Section 4

Crops and the Cultivation Method in East Kalimantan

Contents

1. Preface

Indonesia is an archipelagic country consisting of more than 13,000 islands. At the present time, her population reaches 145 millions and the rate of annual growth is 2.3 - 2.4 %. If this growth would be continued, the population reaches 240 millions by 2,000 A.D. Consequently, the increasing population rises some problems such as deficiency of land for living, food, cloth and others. Therefore, Indonesian government is promoting 'family planning' on one hand and carrying out the projects to increase agricultural production in order to keep food for the people on the other.

One of that projects is the transmigration program from Java island which has high population to other island which have low population i.e. Sumatra, Sulawesi, Irian and Kalimantan.

In that transmigration program, some area in East Kalimantan i.e. Bukitbiru, Maluhu, Sebulu, Samboja and others have been developed for agricultural field. To meet this need, some forest land has been cleared by cutting. Each farmer gets 0.25 ha for farmyard and 2 ha for agricultural field.

Shifting cultivation is very common in this area which is being practiced by native farmers. This was done by clear cutting and burning the forest trees for agricultural purposes, and then left abandoned whenever the land showed the decline in soil fertility. Since, then, that farmer clear cut and burn other forest area for their new agricultural field.

Unfortunately, shifting cultivation was also done by some transmigrant which coming from Java and some by new settler from Sulawesi, etc. Consequently, it will contribute to destroy forest land. If that shifting cultivation is not prevented, the number of destructed forests would be increased from year to year.

Shifting cultivation is done by the farmer because the farmer, generally, does not know the appropriate methods for agricultural developments.

On the other hand, the farmer does not care about the negative effects of destructed forest for the eternal living of human being.

2. Purpose of This Survey

In order to develop agriculture in East Kalimantan, a great deal of importance should be attached to the selection of crops adapted to environmental conditions in the area and the establishment of the cultivation method for them. For that, basic problems in relation to crop cultivation must be understood in the first place.

East Kalimantan locates in the area of humid tropic forest. High temperature and humidity in this condition result rapidly the organic matter decomposition in the soil. Therefore, land productivity is lower than Java which has tropic climate.

In order to find the plans of high crop production with the control of shifting cultivation, appropriate crops and cultivation methods adapted to this condition should be developed. In this connection, the survey had been carried out by agricultural team of Mulawarman University in Indonesia and JICA team of Japan to extract the basic problems on crop growing in East Kalimantan.

3. Method of the Survey

Data collected from the survey are as follows:

A. Climate

Temperature and rainfall data were taken from the some Agricultural Services Agency in Tenggarong or weather station in Samarinda. These data were arranged and featured.

B. Kinds of Crops and Cropping Systems

Data were collected from field survey and hearing of the farmers. Kinds of cropts were listed.

C. Soil and Plant Growth Relationship

Plant height and root system of corn and pepper were measured. Soil sample was taken from a hole (0.7 x 0.7 x 1 m) digging to observe the soil profile and physical properties and the sample was analysed by soil easy tester (Fujihira Indust. Co. Ltd.) to find the chemical properties of soil and study.

D. Plant Deseases

Data were collected from field survey and the literature of Indonesian plant diseases. Kind of plant diseases in East Kalimantan were listed.

E. Weeds

Data were collected from field survey and the literature of Indonesian weeds. Kind of weeds in East Kalimantan were listed.

4. The Location of the Surveyed Area

(1) Surveyed Area

The field survey was tried at the following districts.

1) Tenggarong district, i.e. Loakulu, Maluhu, Rempanga and Bukitbiru.

2) Samarinda district, i.e. Kampung - Batuah and Loajanan.

3) Samboja district, i.e. Muara Java.

Hasfarm in Tenggarong district was added to the above location for the survey of the plant diseases.

(2) Topographical, Geographical and Geological Conditions

These were described in the detailed report regarding the "Land Use Classification based on Geology, Physiography, Soil and Vegetation" made by the Section 1.

(3) Climate

East Kalimantan is located across the equator between 4°21' North and 1°21' South. This area belongs to the tropical rain forest zone covered with evergreen broadleaf trees. Since the weather conditions in East Kalimantan were described in the report prepared by the Section 1, this section deals with the weather conditions of the surveyed area.

1) Temperature

The fluctuation of monthly mean, maximum and minimum temperature at Tenggarong and Balikpapan are shown in Fig. 1.

