years (9.8 %).

In Nakhon Si Thammarat, age of the respondents ranged from 21 to 77 years old with a mean age of 43 years. Most of the respondents (52.9%) belong to the age classes 40-60 years old followed by those belonging to the age classes 20-39 years old (36.8 %) and older than 60 years (9.8 %).

The study confirmed the situation that the average ages of respondent in both locations were 44 and 43 years old. The young group has only small percentage as they were involved in their education or training elsewhere.

3.1.3 Religion

In Phatthalung, 52.3 % of respondents were Buddhism and 47.7 % were Muslim. But 100 % of the respondents at Nakhon Si Thammarat were Buddhism. The present study might not well represent of Nakhon Si Thammarat situation. In fact, the province has about 30 % Muslim. It happened that the Thai village was randomly selected in the present study.

3.1.4 Civil status

In Phatthalung, most of the respondents (86.2 %) were married and only 6.9 % and 6.3 % were remained single and widow respectively. Similarly, most (95 %) of the respondents at Nakhon Si Thammarat site were married followed by single (3.0 %) and widow (2.0 %). Results showed strong family status in both study sites. This is somehow differ remarkably when comparing to the urban family life.

3.1.5 Household status

In Phatthalung, 56.3 % of respondents were household head and 43.7 % were household member. Most of the respondents (69.6 %) at Nakhon Si Thammarat were household head and 30.4 % were household member.

3.1.6 Social status

In Phatthalung site, 36.8 % of the respondents did not have any social status, while 63.2 % had a social status which comprise of member of village activity (44.6 %), village committee (15.4 %), village head (6.2 %), member of subdistrict administration committee (6.2 %), teacher (3.1 %), and others (24.6 %).

In Nakhon Si Thammarat site, most (74.6 %) of the respondents did not had any social status, only 25.4 % have a social status which comprised of member of village activities (31.6 %), village committee (19.7 %), village head (10.5 %), teacher (1.3 %), member of subdistrict administration committee (14.5 %), and others (22.4 %).

3.1.7 Family member

Most of family member of the respondents (67.8 %) in Phatthalung site have 4-6 persons family followed by 1-3 persons family (24.7 %), and more than 6 persons family (7.5 %), respectively.

In Nakhon Si Thammarat site, most of the respondents (66.6 %) have 4-6 persons family followed by 1-3 persons family (30.1 %), and more than 6 persons family (3.3 %), respectively.

The number of family will also show the important of rubber plantation on the livelihood of the people in the study sites. Rubber contribute cash as the main family earning on any tapping day.

3.1.8 Highest education attainment

In Phatthalung site 56.9 % of the respondents completed the education at primary school level, only 14.4 % and 14.9 % were those finished secondary schools and high school. There were 6.3 % of respondents who did not have any basic education, while 3.4 %, 2.9 %, and 1.1 % of the respondents obtained diploma, bachelor degree and above, respectively.

In Nakhon Si Thammarat site, 63.7 % of the respondents completed the primary school, only 14.5 % and 14.2 % of those remained have completed the secondary school and high school. Only 1 % of the respondents was

those who did not have any basic education, while 3.0 %, 3.3 % and 0.3 % obtained diploma, bachelor degree and above, respectively.

3.1.9 Domicile

Most of the respondents (71.8 %) at Phatthalung site were native to Tamot village and 28.2% of the respondents migrated from other areas. They mainly moved with family (81.6 %), moved for finding new planting area (14.3 %), and occupation (4.1 %).

In Nakhon Si Thammarat site, 79.8 % of the respondents were native to Na Mor Boon village and 20.2 % of the respondents migrated from other areas. To the immigrant, they moved with family (86.9 %), moved for finding new planting area (11.5 %), and occupation (1.6 %).

3.1.10 Length of residence in the village

Most of the respondents (81.0 %) in Phatthalung site resided at Tamot village more than 25 years, followed by 21-25 years (5.7 %), 16-20 years (6.3 %), and 6-10 years (4.0 %).

In Nakhon Si Thammarat, most of the respondents (78.9 %) reside in Na Mor Boon village more than 25 years followed by 16-20 years (5.6 %), 21-25 years (3.6 %) years, 11-15 (4.6 %) years, 6-10 (4.3 %) years, and 1-5 years (3.0 %).

3.1.11 Secondary occupation

In Phatthalung site, 43.0 % of the respondents had only activity in rubber plantation, while 57.0 % had others occupation parallel with latex tapping activity. 41.0 % of the respondents in Nakhon Si Thammarat site had only activity in latex tapping, while the remained 59.0 % had others occupation in parallel with latex tapping activity.

Results showed that these were more possibilities to get more jobs for better earning. However, rubber plantation will provide the main income to the family.

3.1.12 Household income (Baht per year)

Considering to the amount of annual income of the respondents families in Phatthalung and Nakhon Si Thammarat, Table 19 showed that 39.8 % of respondents families in Phatthalung, obtained annual income above 100,000 Baht, while 3.5 % respondents received less than 20,000 Baht. Those with annual incomes about 40,001 to 60,000 and 80,001 to 100,000 Baht were 13.5 %, and 9.4 %, while 17.0 % of respondent's annual income ranged from 20,000 to 40,000 and 60,001 to 80,000 Baht.

In Nakhon Si Thammarat, most of the respondents families (51.0 %) obtained annual income more than 100,000 Baht, while 2.3 % respondents received less than 20,000 Baht. Family with annual income ranged between 20,000 to 40,000, 40,001 to 60,000, 60,001 to 80,000, and 80,001 to 100,000 Baht were 5.3 %, 12.7%, 17.7%, and 11.0 %, respectively.

The study showed that the economic situation of smallholder of rubber plantation in Nakhon Si Thammaratwas slightly better than in Phatthalung.

3.1.13 Household expense (Baht per month)

The present study showed that respondents in both villages in Phatthalung and Nakhon Si Thammarat spent about 5,000-10,000 Baht/month by 52.6 % and 45.1 % respectively. The trend however showed that respondents in Phatthalung spent lesser than in Nakhon Si Thammarat.

Respondents spent money for various purposes. The percent present in Table 19 showed the calculation by based on each item. For food,

respondents of both (Phatthalung and Nakhon Si Thammarat) spent money for food with the high percentage of 89.7 % and 96.3. Respondents in Nakhon Si Thammarat showed higher payment on charity, house restoration, and health care than those who live in Phatthalung. Similar payment was found in clothes, education, business management, machine and vehicle repaired.

3.1.14 Debt

The present study showed that the majority of respondents in Phatthalung and Nakhon Si Thammarat has more debt with the percentages of 59.8 to 63.1. There is somehow a need to study the livelihood of people.

