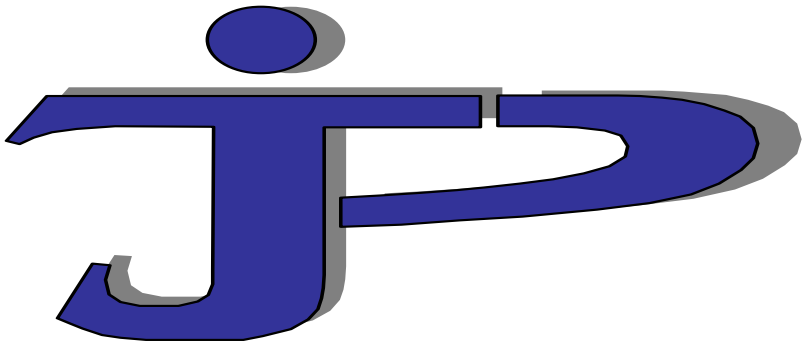
ISSN 1858-2419
Vol. 2 No. 2



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JURNAL TEKNOLOGI PERTANIAN
UNIVERSITAS MULAWARMAN
Volume 2 Nomor 2
Maret 2007

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INFLUENCE OF SHADE TREE GROWTH ON YIELD AND SUGAR CONTENT OF PINEAPPLE (*Ananas comosus*) IN AGROFORESTRY SYSTEM

Pengaruh Pertumbuhan Naungan Pohon terhadap Hasil dan Kandungan Gula dari Nenas (Ananas comusus) dalam Sistem Agroforestry

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Received 10 July 2006 accepted 20 September 2006

ABSTRACT

Reforestation activity has been implemented in East Kalimantan province by local, small- or medium-scale farmers as a part of their daily farming activity. This farming system has been called "Agroforestry". In agroforestry system, farmers cultivate the crops on forest floor and earn an income until the timber has an economic value. After forest formation, the soil erosion is prevented and the fallen leaves and twigs become a land fertilizer. These fertility recovery mechanisms become a preparation of next term agroforestry management. And it is being watched with interest as a sustainable land use system. It is easy to make an agroforestry planning, in case the short period earning crops, but in case the long term earning crops, it is feared that the shade providing trees would decrease the productivity and profitability of the crops. The objective of this paper is to discuss the influence of tree shade within the agroforestry system in East Kalimantan province. Research was conducted on rubber tree (*Ficus elastica*) and pineapple (*Ananas comosus*) farms in Central Kutai regency, East Kalimantan province. The results of the rubber farm measurements show that, as the rubber tree growing up, the quality and quantity of the pineapple decrease. In case the relative sunlight intensity of 80 %; the concentration of sucrose, glucose, and laevulose were 8.46, 1.94, and 2.93 %, respectively. When the relative sunlight intensity was 40 %, the concentration of sugar was decrease to 8.19, 2.31, and 2.99 % for sucrose, glucose, and laevulose, respectively. Moreover the sucrose, glucose, and laevulose decreased to 5.37, 3.51, and 3.41, respectively when relative sunlight intensity was 20 %, and the pineapple had no capability to bear the fruit any longer at relative light intensity less than 20 %. Pineapples bear fruit until 6th year, and one year before it, some rubber tree starting the harvesting of resin. Therefore the agroforestry system realized the economical sustainability of farmer's life. It is expected that reforestation by local, small-scale farmers within the agroforestry practice will become a new industry, which enables sustainable crops-growth production through effective control of sunlight conditions. This type of small-scale industry maybe accessible to large communities of farmers, which is possibly through a system of cooperative trade, will lead to the economic construction for stabile society.

Key word: Agroforestry, light intensity, sucrose, glucose, laevulose.

INTRODUCTION

East Kalimantan is the largest province in Republic of Indonesia and 245,237.80 km^2 in size with a human population of 2.8million individuals in 2003. Due to the exploitation of abundant natural resources, the regional gross domestic product (RGDP) has reached Rp 98.4 trillion in year of 2003 and its average annual economical increment is 4.48 %. Although the oil and gas sector generate 56 % of all RGDP, this sector produces employment opportunities for only 4 % of all working population. The agriculture sector provides employment for 36 % of the working population and executed the large scale production of export commodities

like pulp, cacao, palm oil and shrimp aquaculture encouraged by local government for several decades. This economical policy has caused differences in income between a small group of wealthy and large group of poor people. While once over 26 plywood industry-factories operated, these now also face a crisis caused by the lack of raw material. Some plywood factories have shifted towards plantation wood for the production of particle board or medium density fiberboard. (Badan Pusat Statistik Propinsi Kalimantan Timur, 2005)