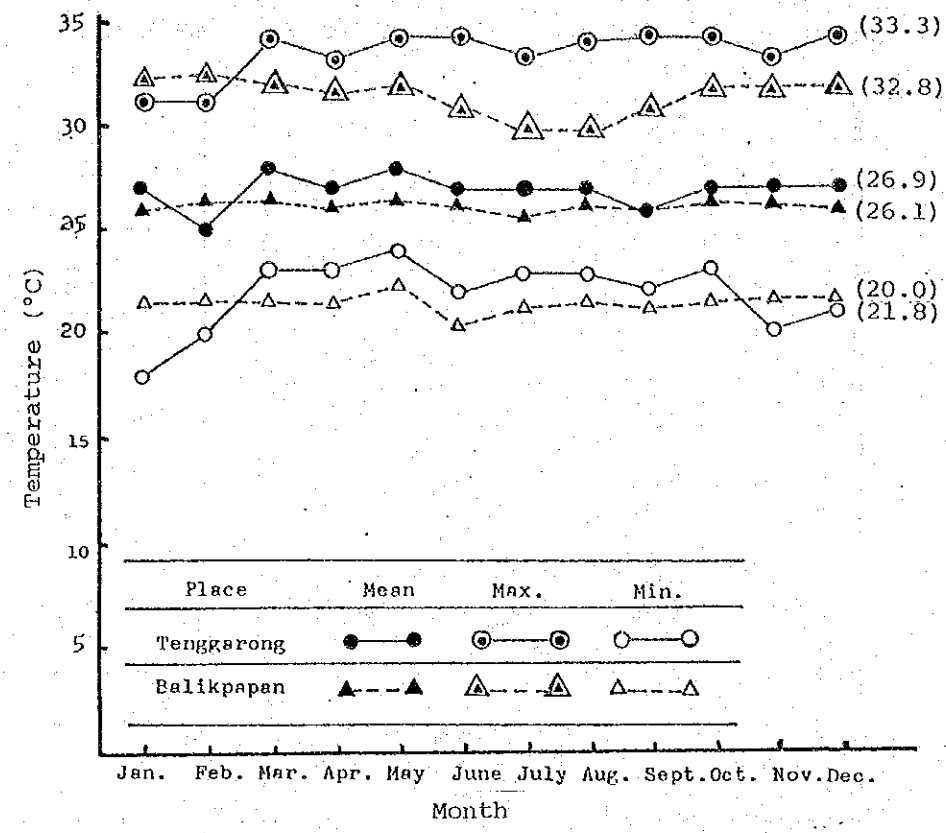

Fig. 1. Fluctuation of monthly mean, maximum and minimum temperature at Tenggarong and Balikpapan.
( ):Annual mean.

In both districts, the annual mean temperature is 26 - 27°C and, taking the case of Tenggarong, the difference among monthly mean is extremely small, namely, about 3°C. However, the daily difference in temperature reaches almost 10°C. Thus the temperature on the flat land (low land) in these area is high throughout the year, and it features that the seasonal changes of the temperature is considerably smaller than what is observed in the temperate zone such as Tokyo.

2) Precipitation

Precipitation in Tenggarong and Samarinda district changes as shown in Fig. 2. The annual mean precipitation in both district are approximately 2,000 mm. In addition, the average number of rainy days throughout the year exceeds 100, which means that there is rainfall in every 2 - 4 days (Table 1). However, since it is also known that the precipitation and the number of rainy days is changeable from year to year, the coefficient of variation of the

annual and monthly mean precipitation was examined.