Table 19 Socio-economic data of the respondents in Phatthalung and Nakhon Si Thammarat sites

Socio-economic data	(n = 174) Phatthalung		(n = 303) Nakhon Si Thammarat	
	Number	**%**	**Number**	**%**
Gender				
Male	91	52.3	201	66.3
Female	83	47.7	102	33.7
Age				
<20	1	0.6	-	-
20-39	64	36.8	125	41.3
40-60	92	52.9	153	50.5
>60	17	9.8	25	8.3
Religion				
Buddhism	91	52.3	303	100.0
Muslim	83	47.7	-	-
Civil status				
Single	12	6.9	9	3.0
Married	150	86.2	288	95.0
Separated	1	0.6	-	-
Widow/er	11	6.3	6	2.0
Household status				
Household head	98	56.3	211	69.6
Household member	76	43.7	92	30.4
Social status				
No	64	36.8	266	74.6
Yes	110	63.2	77	25.4
Village committee	10	15.4	15	19.7
Member of village activities	29	44.6	24	31.6
Teacher	3	3.1	1	1.3
Village head	4	6.2	8	10.5
Member of subdistrict administration committee	4	6.2	11	14.5
Others	16	24.6	17	22.4

Table 19 (Continued)

Socio-economic data	Phatthalung		Nakhon Si Thammarat	
	Number	%	Number	%
Family member				
1-3 person	43	24.7	91	30.1
4-6 person	118	67.8	201	66.6
> 6 person	13	7.5	10	3.3
Highest education attainment				
Never attended school	11	6.3	3	1.0
Primary school	99	56.9	193	63.7
Secondary school	25	14.4	44	14.5
High school	26	14.9	43	14.2
Diploma	6	3.4	9	3.0
Bachelor	5	2.9	10	3.3
Graduate degree	2	1.1	1	0.3
Domicile				
Native	125	71.8	241	79.8
Migrated from other areas, Reason of migration;	49	28.2	61	20.2
With family	40	81.6	53	86.9
Occupation	2	4.1	1	1.6
For finding new planting area	7	14.3	7	11.5
Length of residence				
1-5 years	2	1.1	9	3.0
6-10 years	7	4.0	13	4.3
11-15 years	3	1.7	14	4.6
16-20 years	11	6.3	11	3.6
21-25 years	10	5.7	17	5.6
> 25 years	141	81.0	239	78.9
Secondary occupation				
Yes	98	57.0	173	59.0
No	74	43.0	170	41.0

Table 19 (Continued)

Socio-economic data	Phatthalung		Nakhon Si Thammarat	
	Number	**%**	**Number**	**%**
Annual year income (Baht)				
<20,000	6	3.5	7	2.3
20,000-40,000	29	17.0	16	5.3
40,001-60,000	23	13.5	38	12.7
60,001-80,000	29	17.0	53	17.7
80,001-100,000	16	9.4	33	11.0
> 100,000	68	39.8	153	51.0
Annual monthly expend (Baht)				
<5,000	36	23.4	35	12.2
5,000-10,000	81	52.6	130	45.1
10,001-15,000	20	13.0	51	17.7
15,001-20,000	15	9.7	44	15.3
> 20,000	2	1.3	28	9.7
Expended (answer more than one choice)				
Food	156	89.7	286	96.30
Clothes	77	44.3	128	43.10
Education	100	57.5	187	62.96
Health care	17	9.8	68	22.90
Business development	13	7.5	33	11.11
Machine and vehicle repaired	65	37.4	91	30.64
House restored	26	14.9	17	5.72
Consumption	65	37.4	190	63.97
Entertainment	24	13.8	13	4.38
Charity	65	37.4	262	88.22
Accommodation	43	24.7	27	9.09
Others	7	4.0	9	3.03
Debt				
Yes	104	59.8	185	63.1
No	70	40.2	108	36.9

3.2 Rubber planting data

3.2.1 Rubber plantation area holding

Considering to the size of rubber plantation of the respondents families in Phatthalung and Nakhon Si Thammarat, Table 20 showed that 36.8 % of the respondents in Phatthalung have small rubber plantation (1-5 rai), followed by 6-10 rai (33.3 %), 10-15 rai (15.5 %), and 16-20 rai (14.4 %).

In Nakhon Si Thammarat site, most of the respondents (31.7 %) had 6-10 rai and 16-20 rai rubber plantation, only 19.5 % and 17.2 % of the respondents had 1-5 rai and 10-15 rai rubber plantation, respectively.

This means that there were more larger rubber plantation area in Nakhon Si Thammarat as compared to Phatthalung.

3.2.2 Latex quantity per household (kg/day)

In Phatthalung, most of the respondents (50.6 %) collected latex 1-30 kg/day and only 8.6 % collected latex more than 90 kg/day. 5.7 % of the respondent indicated that the plantation is still too young for latex tapping and rubber plantation has latex production of 31-60 kg/day and 62-90 kg/day were 26.4 % and 8.6 %.

Similarly, 33.9 % of the respondents in Nakhon Si Thammarat collected latex 1-30 kg/day, followed by 31-60 kg/day (23.5 %) and 61-90 kg/day (16.1 %), and 18.5 % collected more than 90 kg/day, while 8.1 % of the respondent indicated that they still have young rubber plantations.

3.2.3 Supporting

Both respondents in Phatthalung and Nakhon Si Thammarat had the supporting with the percentages of 54.6 and 54.0. The rest did not received any supports as caused by the poor communication, the illegal encroachment and the isolation of rubber plantations. The supporters were from the Office of the Rubber Replanting Aid Fund, District Agricultural Office, and Royal Forest Department.

The supporting included the materials for planting, i.e. rubber seedlings, money, fertilizer, knowledge, and others (herbicide, intercrop plants, etc.). In Phatthalung site, the majority was the fertilizer support (74.23 %) followed by the financial support (73.20 %), rubber seedlings (37.11 %), and knowledge (17.53 %). In Nakhon Si Thammarat, 84.4 % supported in fertilizer, 70.9 % supported in money, 63.8 % supported in rubber seedlings, 10.6 % supported in herbicide or intercrop plants, and 9.2 % supported in knowledge.

3.2.4 Latex management

After collecting latex, the respondents managed and sold latex and latex products by one of the three methods. These were latex, rubber sheet, and latex residue. In Phatthalung, most of the respondents (93.9 %) sold latex while 4.9 % and 11.7 % sold rubber sheet and latex residue. In Nakhon Si Thammarat, most of the respondents sold latex residue (56.2 %) follow by latex (32.2 %), and rubber sheets (19.2 %).

3.2.5 Market

Most of the respondents in Phatthalung sold rubber products to dealers or brokers (97.2 %) while 4.6 % and 21.8 % of the respondents sold to rubber market center and the cooperative of Office of the Rubber Replanting Aid Fund. Similarly, 89.1 % of the respondents in Nakhon Si Thammarat sold rubber products to dealers or brokers. While 1.5 % and 10.2 % sold to rubber market center and the

cooperative of Office of the Rubber Replanting Aid Fund. In all cases, all products were sold out but the price will be uncontrolled by the buyers.

3.2.6 Intercrop plants

In term of intercrop plants, results showed that 47.1 % of the respondents in Phatthalung planted rubber intercrop plants. In Nakhon Si Thammarat only 31.8 % planted rubber intercrop plants. Small scale plantings are mainly caused by the limitation in knowledges and it was not the common practices in the region.

The species of rubber intercrop plants were; fruit trees, economic trees, edible plants, and medicinal plants. In Phatthalung, 53.1 % of the respondents planted trees and fruit trees followed by edible plants (34.6 % of the respondents) and medicinal plant (1.2 % of the respondents). In Nakhon Si Thammarat, 61.9 % of the respondents planted trees followed by edible plants (53.6 % of the respondents) and fruit tree (16.5 % of the respondents). Each respondent planted different kinds of plants.

Concerning the time for planting rubber intercrop plants, most of the respondents in Phatthalung (54.3 %) planted rubber intercrop plants after planted rubber seedling. 17.3 % of the respondence planted before planted rubber seedlings and 35.8 % of the respondent planted with rubber seedlings. In Nakhon Si Thammarat, 40.2 % of the respondents planted rubber intercrop plants after planted rubber seedlings. 38.1 % planted with rubber seedlings and 28.9 % planted before planted rubber seedlings.

The planting system of rubber intercrop plants were; between rubber rows, edge of rubber plantation, and widely distribute over the area. In Phatthalung, most of the respondents (55.6 %) planted rubber intercrop plants between rubber tree rows followed by planted rubber intercrop plants at the edge of rubber plantation (38.3 %) and planted widely distribute in rubber plantation (7.4 %). In Nakhon Si Thammarat, most of the respondents (44.3 %) planted rubber intercrop

plants between rubber tree rows followed by planted widely distribute in rubber plantation (33.0 %) and planted rubber intercrop plants at edge of rubber plantation (19.6 % of the respondence).