Under these current prevailing circumstances East Kalimantan Province has started reforestation activities executed by local small-scale farmers. This type of farming system is traditionally called "Tumpang Sari" and nowadays is called "Agroforestry". Agroforestry is the collective name for all land-use systems and practices in which woody perennials are deliberately grown on the same land management unit as crops and/or animals. This can be either in some form of spatial arrangement or in a time sequence. To qualify as agroforestry, a given land-use system or practice must permit significant economic and ecological interactions between the woody and non-woody components. The ultimate objective of agroforestry is not timber production but sustainable land use and food production. To achieve this objective, agroforestry management seeks to optimize the positive interactions between components of the system in order to achieve a more productive, sustainable and/or diversified output from the land (Lundgren, 1987). The interactions exist on each stratum, from root systems which benefit from micolyzal symbiosis and fertilization via nitrogen fixing functions, to forest crowns influenced by the distribution of sunlight which in turn determine temperature and humidity.

Nevertheless, only a few research about the quality and quantity transition based on the dynamics of succession of agroforestry field. Therefore, we try to clear the relationship between relative sunlight intensity of the forest floor and productivity and quality of farming product. The objective of this paper is to verify the role of shade trees within the agroforestry system from both physiological and economical aspects.

MATERIAL AND METHODS

Study site

The study site was a rubber farm in Central Kutai regency Samboja, East Kalimantan Province. Annual precipitation is 2000-2500 mm, the dry season came from June to October. Annual air temperature in 2004 were 22.4 and 34.5 ^{o}C for minimum and maximum, respectively. The measurement was done on several years old rubber farm namely, one year, three years, five years, and seven years. Rubber tree (*Ficus elastica*) planted at inter-val of 3 m x 6 m and the pineapples (*Ananas comosus*) planted between the rubber tree line. Each plants row made in East to West direction and there were three pineapples ridges, regarded 1) north ridge, 2) center ridge and 3) south ridge. The distance of each ridge was one meter. Each pineapple ridge set the quantum sensor on the 1.5 m height from land surface. The light intensity was measured by LI-19SA Quantum Sensor and LI-1400 Data Logger (LI-COR, Inc.) The sensor measures photosynthetically active radiation (PAR) in the 400 to 700 nm wavebands. The unit of measurement is micro moles radiation per second per square meter (μmol s-1 m-2). On this paper, all of sunlight intensity conversed to unit of percentage (%) which compared with open space sunlight intensity.

The total sugar content of the pineapple was measured at Laboratory of Silviculture and Landscape Nihon University in Japan. The sample was chosen the same maturation level and size (Figure 1.).

Figure 1. Pineapple fruit body. From left, the fruit was grown under relative light intensity of 20, 40, and 80 %.

One grams of dry pineapple sample was extracted by 19 grams of Ultra Pure Water. Sugar concentration was analyzed by High Performance Liquid Chromatography Shimadzu LC-6A, degasser DGU-3A, Analysis Column Shim-pack SCR-101N, Guard Column SCR(N), column comportment CTO-10A, column temperature at 40 ^{o}C, Refractive Index Detector L-3300 RI Detector (Hitachi corp.). The ultra pure water was used as a mobile-phase and the flow rate was 1.2 mL min^{-1} injection sample used micro syringe and the injection amount was 10 μL. The chromatogram was recorded with chromatopac C-R5A (Shimadzu corp.).

RESULT AND DISCUSSION

One year old rubber farm

The rubber tree planted in East to West direction. The pineapple cultivate ridge was divided from left south ridge, center ridge and north ridge. One year after rubber tree planted, the height of rubber was less than one meter. The relative light intensity on pineapple leaves reaches 80-100 %. In this age pineapple fruit was produced of 5,805 kg ha^{-1} (Figure 5-A)

The result of total sugar content chromatogram shows in Figure 2. The sugar analyzed of pineapple fruit by HPLC showed that there are three kinds of sugar in pineapple. They are sucrose, glucose, and laevulose. The retention time of sucrose, glucose, and laevulose were 8.198, 10.194 and 11.419 min., respectively. The average of moisture content of fruit was 83.72 %. The concentration of sucrose, glucose, and laevulose of the pineapple cultivated under one year old rubber farm were 8.46, 1.94, and 2.93 %, respectively.