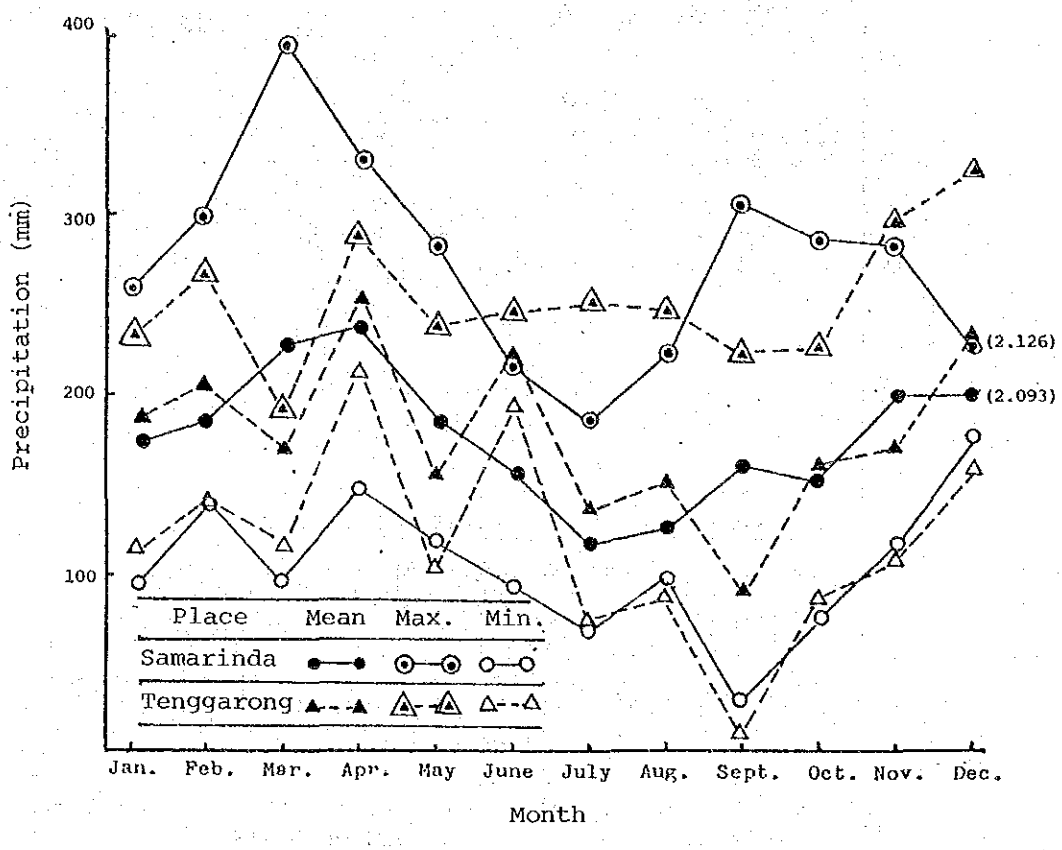

Fig. 2. Fluctuation of monthly mean, maximum and minimum precipitation at Samarinda and Tenggarong.
( ):Annual mean.

The results are shown in Table 2, in which the coefficient of variation in both districts is smaller than that of the temperate zone such as Tokyo, that is, the variations among years are shown to be small.

The monthly coefficient of variation is greater than the annual one, particularly that in September is greater than other months. Consequently, we suppose that, even if these area are located in the tropical rain forest zone, the drought injury may be occurred in some area taking consideration of the minimum precipitation (30 mm or less) in September with compact property of soil construction.

Table 1. Mean raindays at Samarinda, Tenggarong and Batu Ampar

Districts \ Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Samarinda*	8	9	10	11	10	9	7	8	8	8	10	12	110
Tenggarong*	17	16	15	15	16	15	10	14	9	16	16	18	177
Batu Ampar*	11	12	16	14	14	13	9	10	13	14	13	16	155

* Annual mean precipitation: Samarinda 2.093 mm, Tenggarong 2.126 mm, Batu Ampar 2.703 mm.

Table 2. Coefficient of variation on monthly and annual precipitation at Samarinda and Tenggarong

Districts \ Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Samarinda	37.4%	59.7	55.3	24.2	35.9	24.6	36.6	34.3	66.5	46.4	38.8	10.7	12.7
Tenggarong	17.1	25.7	20.0	13.4	38.0	10.0	56.6	50.9	103.4	37.1	50.0	32.7	13.7
Tokyo (Japan)	91.1	61.1	56.0	18.5	34.5	32.4	70.4	82.8	37.4	54.4	74.9	96.9	16.6

3) Other Factors

In general, most of the Southeast Asian Countries are covered with cloud throughout the year, and accordingly, sunshine duration is said to be less than possible duration of it. This phenomenon is said to appear most typical in the area coming up to the equator. In Jakarta (Java) that located in the tropical rain zone, sunshine duration reaches about 2,300 hrs. per year, less than 70 % of possible duration of sunshine. In Pontianak (West Kalimantan), right under the equator, it reaches about 2,200 hours per year.

Unfortunately, no data obtained about sunshine duration in the surveyed area available.

5. Results and Discussion

Most of the surveyed land located in a hilly area and there was no terraced field on the slope land like in central Java.