In Phatthalung, 43.2 % of the respondents got rubber intercrop seedlings by propagated from mother trees and 32.1 % bought from private orchard while, other sources of seedlings, including rubber intercrop seedlings collected from natural forests, bought from government institute, supported from government institute, and others were 21.0, 2.5, 4.9, and 6.2 %, respectively. In Nakhon Si Thammarat, 50.5 % of the respondents got rubber intercrop seedlings by propagated from mother trees and 25.5 % got from collected seedlings from natural forest. While rubber intercrop seedlings bought from private orchard, bought from government institute, and others were 11.3, 6.2, and 18.6 %, respectively.

In term of intercrop plant utilization, most (60.5 %) of the respondents in Phatthalung wanted to consume products in their household. 37.0 % wanted to sell products from rubber inter crop plants and 16.0 % wanted to consume in household and share with neighbor. Only 1.2 % waned to process new products and sold out. In Nakhon Si Thammarat, 66.0 % of the respondents wanted to consume products in household and 36.1 % wanted to consume in household and share with neighbor. 14.4 % wanted to sell products and only 2.1 % wanted to process new products and sold out.

Table 20 Rubber planting data of respondents in Phatthalung and Nakhon Si Thammarat sites

Rubber planting data	Phatthalung (n = 174)		Nakhon Si Thammarat (n = 303)	
	Number	**%**	**Number**	**%**
Rubber plantation area				
1-5 Rai	64	36.8	59	19.5
6-10 Rai	58	33.3	96	31.7
10-15 Rai	27	15.5	52	17.2
16-20 Rai	25	14.4	96	31.7
Latex quantity (kg/day)				
0 (Non tapping)	10	5.7	24	8.1
1-30 kg.	88	50.6	101	33.9
31-60 kg.	46	26.4	70	23.5
61-90 kg.	15	8.6	48	16.1
> 90 kg.	15	8.6	55	18.5
Supporting				
No	95	54.6	160	53.0
Yes	79	45.4	142	47.0
Office of the Rubber Replanting Aid Fund (ORRAF)	89	92.7	142	100.0
District Agricultural Office (AAO)	6	6.3	-	-
Royal Forest Departmrnt (RFD)	1	1.0	-	-
Supporting Materials (answer more than one choice)				
Rubber seedling	36	37.11	90	63.8
Money	71	73.20	100	70.9
Fertilizer	72	74.23	119	84.4
Knowledge	17	17.53	13	9.2
Others	-	-	15	10.6
Latex Management (answer more than one choice)				
Latex	153	93.9	89	32.2
Rubber sheet	8	4.9	53	19.2
Latex residue	19	11.7	155	56.2
Market (answer more than one choice)				
Dealer/Broker	117	97.2	245	89.09
Rubber market center	8	4.6	4	1.45
Other (ORRAF)	38	21.8	28	10.18

Table 20 (continued)

Rubber planting data	Phatthalung		Nakhon Si Thammarat	
	Number	%	Number	%
Intercrop plants				
Yes	82	47.1	95	31.8
No	92	52.9	204	68.2
Type of intercrop plant (answer more than one choice)				
Fruit tree	43	53.1	16	16.5
Tree	43	53.1	60	61.9
Edible plants	28	34.6	52	53.6
Other	1	1.2	-	-
Time for planting (answer more than one choice)				
With rubber seedlings	29	35.8	37	38.1
After planted rubber seedlings	44	54.3	39	40.2
Before planted rubber seedlings	14	17.3	28	28.9
Planting characteristics (answer more than one choice)				
Between row	45	55.6	43	44.3
Edge	31	38.3	19	19.6
Distribute	6	7.4	32	33.0
Source of seedlings (answer more than one choice)				
Buy from private orchard	26	32.1	11	11.3
Buy from government institute	2	2.5	6	6.2
Propagated from mother trees	35	43.2	49	50.5
Support from government institute	4	4.9	0	0.0
Collected from natural forest	17	21.0	25	25.8
Others	5	6.2	18	18.6
Utilization of products (answer more than one choice)				
Household	49	60.5	64	66.0
Household and neighbor	13	16.0	35	36.1
Sell	30	37.0	14	14.4
Process to new products and sell	1	1.2	2	2.1

3.3 Chi-Square Analysis

The Chi-square Analysis was used for hypothesis test. The hypothesis test was carried out to test the relationship between the independent variables namely gender, age, education level, secondary occupation, household income, debt, and rubber plantation area with dependent variables, attitude of rubber smallholder toward rubber intercrop planting. The Chi-square Test was employed to find out the relationship between the independent variable and attitude of rubber smallholder at 0.05 statistics significant level. The following hypotheses were tested:

Hypothesis one: Gender is relating to attitude of rubber smallholders toward rubber intercrop planting.

Table 21 illustrated the relationship between the variable gender and attitude of rubber smallholders toward rubber intercrop planting at Phatthalung and Nakhon Si Thammarat sites. It was found that gender was related to attitude of rubber smallholders toward rubber intercrop planting, (χ^2 = 8.235* and 6.203*). This means that male has attitude differently to female toward rubber intercrop planting.

Table 21 Relationship between gender and level of attitude of rubber smallholders toward rubber intercrop planting in Phatthalung (Site 1) and Nakhon Si Thammarat (Site 2)

Site	Gender	Level of attitude			Total
		Low (%)	Moderate (%)	High (%)	
1	Male	10 (5.7)	63 (36.2)	18 (10.3)	91 (52.3)
	Female	20 (11.5)	56 (32.2)	7 (4.0)	83 (47.7)
	Total	30 (17.2)	119 (68.4)	25 (14.4)	174 (100)
	χ^2 = 8.235*				
2	Male	24 (7.9)	135 (44.6)	42 (13.9)	201 (66.3)
	Female	19 (6.3)	72 (23.8)	11 (3.6)	102 (33.7)
	Total	43 (14.2)	207 (68.3)	53 (17.5)	303 (100)
	χ^2 = 6.203*				

Note: * Significant at 0.05 statistic significant level

Hypothesis two: Age is relating to attitude of rubber smallholders toward rubber intercrop planting.

Table 22 showed the relationship between respondent's age and attitude of rubber smallholders toward rubber intercrop planting in Phatthalung and Nakhon Si Thammarat. In Phatthalung, 56.9 % of the respondent age were less than or about 44 years old and 43.1 % of the respondents were higher than 44 years old. Most of the respondents (68.4 %) were moderately attitude level followed by low (17.2 %) and high (14.4 %). The χ^2 was 0.615^{ns} which age was insignificantly related to attitude of rubber smallholders toward rubber intercrop planting. Similarly the study in Nakhon Si Thammarat, revealed that 57.8 % of the respondents age were less than or about 43 years old and 42.2 % were higher than 43 years old. Most (68.3 %) of the respondents were moderately attitude level followed by high (17.5 %) and low (14.2 %). The χ^2 was 5.639^{ns} which was insignificantly related to attitude of rubber smallholders toward rubber intercrop planting. This means that the different age range does not make any different agreed on rubber intercrop planting in Phatthalung and Nakhon Si Thammarat.