Three years old rubber farm

After three years passed, the average diameter of rubber tree reached 6.1 cm and the height of tree was 5.5 m (Figure 5-B). Total production of pineapple fruit at this age reduced to 4,550 kg ha^{-1}.

The reduction of pineapple productivity was caused by the growth of rubber tree crown. As the rubber tree grew up, the shade of the crown expiation and it inhibited pineapple fruit production. The relative sunlight intensity was measured from 8:00 to 16:00 (Figure 5-C). From 8:00 to 11:00 there ware few difference among three ridge. But from 11:00 to 14:00 the center ridge got higher sunlight than south and north ridge, so that the center ridge had hard influence because of the shade of crown of rubber tree. On the other hand, the south and north ridge just had little influence of it.

The content of sucrose, glucose, and laevulose of pineapple cultivated under three years old rubber farm were 8.19, 2.31, and 2.99 %, respectively (Figure 3).

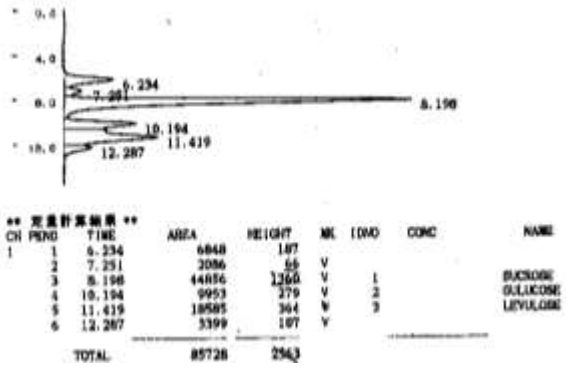


Figure 2. Chromatogram of total sugar of pine-apple cultivated under one year old rubber tree (relative light intensity 80-100 %).

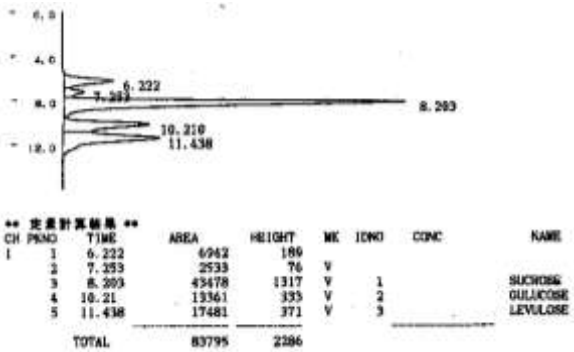


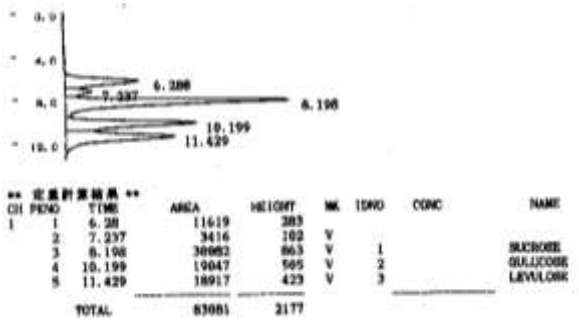
Figure 3. Chromatogram of total sugar of pineapple cultivated under three years old rubber tree.

Five years old rubber farm

After five years passed, the average diameter of rubber tree reached 8.3 cm and the height of tree was 7.4 m. Total production of pineapple fruit this year was 800 kg ha^{-1}. This year 110 trees (19.8 %) start to cultivate the resin. Average relative sunlight intensity

dropped to 21 % (Figure 5-D, E).

The content of sucrose, glucose, and laevulose of pineapple cultivated under five years old rubber farm were 5.37, 3.51, 3.41 %, respectively (Figure 4).



CH	PEND	TIME	AREA	HEIGHT	MK	IDNO	CONC	NAME
1	1	6.28	11619	383				
	2	7.237	3416	102	V			
	3	8.198	30982	863	V	1		SUCROSE
	4	10.199	19047	595	V	2		GULUCOSE
	5	11.429	18917	423	V	3		LEVULOSE
		TOTAL	83081	2177				

Figure 4. Chromatogram of total sugar of pineapple cultivated under five years old rubber tree.

Seven years old rubber farm

After seven years passed, the average diameter of rubber tree reached 12.5 cm and the height of tree was 9.7 m. Average sunlight intensity drops to 10 % and the pineapple cannot bear fruit any longer (Figure 5-F, G). Nevertheless almost all rubber tree were started to harvesting the resin.