(1) Kinds of Crops Observed in the Transmigration Area

Number of crops observed during survey time in Tenggarong, samarinda and Muara Java reaches about 30 families with 50 genera (Table 3, Figs. 3 - 22) and, it seems that a detailed survey will reveal more species, especially, because almost no survey was made of ornamental plants. These crops can be classified as follows:

Table 3. Kinds of crops observed in transmigration area

Common name	Scientific name
Cereal crops	
*Lowland rice	Oryza sativa L. var. Indica Kato
*Upland rice	"
*Corn (Maize)	Zea mays L.
Root crops	
*Cassava (Mandioca)	Manihot esculenta Crantz.
*Sweet potato	Ipomoea batatas Lam.
*Taro	Colocasia esculenta (L.) Schott.
*Ginger	Zingiber officinale Roscoe
Lotus	Nelumbo nucifera Gaerth.

Common name	Scientific name	
Legumes		
*Peanut (Groundnut)	Arachis hypogaea L.	
*Mung bean	Phaseolus aureus Roxb.	
*Lima bean	P. lunatus L.	
*Soybean (Soya bean)	Glycine max (L.) Merr.	
*Winged bean	Psophocarpus tetragonolobus DC.	
Vegetable crops		
*Tomato	Lycopersicum esculentum Mill.	
*Egg plant	Solanum melongena L.	
*Chilli	Capsicum annuum L.	
*Ganges amaranth	Amaranthus gangeticus L.	
*Water-convolvulus (Swamp cabbage)	Ipomoea reptans (L.) Poir.	
*Cabbage	Brassica oleracea L.	
*Celery	Apium graveolens L.	
Lettuce	Lactuca sativa L.	
*Cucumber	Cucumis sativus L.	
Fruit and estate crops		
*Banana	Musa sapientum L.	
*Pineapple	Ananas comosus (L.) Merr. ----------	(Fig. 3)
*Citrus	Citrus Spp. ----------	(Fig. 4)
Bread-fruit tree	Artocarpus incisa L.f. ----------	(Fig. 5)
*Jackfruit (Nangka)	Artocarpus heterophyllus Lam.	
*Small-jack	Artocarpus integer L.f.	
*Gnemon tree	Gnetum gnemon L. ----------	(Fig. 6)
*Soursop	Annona muricata L. ----------	(Fig. 7)
*Avocado	Persea americana Mill. ----------	(Fig. 8)
*Carambola	Averrhoa carambola L. ----------	(Fig. 8)
*Mango	Mangifera indica L.	
*Cashew-nut tree	Anacardium occidentale L. ----------	(Fig. 9)
*Rambutan	Nephelium lappaceum L. ----------	(Fig. 10)
*Langsat	Lansium domesticum Jacq.	
*Durian	Durio zibethinus Murr.	
(Red/or yellow durian)	Durio zibethinus var. roseiflorus ----------	(Fig. 11)
*Mangosteen	Garcinia mangostana L. ----------	(Fig. 12)
*Papaya	Carica papaya L.	
*Malaya apple	Eugenia malaccensis L. ----------	(Fig. 13)
Wax jambu	Eugenia javanica Lam.	

Common name	Scientific name	
Guava	Psidium guayava L.	
Sapodilla	Achras zapota L.	(Fig. 14)
*Coconut palm	Cocos nucifera L.	(Fig. 15)
*Coffee	Coffea arabica L.	
*Cacao	Theobroma cacao L.	(Fig. 16)
*Clove	Eugenia aromatica Kuntze	
*Nutmeg	Myristica fragrans Houttuyn	(Fig. 17)
*Cinnamon	Cinnamomum zeylanicum Nees	
*Pepper	Piper nigrum L.	(Fig. 18)
*Mangrove	Rhizophora mucronata Lam.	
*Para rubber tree	Hevea brasiliensis Mueli. Arg.	(Fig. 19)
India-rubber tree	Ficus elastica Roxb.	
*Kapok	Ceiba pentandra (L.) Caern.	
*Oil palm	Elasis guineensis Jacq.	
Sago palm	Metroxylon Sagus Rott B.	(Fig. 20)
*Sugar palm	Arenga pinnata Merr.	
*Sugar cane	Saccharum officinarum L.	
Ornamentals		
*Orchids	Many species	
*Nobotan	Melastoma Spp.	(Fig. 21)
Pitcher plants	Nepenthes Spp.	(Fig. 22)
*Canna	Canna indica L.	
Edible canna	Canna edulis Ker.	

* Popular crop.

Fig. 3. Pineapple (Ananas comosus) field and collected fruits at bazaar.

Fig. 4. Citrus fruit (Citrus sp.) and the field at Tenggarong district.

Fig. 5 Bearing fruit of bread tree (Artocarpus Incisa).