Table 22 Relationship between age and level of attitude of rubber smallholders toward rubber intercrop planting in Phatthalung (Site 1) and Nakhon Si Thammarat (Site 2)

Site	Age (years)	Level of attitude			Total
		Low (%)	Moderate (%)	High (%)	
1	Lower or equal 44	19 (10.9)	66 (37.9)	14 (8.0)	99 (56.9)
	More than 44	11 (6.3)	53 (30.5)	11 (6.3)	75 (43.1)
	Total	30 (17.2)	119 (68.4)	25 (14.4)	174 (100)
	$\chi^2 = 0.615$				
2	Lower or equal 43	20 (6.6)	129 (42.6)	26 (8.6)	175 (57.8)
	More than 43	23 (7.6)	78 (25.7)	27 (8.8)	128 (42.2)
	Total	43 (14.2)	207 (68.3)	53 (17.5)	303 (100)
	$\chi^2 = 5.639^{ns}$				

Note: ^{ns} Insignificant at 0.05 statistic significant level

Hypothesis three: Education level is relating to attitude of rubber smallholders toward rubber intercrop planting.

Table 23 illustrated the relationship between the respondent's education level and attitude of rubber smallholders toward rubber intercrop planting in Phatthalung and Nakhon Si Thammarat.

In Phatthalung, 60.7 % of the respondents attended primary school while 39.3 % finished higher education than primary school level. The χ^2 was 3.161^{ns} which showed that the education level was insignificantly related to attitude of rubber smallholders toward rubber intercrop planting. This means that the different education level dose not make any different agreed on rubber intercrop planting.

In Nakhon Si Thammarat, 64.3 % of the respondents attended primary school while 35.7 % finished higher education than primary school. The χ^2 was 0.215^{ns} which education level insignificantly related to attitude of rubber smallholders toward rubber intercrop planting, result indicated that the different education level dose not make any different agreed upon rubber intercrop planting.

Table 23 Relationship between education level and level of attitude of rubber smallholders toward rubber intercrop planting in Phatthalung (Site 1) and Nakhon Si Thammarat (Site 2)

Site	Education level	Level of attitude			Total
		Low (%)	Moderate (%)	High (%)	
1	Basic education	21 (12.9)	69 (42.3)	9 (5.5)	99 (60.7)
	More than basic education	9 (5.5)	44 (27.0)	11 (6.7)	64 (39.3)
	Total	30 (18.4)	113 (69.3)	20 (12.3)	163 (100)
	$\chi^2 = 3.161^{ns}$				
2	Basic education	28 (9.3)	133 (44.3)	32 (10.7)	193 (64.3)
	More than basic education	15 (5.0)	72 (24.0)	20 (6.7)	107 (35.7)
	Total	43 (14.3)	205 (68.3)	52 (17.3)	300 (100)
	$\chi^2 = 0.215^{ns}$				

Note: ^{ns} Insignificant at 0.05 statistic significant level

Hypothesis four: Secondary occupation is relating to attitude of rubber smallholders toward rubber intercrop planting.

Table 24 illustrated the relationship between the respondent's secondary occupation and attitude of rubber smallholders toward rubber intercrop planting in Phatthalung and Nakhon Si Thammarat.

In Phatthalung, 57.0 % of the respondents had a secondary occupation while 39.3 % did not have any secondary occupation. The χ^2 was 4.957^{ns} which secondary occupation was insignificantly related to attitude of rubber smallholders toward rubber intercrop planting. This means that the different secondary occupation dose not make any different agreed upon rubber intercrop planting.

In Nakhon Si Thammarat, 59.0 % of the respondents had a secondary occupation while 41.0 % did not have any secondary occupation. The χ^2 was 2.701^{ns}

which secondary occupation was insignificantly related to attitude of rubber smallholders toward rubber intercrop planting. This means that the different secondary occupation dose not make any different agreed on rubber intercrop planting.

Table 24 Relationship between secondary occupation and level of attitude of rubber smallholders toward rubber intercrop planting in Phatthalung (Site 1) and Nakhon Si Thammarat (Site 2)

Site	Secondary occupation	Level of attitude			Total
		Low (%)	Moderate (%)	High (%)	
1	Yes	12 (7.0)	69 (40.1)	17 (9.9)	98 (57.0)
	No	18 (10.5)	48 (27.9)	8 (4.7)	74 (43.0)
	Total	30 (17.4)	117 (68.0)	25 (14.5)	172 (100)
	$\chi^2 = 4.957^{ns}$				
2	Yes	29 (9.9)	114 (38.9)	30 (10.2)	173 (59.0)
	No	12 (4.1)	86 (29.4)	22 (7.5)	120 (41.0)
	Total	41 (14.0)	200 (68.3)	52 (17.7)	293 (100)
	$\chi^2 = 2.701^{ns}$				

Note: ^{ns} Insignificant at 0.05 statistic significant level

Hypothesis five: Household income is relating to attitude of rubber smallholders toward rubber intercrop planting.

Table 25 illustrated the relationship between household income and level of attitude of rubber smallholders toward rubber intercrop planting in Phatthalung and Nakhon Si Thammarat.

In Phatthalung, most of the respondents (60.2 %) had a household annual income (2006) less than 100,000 Baht while 39.8 % had a household income per year more than 100,000 Baht. 68.4 percent of the respondents were moderately attitude level followed by low (17.0 %) and high (14.6 %). The χ^2 was 4.819^{ns} which

indicated that household income was insignificantly related to attitude of rubber smallholders toward rubber intercrop planting. This means that the different household income does not make any different agreed upon rubber intercrop planting.

In Nakhon Si Thammarat, most of the respondents (49.0 %) had a household income per year (situation in 2006) less than 100,000 Baht while 51.0 percent had a household income per year more than 100,000 Baht. 68.7% of the respondents were moderately attitude level followed by high (17.7 %) and low (13.7 %). The χ^2 was 2.026 ^{ns} which household income was insignificantly related to attitude of rubber smallholders toward rubber intercrop planting. This means that the different household income dose not make any different agreed upon rubber intercrop planting.

Table 25 Relationship between household income and level of attitude of rubber smallholders toward rubber intercrop planting in Phatthalung (Site 1) and Nakhon Si Thammarat (Site 2)

Site	Household income (Baht per year)	Level of attitude			Total
		Low (%)	Moderate (%)	High (%)	
1	Lower than 100,000 Baht	16 (9.4)	67 (39.2)	20 (11.7)	103 (60.2)
	More than 100,000 Baht	13 (7.6)	50 (29.2)	5 (2.9)	68 (39.8)
	Total	29 (17.0)	117 (68.4)	25 (14.6)	171 (100)
	$\chi^2 = 4.819^{ns}$				
2	Lower than 100,000 Baht	16 (5.3)	103 (34.3)	28 (9.3)	147 (49.0)
	More than 100,000 Baht	25 (8.3)	103 (34.3)	25 (8.3)	153 (51.0)
	Total	41 (13.7)	206 (68.7)	53 (17.7)	300 (100)
	$\chi^2 = 2.026^{ns}$				

Note: ^{ns} Insignificant at 0.05 statistic significant level

Hypothesis six: Debt is relating to attitude of rubber smallholders toward rubber intercrop planting.

Table 26 illustrated the relationship between debt and level of attitude of rubber smallholders toward rubber intercrop planting in Phatthalung and Nakhon Si Thammarat.

In Phatthalung, most (59.8 %) of the respondents had a debt, while 39.8 % did not have any debt. The χ^2 was 5.060 ^{ns} which debt was insignificantly related to attitude of rubber smallholders toward rubber intercrop planting. This means that the different debt dose not make any different agreed upon rubber intercrop planting.

In Nakhon Si Thammarat, most of the respondents (63.1 %) had a debt. The χ^2 was 2.426 ^{ns} which indicated that debt insignificantly related to attitude of rubber smallholders toward rubber intercrop planting. This means that the different debt dose not make any different agreed upon rubber intercrop planting.