Result of study indicated that, as the sunlight intensity decrease on the forest floor, the yield and the sucrose content of pineapple decrease. Figure 6 shows the change of sugar content of pineapple based on relative sunlight intensity. The pineapple which was grown under relative sunlight intensity of 80 and 40 % has a small deference, but the relative sunlight inensity of 40 and 20 % shows significant difference. This result showed the threshold value of sunlight exist between 40 to 20 % on East Kalimantan Province. So it is necessary in pineapple cultivation to have relative sunlight intensity above 40 % to get high sucrose content. The relationship between yield of pineapple production and relative sunlight intensity is shown at Figure 7. The productivity of pineapple correlated closely with relative sunlight intensity.

In case cultivate pineapple under combination rubber tree which plantation interval was 3 m by 6 m, it would be cultivated until fifth year. Over the fifth year, the crown of the tree had closed and the sunlight condition on forest floor does not suitable for pineapple cultivation. Nevertheless, before pineapple production finished, the rubber tree had been stated the resin harvesting. Therefore the farmer's economical sustainability was guaranteed (Figure 8).

For determinate the agroforestry management, the control of sunlight intensity distribution is the most important point. Distribution of sunlight was executed by controlling the plantation interval or the silvicultureal treatment like pruning. By suitable controlling of the sunlight distribution and suitable combination of plants, it would be realize the economical and ecological sustainable land use with a small capital.

The result of this study shows that, the importance of sun light distribution control. East Kalimantan province get a lot of natural energy like a sun light, rain fall, and year all stable climate. It is necessary to store, distribution and abolition of natural energy which enter unconditionally by human device. In case much capital, we can use heavy machine, green house, irrigation canal and synthesis land fertilizer. But under little capital, we must make same function by utilize the natural component. The latter system named agroforestry. The woody plants create shade, and it stabilizing temperature and humidity on the forest floor. In addition, woody plants have a water keep function and its fallen leaves and branches becomes a land fertilizer. In addition East Kalimantan province has a lot of useful shade tree.

It is expected the reforestation by local small scale farmer with agroforestry system become a new industry by taking advantage of good environment. Though, the small scale industry, but it carry on the impartial share of wealth, it will be leading to grow out of social structure which depend on a huge capital enterprise or small group of elite and construction of the economical stabile society.