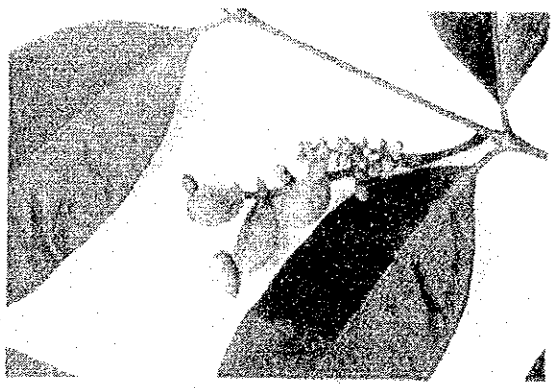

Fig. 6. Fruits and nut of Gnemon (Gnetum gnemon).

Fig. 7. Fruit of Soursop (Annona Muricata).

Fig. 8. Flowering and bearing fruits of Carambola (Averrhoa Carambola).

Fig. 10. Fruits of Rambutan (Nephelium lappaceum) at bazzar.

Fig. 9. Flowering and fruiting of Cashew (Anacardium occidentale).

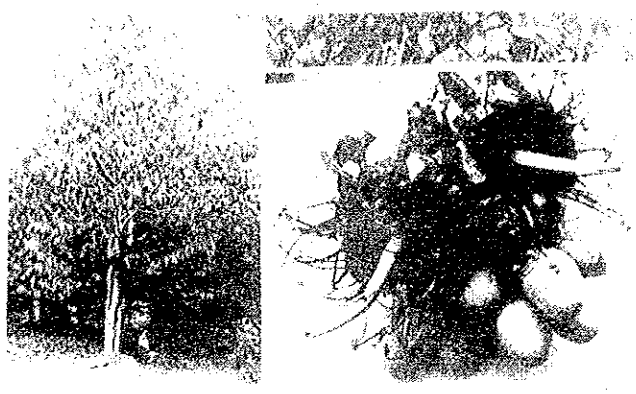

Fig. 11. Native durian tree (Durio zibethinus var. roseiflorus) and flowering.

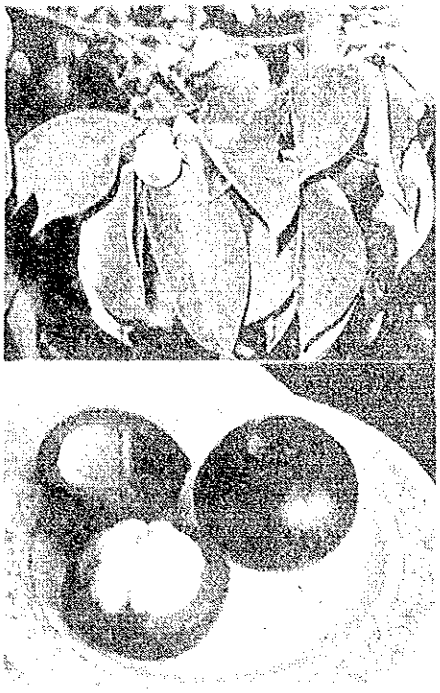

Fig. 12. Fruits of Mangosteen (Garcinia mangostana).

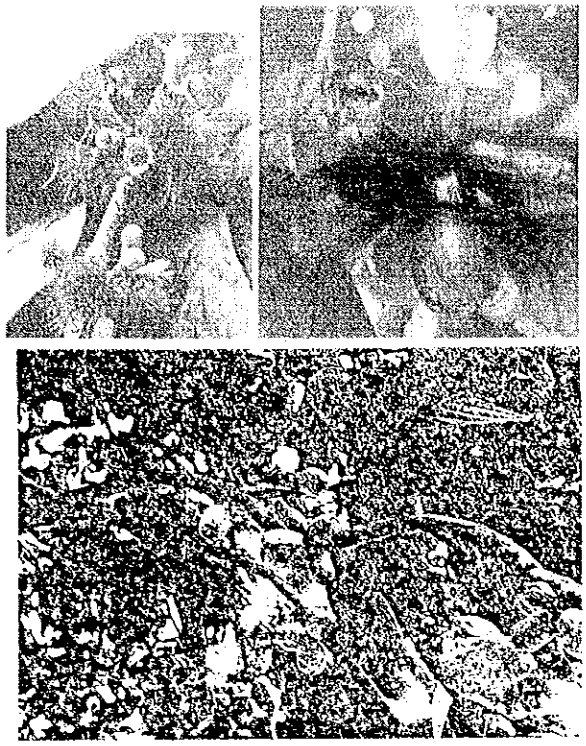

Fig. 13. Flowers and bearing fruits of Malay apple (Eugenia malaccensis).