Table 26 Relationship between debt and level of attitude of rubber smallholders toward rubber intercrop planting in Phatthalung (Site 1) and Nakhon Si Thammarat (Site 2)

Site	Debt	Level of attitude			Total
		Low (%)	Moderate (%)	High (%)	
1	Yes	23 (13.2)	65 (37.4)	16 (9.2)	104 (59.8)
	No	7 (4.0)	54 (31.0)	9 (5.2)	70 (40.2)
	Total	30 (17.2)	119 (68.4)	25 (14.4)	174 (100)
	$\chi^2 = 5.060^{ns}$				
2	Yes	25 (8.5)	132 (45.1)	28 (9.6)	185 (63.1)
	No	17 (5.8)	68 (23.2)	23 (7.8)	108 (36.9)
	Total	42 (14.3)	200 (68.3)	51 (17.4)	293 (100)
	$\chi^2 = 2.426^{ns}$				

Note: ^{ns} Insignificant at 0.05 statistic significant level

Hypothesis seven: Rubber plantation area is relating to attitude of rubber smallholders toward rubber intercrop planting.

Table 27 illustrated the relationship between rubber plantation area and level of attitude of rubber smallholders toward rubber intercrop planting in Phatthalung and Nakhon Si Thammarat.

In Phatthalung, 49.8 %of the respondent's rubber plantation area was equal or lower than 9 rai while 39.8 % of those have more than 9 rai. Most of the respondents (68.4 %) were moderately attitude level followed by low (17.2 %) and high (14.4 %). The χ^2 was 0.0093 ^{ns} which rubber plantation area was insignificantly related to attitude of rubber smallholders toward rubber intercrop planting. This means that the different rubber plantation area dose not make any different agreed upon rubber intercrop planting.

In Nakhon Si Thammarat, 54.5 % of the respondent's rubber plantation area was equal or lower than12 rai while 50.6 % of those was more than12 rai. Most (68.3 %) of the respondents were moderately attitude level followed by high (17.5 %) and low (14.2 %). The χ^2 was 0.813 ^{ns} which rubber plantation area was insignificantly related to attitude of rubber smallholders toward rubber intercrop planting. This means that the different rubber plantation area does not make any different agreed upon rubber intercrop planting.

Table 27 Relationship between rubber plantation area and level of attitude of rubber smallholders toward rubber intercrop planting in Phatthalung (Site 1) and Nakhon Si Thammarat (Site 2)

Site	Rubber plantation area (Rai)	Level of attitude			Total
		Low (%)	Moderate (%)	High (%)	
1	Equal or lower 9	15 (8.6)	58 (33.3)	13 (7.5)	86 (49.4)
	More than 9	15 (8.6)	61 (35.1)	12 (6.9)	88 (50.6)
	Total	30 (17.2)	119 (68.4)	25 (14.4)	174 (100)
	$\chi^2 = 0.093^{ns}$				
2	Equal or lower than 12	21 (6.9)	116 (38.3)	28 (9.2)	165 (54.5)
	More than 12	22 (7.3)	91 (30.0)	25 (8.3)	138 (45.5)
	Total	43 (14.2)	207 (68.3)	53 (17.5)	303 (100)
	$\chi^2 = 0.813^{ns}$				

Note: ^{ns} Insignificant at 0.05 statistic significant level

In the present study, independent variable, gender, age, education level, secondary occupation, household income, debt, and rubber plantation area are relating to attitude of rubber smallholders toward rubber intercrop planting. The results from Chi-square Analysis of Phatthalung and Nakhon Si Thammarat sites were summarized in Table 28. Results showed that gender was significantly related to attitude of rubber smallholders toward rubber intercrop planting at 0.05 statistic significant level of both areas. While age, education level, secondary occupation, household income, debt, and rubber plantation area in both areas were insignificantly related to attitude of rubber smallholders toward rubber intercrop planting.

Table 28 Chi-square analysis for independent variables on attitude of rubber smallholders toward rubber intercrop planting

Independent variables	Significant value		Relationship
	Phatthalung	Nakhon Si Thammarat	
Gender	0.016	0.045	Significant
Age	0.735	0.06	Insignificant
Education level	0.206	0.898	Insignificant
Secondary occupation	0.084	0.259	Insignificant
Household income	0.09	0.363	Insignificant
Debt	0.08	0.297	Insignificant
Rubber plantation area	0.955	0.666	Insignificant

The final results of plant diversity, soil properties, and attitude of rubber smallholder were shown in Figure 11.

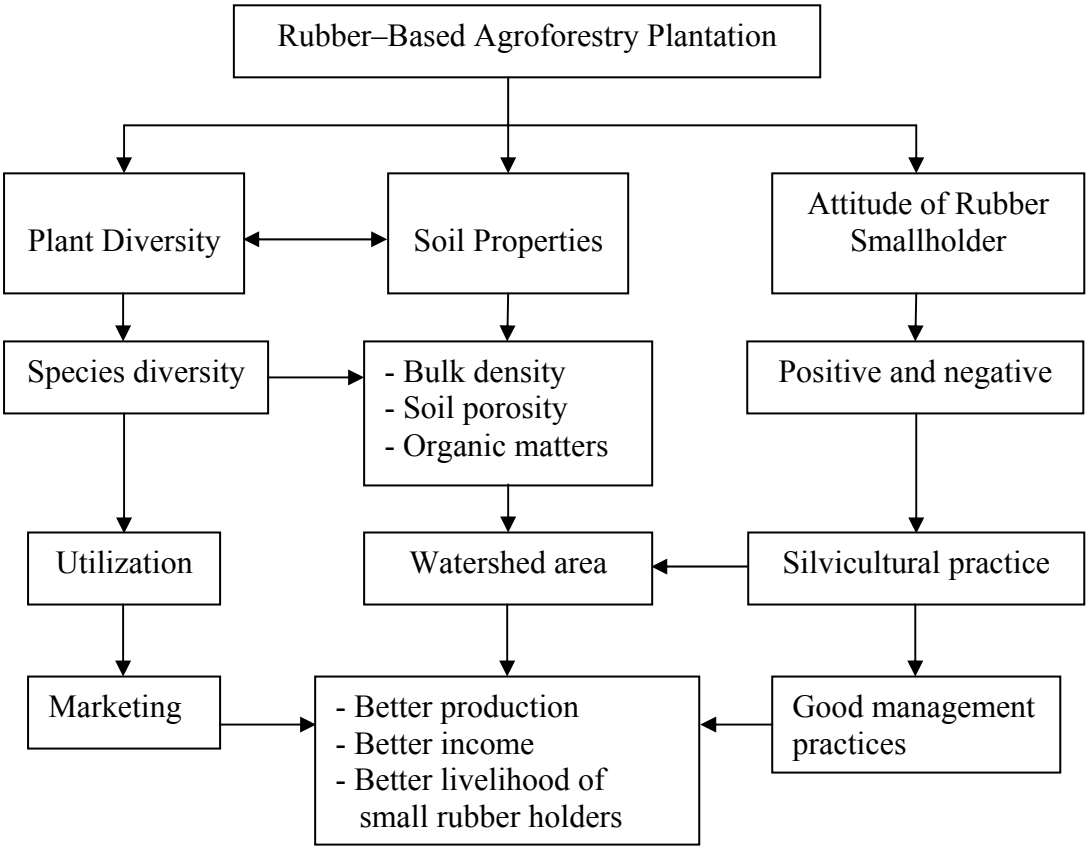

Figure 11 Showed results of plant diversity, soil properties, and attitude of rubber smallholder.

In small old rubber plantation with colonization of native plant, plant diversity showed species abundance in plant community. In addition, it also indicated about the direct-indirect advantage of plants. Beside latex tapping from rubber tree, the rubber smallholder can make use of colonizing species for timber, pole, fuel wood, edible plants, medicinal plants, etc in their households which reduce some family expense. Indirectly, plants diversity and difference crown cover in old rubber plantation can help in conserving soil and water, especially in watershed area.