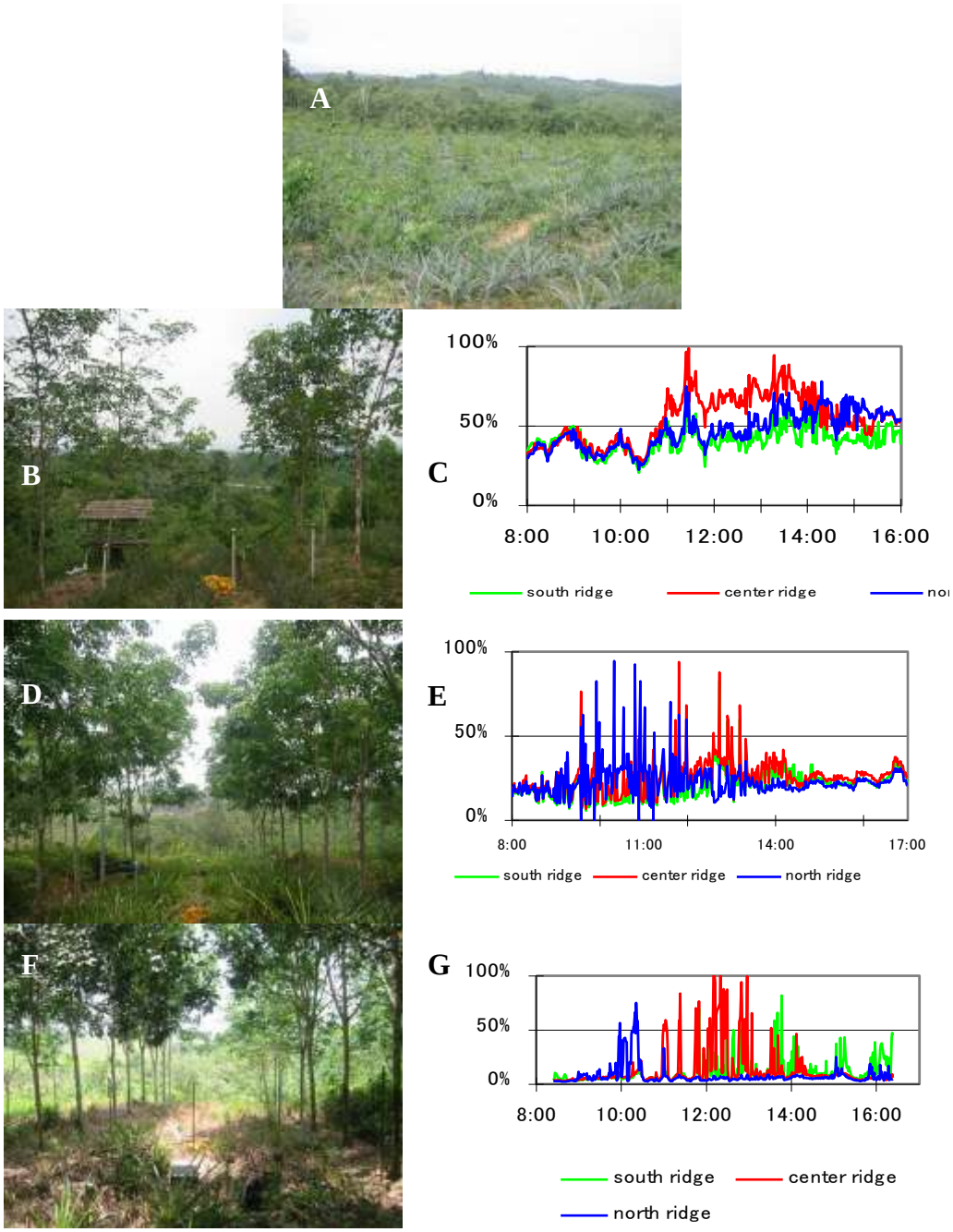


Figure 5. The growth of shade tree (rubber tree) and change of relative sunlight intensity on the forest floor. (A) One year old rubber farm; (B) The view of tree years old rubber farm. On the picture, the right side placed the north side; (C) Relative sunlight intensity of three yeas old farm, the average was 51 %; (D) The view of five yeas old rubber farm; (E) Relative sunlight intensity of five yeas old farm, the average was 24.4 %; (F) The view of seven yeas old rubber farm; (G) Relative sunlight intensity of seven yeas old farm, the average was 11.2 %.

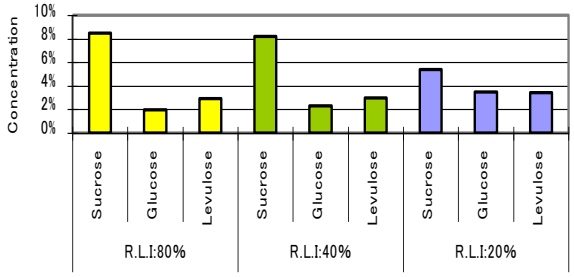


Figure 6. Sugar contents of pineapples grown under difference relative sunlight intensity condition. RLI=Relative Light Intensity

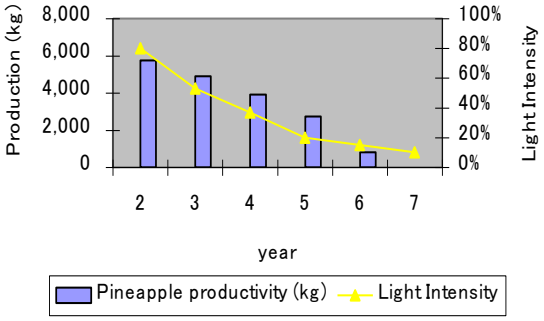


Figure 7. The relationship between the pineapple productivity and relative sunlight intensity.

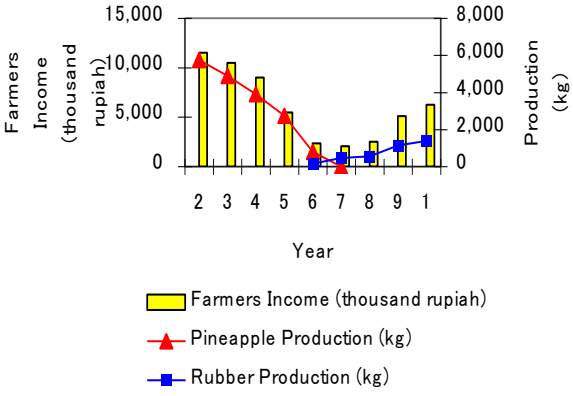


Figure 8. Total farmer's income based on the pineapple-rubber tree combination agroforestry model.

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