Fig. 14. Bearing fruits of Sapodilla (Achras zapota)

Fig. 15. Coconut (Cocos nucifera) and plantation field.

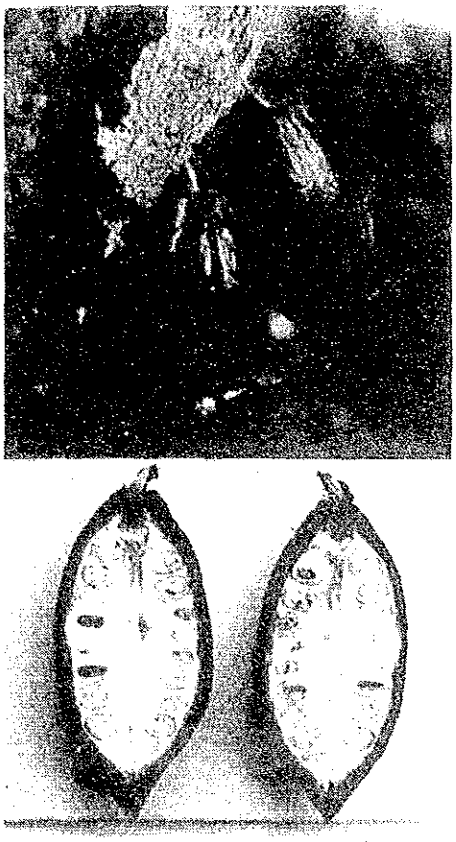

Fig. 16. Bearing fruits of cacao (*Theobroma cacao*).

Fig. 17. Field and fruits of nutmeg (Myristica fragrans).

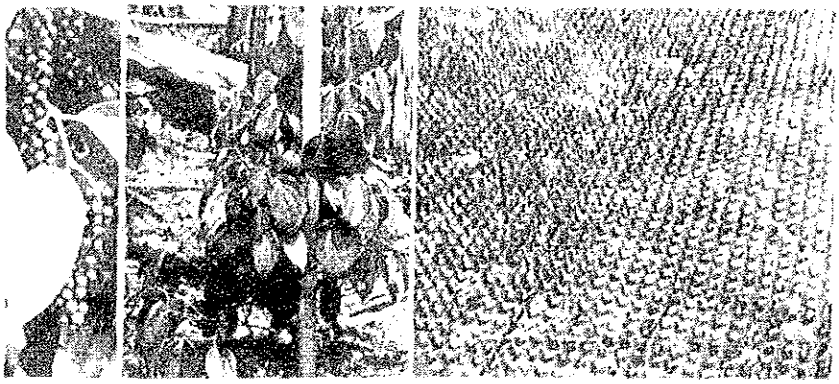

Fig. 18. Pepper (Piper nigrum) and plantation Field

Fig. 19. Para rubber tree (Hevea brasilliensis).

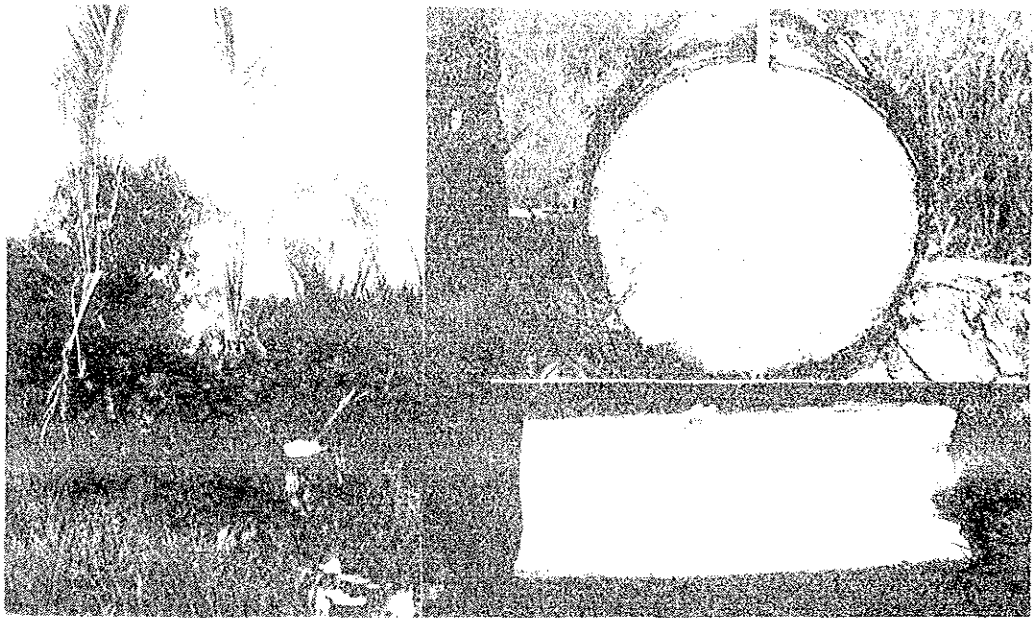

Fig. 20. Sago palm (Metroxylon sagus) and profile of the stem.