The succession of plants in the old rubber plantation showed that plants can improved soil porosity and bulk density as well as provide high organic matters through the root distribution activities and decompose from litterfalls. Rubber plantation-based agroforestry plantation should be applied in other small rubber plantation because can be utilized intercrop plants and very well suitable for watershed management practices.

Positive and negative attitude of rubber smallholders relate with rubber intercrop planting by taking silvicultural practice in rubber plantation-based agroforestry. This will lead to the sustainable forest management.

With the exception of gender, the attitude of rubber smallholder toward rubber intercrop planting showed that age, education level, secondary occupation, household income, debt, and rubber plantation area in both areas were insignificantly related to attitude of rubber smallholders toward rubber intercrop planting in both areas. This means that the different 6 variable dose not make any different agreed upon rubber intercrop planting. Also, it was mean that male has attitude differently to female toward rubber intercrop planting. In this case, training about rubber intercrop plant for woman needed to be conducted.

CONCLUSION

Study on trees, medicinal plants diversity, soil properties and attitude of rubber smallholder toward rubber intercrop planting in Phatthalung and Nakhon Si Thammrat Provinces can be concluded, as follows;

1. Trees and Medicinal Plants Diversity

In Phatthalung 37 tree species were found, comprising of 18 tree species, 28 sapling species, and 7 seedling species. Richness Index, Evenness Index, and Shannon-Wiener's Index were 5.69, 0.49 and 2.58 respectively. In Nakhon Si Thammarat, 30 tree species were found, comprising of 19 tree species, 16 sapling species, and 9 seedling species. Richness Index, Evenness Index, and Shannon-Wiener's Index were 5.69, 1.89 and 9.27, respectively. Similarity of Sorensen between old rubber plantation and secondary forest was 30.64 %.

Medicinal plants in Phatthalung was found to be 41 plant species with Shannon-Wiener's Index of 4.25. In Nakhon Si Thammarat, 49 plant species were found with 4.04 of Shannon-Wiener's index.

2. Traditional Uses of Tree Species

The traditional uses of tree species can be separated to two groups, which were production species (timber, pole, latex and resin, medicinal plant, food, and fodder) and conservation species or protection species (soil and water conservation, shelter belt, and aesthetic).

3. Soil Properties

In the old rubber plantation and monoculture of rubber plantation at Phatthalung site, soil texture was sandy loam. In both plantations, bulk density at a depth of 0-15 cm was less than at a depth of 15-30 cm. In the old rubber plantation,

bulk density was less than monoculture of rubber plantation. On contrary, the porosity of both plantations at a depth of 0-15 cm was higher than at a depth of 15-30 cm and the porosity of the old rubber plantation was higher than the porosity observed monoculture of rubber plantation. In both plantations, particle density was similar in both soil depths.

Soil nutrients content (nitrogen, phosphorus, potassium, calcium and magnesium) at a depth of 0-15 cm was higher than those at a depth of 15-30 cm in both plantations. The monoculture of rubber plantation had more available phosphorus and exchangeable potassium than old rubber plantation, while total nitrogen content in the old rubber plantation had more than monoculture of rubber plantation in both plantation. The exchangeable calcium and magnesium in the old rubber plantation at a depth of 0-15 cm was higher than at a depth of 15-30 cm. Organic matters and percent base saturation at a depth of 0-15 cm were higher than a the depth of 15-30 cm. The pH range of both plantations was 4.17-4.38. Cation Exchangeable Capacity increased with soil depth.

In Nakhon Si Thammarat, it was found that soil physical property at a depth of 0-15 cm in the old rubber plantation and monoculture rubber plantation. Soil texture were sandy loam and silt loam. While at a depth of 15-30 cm soil texture were clay loam and silt loam. The bulk density at a depth of 0-15 cm of both plantations were 1.31 and 1.32 g/cm^3, whereas at a depth 15-30 cm that was 1.47 g/cm^3 in two plantations. The soil porosity at the depth of 0-15 and 15-30 cm in the old rubber plantation were 49.25 and 48.24 %, while in the monoculture of rubber plantation were 44.38 and 43.28 %. The particle density of both plantations ranged from 2.56-2.60 g/cm^3.

Soil nutrients content, Nitrogen, Phosphorus, Calcium and Magnesium at a depth 0-15 centimeter and 15-30 cm of old rubber plantation was higher than the monoculture of rubber plantation, whereas potassium was similar. The percent of organic matters at the depth of 0-15 and 15-30 cm in old rubber plantation were 1.7 and 1.1 % which were higher than those in monoculture of rubber plantation (1.2 and

0.8 %). The pH range of old rubber plantation was 4.3-4.6, while the monoculture of rubber plantation was 4.3-4.4. The cation exchangeable capacity and percent base saturation at a depth of 0-15 and 15-30 cm of old rubber plantation were higher than monoculture of rubber plantation.

4. Attitude of Rubber Smallholder toward Rubber Intercrop Planting

The attitude of rubber smallholders toward rubber intercrop planting found that gender related with attitude, whereas age, education level, secondary occupation, household income, debt and rubber plantation area doesn't have related with attitude level.

RECOMMENDATIONS

1. Priority list of trees and medicinal plants can be applied in planting these plants in the old rubber plantation. Appropriate planting design can be set up by establishing the permanent plot for more detailed studies. Suitable silvicultural practices can be performed so as to stimulate tree growth and improve stem quality.

2. Enrichment planting in the old rubber plantation with suitable edible plants like *Parkia speciosa*, *Parkia timoriana*, *Gnetum gnemon* var. *gnemon* are recommended.

3. In this study in Phatthalung, Nuan (*Garcinia eugeniaefolia*) had high density, frequency and grown well under rubber tree covering. The next research should be continued in propagation and assess on intercropping between Nuan and rubber tree prior to the promotion to farmers.

4. In term of medicinal plants, Tan Bid (*Schizaea digitata*) was the most important medicinal species for uses in household in Phatthalung site but it had lower IVI. So these species should be conserved or well care in nursery and release replant in the natural forests or in the old plantation. In Nakhon Si Thammarat, Do mai ru lom (*Elephantopus scaber*) had highest IVI and it was an important medicinal species.

LITERATURE CITED

Bhumibhamon, S. 1983. **Foreest Genetics in the Tropics.** Faculty of Forestry, Kasetsart University.

Bishop, J.G. and D.W. Shenske. 1998. Variation in flowering phenology and its consequences for lupines colonizing Mount St. Helens. **Find Articles.** Available Source: http://www.findarticles.com/p/articles/mi_m2120/is_n2_v79/ai_20574297, May 21, 2006.

Chameekorn, S. 1983. **Analyze Statistics in Social Science Research.** Department of Statistics, Faculty of science, Kasetsart University.

Chandrashekar, T.R., M.A. J.G. Nazeer, G.P. Prakash, K. Annamalainathan and J. Thomas. 1998. An analysis of growth and drough tolerance in rubber during the immature phase in a dry sunhumid climate. **Expl.** 34: 287-300.

Chisalee, P. 2002. **Attitudinal of Villagers on Khaoson Community Forest, Tambon Khaokrapuk, Amphoe Tayang, Changwat Petchaburi.** Royal Forest Department.

Curtis, J.T. and R.P. McIntosh. 1951. An Upland Forest Continuum in the Prairie-Forest Border Region of Wisconsin. **Ecology** 32: 476-498.

Department of Agriculture. 2003. **Rubber.** Department Of Agriculture, Bangkok.