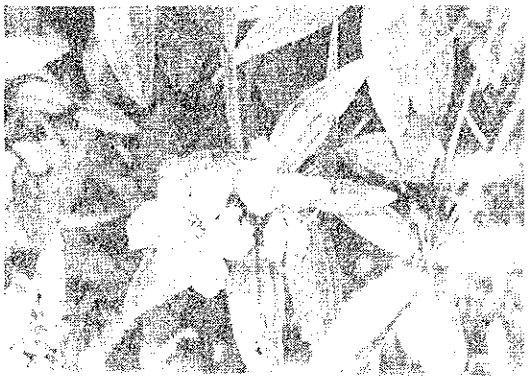

Fig. 21. Wild type of Nobotan (Melastoma Sp.).

Fig. 22. Wild type of pitcher plant (Nepenthes Sp.).

1) Annual Crops

The annual crops observed in the surveyed area were cereal, root, leguminous and vegetable crops. The most important crop is rice plant. The rice grows either in lowland or upland condition. The rice cultivation in East Kalimantan is mostly carried out through the shifting-cultivation by reclamation on upland and the rainfed (Table 4), and the rice cultivation is done single cropping a year in the surveyed area (Fig. 23).

The production of rice under upland condition is lower than lowland conditions. It is understandable because high temperature and humidity promote the organic decomposition which caused the decreasing of soil fertility rapidly. However, under lowland condition, the decreasing of soil fertility can be balanced by nutrients brought by irrigated water.

The irrigation system is not running well yet. The farmer in this area get difficulty in growing their rice due to lack of water. Suppose irrigation system is good enough, the weather condition would be enable to supply water for rice growing. Improvements of facilities for irrigation and draining, and proper operation of that ones while the above-mentioned weather conditions are taken into consideration, may be possible to grow two times cropping within a year in the rainfed for rice planting taking the weather condition together, since 4 - 5 months are required for paddy rice planting to harvesting within the surveyed area. Therefore, to increase rice production in lowland condition, it is suggested to promote good facilities for irrigation system.

In East Kalimantan, there are three types of lowland rice, it can be classified as follows:

A. Water logged or rainfed rice.

B. Deep water rice suitable for depth of about one meter.

C. Floating rice which can put up with water up to several meters deep.

Table 4. Acreage of rice cultivation in Kalimantan, Indonesia

Province	Upland rice	Lowland rice							Total rice area
		Irrigated lowland*			Rainfed	Swap (lebak)	Polder	Tidal	
		Guaranted	Partial	Simple					
West Kalimantan	115.500	-	5.700	29.210	179.650	-	-	25.000	355.060
Central Kalimantan	47.635	-	45.500	-	12.000	5.233	2.300	80.000	192.668
South Kalimantan	16.120	-	20.300	51.700	69.300	73.970	5.000	279.668	516.058
East Kalimantan	40.900	-	-	-	26.130	-	-	-	67.030
Total	220.155	-	71.500	80.910	287.080	79.203	7.300	384.668	1.130.816

* Public work and rural irrigation.

Data from Kumpulan data Statistic Tanaman pangan 1978.