Devakumar, A.S., P.G. Prakash and M.B.M. Sathik. 1999. Drought althers the canopy architecture and micriclimate of *Hevea braziliensis* trees. **Trees** 13: 161-167.

Etherington, J.R. 1975. **Evironment and Plant Ecology.** Wiley, London.

Food and Agriculture Organization. 2000. **Asia-Pacific Forestry Sector Outlook Study: The Utilization, processing and demand for Rubberwood as a source of wood supply.** FAO, Thailand.

Goth, E., P. Chantuma, U. Silpi, A. Chantuma, P. Thaler, S. Thanisawanyangkura and J. Kosaisawe. 2001. Compettition between growth and rubber production of *Hevea braziliensis*: havest index and metabolic efficiency of three clones in a non-traditional area (Chachoengsao province, Thailand). *In* **Rubber seminar ogganized by KU-DORAS Center/DAO-RRIT/CIRAD-CP on June 6th 2001**, Kasetsart University, Bangkok.

Herath, P.H.M.U. and H. Takeya. 2003. Factors determining intercropping by rubber smallholders in Sri Lanka: a logit analysis. **Agriculture Economics.** 29: 159-168.

Hill, K. 2001. Beach Habitats. **Smithsonian Marine Station.** Available Source: http://www.sms.si.edu/IRLSpec/Beaches.htm, January 4, 2006.

Hill, M.O. 1973. Diversity and evenness: A unifying notation and its consequences. **Eco.** 54: 427-432

International Rubber Study Group. 2005. **The Rubber Industry of Thailand (Review Process and Prospects to 2020).** Rubber Research Institute of Thailand, Bangkok.

Keermaeker, L.D., L.M. Marlens, K. Verheyen, M.Hermy, A.D. Schrijver and N. Lust. 2003. Impact of soil fertility and isolution on diversity of herbaceous woodland species colonizing afforestation in Muizen forest (Balgium). **Forest Ecology and Management.** 188: 291-304.

Kermanee, P. 1985. **Anatomy of *Hevea brasiliensis* (Willd. Ex A. Juss.) Muell. Arg. Traditional Variety and RRIM 600 Clone.** M.S. thesis, Kasetsart University.

Krishna, T.M., C.V.S. Bhaskar, Rao, T.R. Chandrashekar, M.R. Vijayakumar. 1991. Effect of irrigation on physiological performance of immature plant of Hevea braziliensis in North Konkan. **India J. Nat. Rub.** Res. 4(1): 36-45.

Krishnapillay, B., L.H. Ang and M.A.A. Razak. 2003. Agroforestry Research and Development in Malaysia, 50-65. *In* B. Thaiutsa, L. Pungchit, D.K. Lee and S.W. Ahn. **Role of Agroforestry in restoration of Degraded Forest Ecosystem.** Aksorn Siam Printing, Bangkok.

Kutintara, U. 1998. **Fundamental Basics in Forestry.** Faculty of Forestry, Kasetsart University, Bangkok.

Land Development Department. 1987. **Soil Surveying Report.** Land Development Department, Ministry of Agriculture and Cooperative.

Land Development Department. 2004. **Soil-Plant Analysis.** Land Development Department, Ministry of Agriculture and Cooperative.

Lemenih, M., T, Gidyelew. and D, Teketay. 2004. Effect of canopy cover and undestroy environment of tree plantations on richness, density and size of colonizing woody species in southern Ethiopia. **Forest Ecology and Management.** 194: 1-10.

Maneekul, R. 1998. **Dissonance among, and response of Ban Sam Phak Nam Village in Phu Pha Man National Park, Northern Thailand.** M.S. thesis, Kasetsart University.

Marglef, R. 1958. Information theory in ecology. **General Systematic.** 3: 36-71.

Mueller-Dombois, D. and H. Ellenberg. 1974. **Aims and Methods of Vegetation Ecology.** John Wiley and Sons, Inc., Canada.

Nation Research Council of Thailand, 2004. **Status and Priority of National Research Project in Agriculture and Agro industry.** Aksorn Siam Printing, Bangkok.

Neeranathpibul, J. 2002. **Plant Species Diversity and Soil Properties Change in Diffeent Teak Plot Ages of Maehad Plantation, Nongmuangkahi District, Phrae Province.** M.S. thesis, Kasetsart University.

Paardekooper, E.C. and S. Sookmark. 1969. Diurnal variations in latex yield and dry matter content and relation to the saturation deficit of the air. **Rubber Res.** 21: 341-347.

Panichpan, S. 2005. **Media Affecting Opinion of Backpackers' Tourist to Visit Thailand.** M.S. thesis, Kasetsart University.

Rao, P.S., C.K. Saraswathyamma and M.R. Sethuraj. 1998. Studies on the relationship between yield and metrological parameters of para rubber tree (*Hevea braziliensis*). **Agr. Forest Meteo.** 90: 235-245.

Rao, P.S., C.K. Saraswathyamma and M.R. Sethuraj. 1998. Studies on the relationship between yield and metrological parameters of para rubber tree (*Hevea braziliensis*). **Agr. Forest Meteo.** 90: 235-245. Cited M.R. Monteny, B.A., Barbier, J.M., Bermos, C.M. 1985. In: Hutchison, B.A., Hicks, B.B. eds. **Determination of the Energy Exchange of a Forest-Type Culture: *Hevea brasiliensis*.** Reidel Publishing, Dordencht.

Rao, P.S. and K.R. Vijayakumar. 1992. Climatic Requirements, pp. 200-219. *In* M.R. Sethuraj, N.M. Mathew, eds. **NATURAL RUBBER: Biology, Cultivation and Technology, Development in Crop Science 23**. Elsevier, Amterdam.

Rishi, P. 2006. Joint forest management in India: An attitudinal analysis of stakeholders. **Resource Conservation and Recycling.** 1-10.

Roasal, J., G. Cuenca., N. Ramirez and Z. De Andrade. 1997. Native Colonizing Species and Degraded Land Restoration in La Gran Sabana, Venezuela. **Restoration Ecology.** 5: 147-155.

Rubber Research Institute of Thailand. 2005. **Rubber Knowledge 2004.** 5st ed. Department Of Agriculture, BAngkok.

Rubber Research Institute of Thailand. 2006. Thailand Rubber Statistics. **Rubber Knowledge.** Available Source: http://www.rubberthai.com, September 23, 2006.

Shannon, C.E. and W. Weaver. 1949. **The mathematical theory of communication.** Univ. Illinois Press, Urbana.

Soil Division Staff. 1976. **Principle of Soils.** Kasetsart University, Bangkok.

Soil Division Staff. 2001. **Principle of Soils.** Kasetsart University, Bangkok.

Somboonsuke, B., P. Cherdchom. 2000. Socio-Economic Adjustment of Smallholding Rubber-Based Farming System: Case Study in Southern Region Thailand. **Kasetsart J.** 21: 158-177.

Su, Z.Y. and L.H. Zhao. 2003. Soil properties and plant species in an age sequence of *Caragana microphylla* plantations in the Horqin Sandy Land, north China. **Ecological Engineerin**g**.** 20: 223-235.

Thaler, P. and L. Pages. 1996. Periodicity in the development of the root system of young rubber tree (*Hevea braziliensis* Muell. Arg.): relationship with shoot development. **Plant Cell Evn.** 19: 56-64.

Thompson, L.M. and R.T. Frederick 1973. **Soils and Soil Fertility.** 3rd ed., McGraw-Hill, Inc., America.

Vijayakumar, K.R., S.K. Dey, T.R. Chandrasekhar, A.S. Denvakumar, T. Mohankrishna, P. Sanjeeva Rao and M.R. Sethuraj. 1998. Irrigation requirement of rubber trees (*Hevea braziliensis*) in the subhumid tropics. **Agr. Water. Manage.** 35: 245-259

Watson, G.A., P.W. Wong and R. Narayanan. 1964. Effects of cover plants on soil nutrient status and growth of Hevea III : A comparison of leguminous creepers with grasses and *Mikana cordata*. **J. Rub. Res. Inst. Malaysia.** 18: 80.

Webster, J.M. and W.J. Bualkwill. **The botany of the rubber tree.** Longman Scientific and Technical Publisher, New York.

Yamane, T. 1973. Statistics: **An Introductory Analysis.** 3rd ed. Times printer, Singapore.

Yingjajaval, S. and J. Bangjan. 2001. Biomass of rubber tree in the lower part of southern, pp. 1-25. *In* Anonymous, eds. **Kaset ku chart annual reported 2000**. Kasetsart University, Bangkok.

Young, A. 1997. **Agroforestry for Soil Management.** 2nd ed., BPCC Wheatons Ltd, United Kingdom.

APPENDIX

Interview schedule No……

Interview Schedule

Title: The attitude of rubber smallholders toward rubber intercrop planting at Phatthalung and Nakhon Sri Thammarat Province.

Explain;

1) The interview schedule comprises 4 sections as followed;

1.1) Socio-economic data of rubber smallholder

1.2) Rubber planting data

1.3) The attitude of rubber smallholder toward rubber intercrop planting.

1.4) Problems and recommendations of rubber smallholder about rubber intercrop planting

2) The data will be taken to evaluate the assessment thesis title: Diversity of Trees, Medicinal Plants and Soil Properties in Old Rubber Plantation: Case Study of Rubber Agroforestry Smallholding Phatthalung and Nakhon Sri Thammarat.

3) Please put a tick (✓) in the space provided at the front of every question that you think match you the most.

Interviewee's name ( ) Mr. ( ) Miss ( ) Mrs. …….

Address……...

Interviewer.....

Date.....

Section 1: Socio-economic data of rubber smallholder

1.1 Gender

( ) Male ( ) Female

1.2 Age……..years

1.3 Religion

( ) Buddhist ( ) Muslim ( ) Other

1.4 Civil Status

( ) Single ( ) Married

( ) Separated ( ) Widow/er

1.5 Household status

( ) Household head ( ) Household member

1.6 Do you have a social status?

( ) Yes ( ) No

If yes, What is your social status?

( ) Village committee ( ) Member of village activity

( ) Teacher ( ) Village head

( ) Member of subdistrict administration committee

( ) Other (specify)……

1.7 How many members in your household?.....persons

( ) Male……..persons ( ) Female……persons

1.8 Highest education attainment

( ) Never attended school ( ) Primary school

( ) Secondary school ( ) High school

( ) Diploma ( ) Bachelor

( ) Postgraduate

1.9 Where is your hometown (old domicile, Province)?

( ) Here

( ) Move from other place cause by;

( ) Family

( ) Occupation

( ) New planting area

1.10 How long have you been settle in this village?

( ) 1 – 5 years ( ) 6-10 years ( ) 11-15 years

( ) 16 – 20 years ( ) 21 – 25 years ( ) > 25 years

1.11 Do you have a secondary occupation?

( ) No ( ) Yes (specify)…….

1.12 How much your household income (approximately baht) per year?

( ) < 20,000 ( ) 20,001- 40,000

( ) 40,001-60,000 ( ) 60,001-80,000

( ) 80,001-100,000 ( ) > 100,000

1.13 How much your household expend (approximately) per month and what for? ……. baht.

( ) Food ( ) Clothes

( ) Education ( ) Health care

( ) Business development ( ) Machine and vehicle repaired

( ) House restored ( ) Consumption

( ) Entertainment ( ) Charity

( ) Accommodation ( ) Other

1.14 Are you having debt?

( ) Yes ( ) No

1.15 How many your owner area?

( ) NS 3.....Rai

( ) SK 1).....Rai

( ) SPK.....Rai

( ) Title deed.....Rai

( ) Other.....Rai

Section 2: Data of Rubber planting.

2.1 How many your own rubber plantation area? …….Rai

2.2 How many the product of latex (approximately)……Kg/day

2.3 Did you plant some intercrops in your rubber plantation area?

( ) Yes ( ) No

If yes; Please do No. 2.3.1 -2.3.5

2.3.1 What is the species of intercrop?

1.1).....
1.2).....
1.3).....
1.4).....

2.3.2 When do you plant the intercrop?

( ) Plant together with rubber tree
( ) Plant after planted rubber tree
( ) The remained trees before planting rubber tree

2.3.3 How do you plant the intercrop?

( ) Plant between the row of rubber tree
( ) Plant on the edge of plot
( ) Plant spread everywhere
( ) Other (Specify).....

2.3.4 Where is the source of intercrop from?

( ) Buying from the private orchard
( ) Buying from the government institute
( ) Propagated from mother trees
( ) Supported from the government institute
( ) Collect from natural forest
( ) Other (Specify).....

2.3.5 What is the utilization of intercrop?

( ) Utilize in household

( ) Utilize in household and share out to the neighbour

( ) Selling merchant

( ) Process the product for selling

( ) Other (Specify).....

2.4 Are you supported from the institute about your planting rubber tree?

( ) Yes ( ) No

If yes; Please do 2.4.1-2.4.2

2.4.1 What is the institute support you?.....

2.4.2 What is the kind of helping that you receive from the institute?

( ) Seedling ( ) Fund

( ) Chemical fertilizer ( ) Academic document/Knowledge

( ) Other (Specify) .....

2.5 What is the kind of latex product that you sell?

( ) Latex ( ) Rubber sheet

( ) Latex residue ( ) Others (specify).....

2.6 Where do you sell your product?

( ) Merchant ( ) Center market

( ) Others (specify).....

<u>Section 3:</u> The attitude of rubber smallholders toward rubber intercrop planting

Note; the attitude scale in each level are;

5 = Strongly agree

4 = Agree

3 = Neutrality

2 = Disagree

1 = Strongly disagree

Items	Attitude scale				
	5	4	3	2	1
1. Rubber intercrop planting increases income for farmer					
2. Rubber intercrop planting reduces latex product					
3. Rubber intercrop planting humidified tap area is unable to tap					
4. Rubber intercrop planting can not be livestock in rubber plantation					
5. Rubber intercrop planting had more investment and less revenue than monoculture					
6. Annual rubber intercrop planting early 1-3 years better than tree and fruit tree					
7. Rubber intercrop planting make more product than monoculture					
8. Rubber intercrop planting make product diversity					
9. Rubber intercrop planting maintains soil moisture					
10. Rubber intercrop planting makes better fertile soil					
11. Rubber intercrop planting make soil and water conservation to community					
12. Rubber intercrop planting can be use intercrop plant for household and share out neighbour					
13. Rubber intercrop planting can be edible plant					
14. Rubber intercrop planting is harmful for tapper					

Items	Attitude scale				
	5	4	3	2	1
15.Rubber planting mix medicinal plant can be use in household and share out to neighbour					
16. Rubber intercrop planting is habitat of wild animal such as bird, squirrel, etc.					
17. Rubber intercrop planting reduces the forest encroachment					
18. Rubber intercrop planting reduces chemical fertilizer application					
19. Rubber intercrop planting reduces herbicide use and labour for weeding					
20. Rubber intercrop planting is makes species diversity in rubber plantation and conserve native species					
21. Rubber intercrop planting is tool for sustainable agriculture					

<u>Section 4</u> Problems and recommendation on attitude of smallholder toward intercrop planting

4.1 What are your problems in rubber intercrop planting?

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4.2 What are your recommendation for problem in 4.1?

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