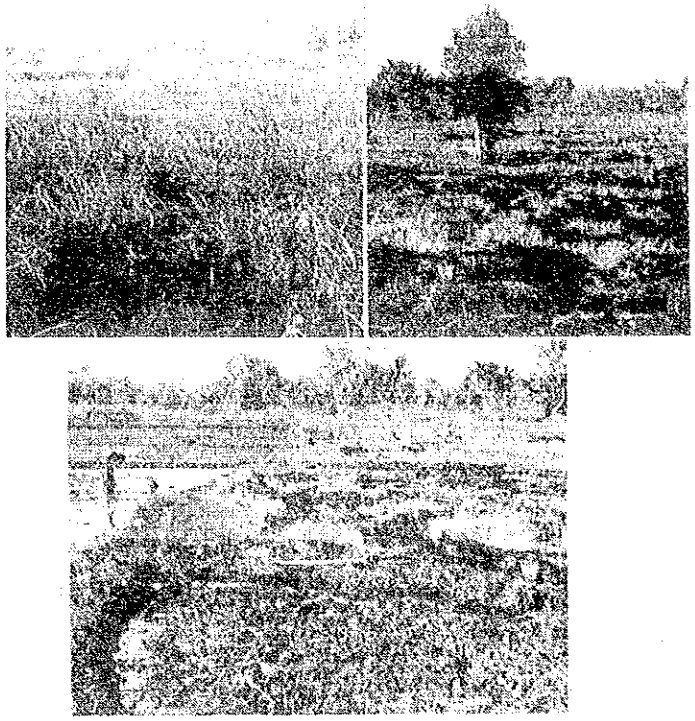

Fig. 23. Field preparation for planting of rice seedling on lowland paddy field (rainfed).

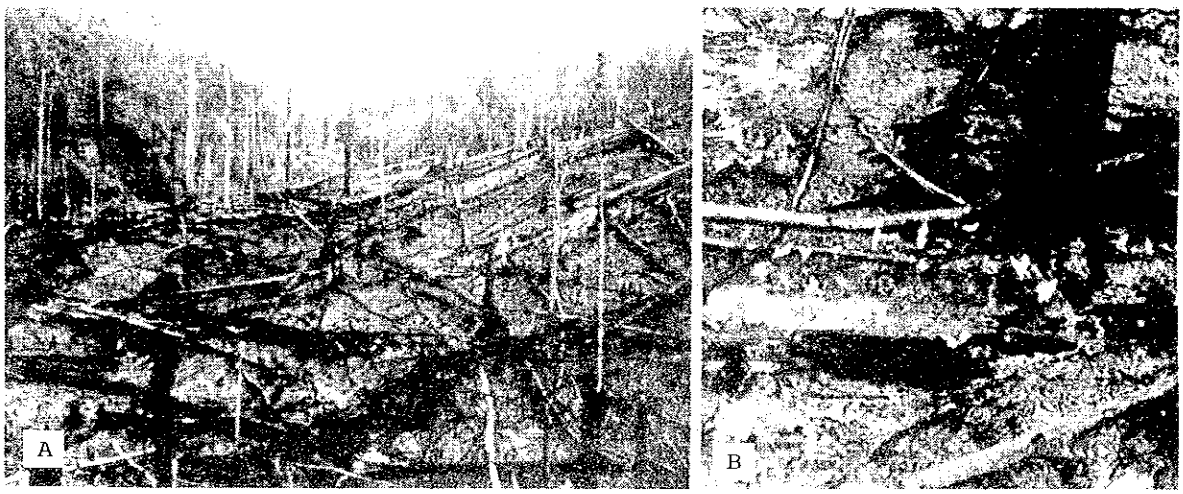

Fig. 24. Field just after burning for shifting cultivation(A) and mung bean cultivation (B).

In East Kalimantan, there is a lot of marshy land where still unused which can be developed for deep water rice and floating rice. This also requires the investigation of water level variation in the vast marshy land including the studies of stable irrigation and draining facilities. Besides, breeding program would play important role to develop rice cultivation adaptable to such condition.

As rice plants grown in upland fields in this area, there were glutinous rice and non-glutinous rice plants, both of which were growing by shifting and reclamation field on the slope land. In certain parts of this area, it was found that more glutinous rice than non-glutinous rice was cultivated and the rice played to have a role of important cash-crop.

Upland farming in East Kalimantan is carried out on the slope land of the hilly area because of topographic conditions. Deforestation and burning were employed to make cultivable field. According to the traditional shifting cultivation, The field was not plowing and no fertilizer application or manuring, and then the farmer moves to other places several years later when crop production had been lowered for the decline of soil fertility (Fig. 24).

In these fields under high temperature and humidity, it seems that the reduction of soil fertility is induced rapidly by the decomposition of organic matter contained in the soil and run-off of the soil nutrients. On the contrary, because paddy field is supplied the nutrients by irrigation water, it is rather easy to maintain the soil fertility in paddy fields as compared with upland fields.

Maize is the second crop that had been cultivated by the farmer in the surveyed area and the crop is planted in upland condition mostly in hilly land.

Cassava and sweet potato were also popular in these areas particularly planted by transmigrant.

Vegetables which are commonly planted by transmigrants are tomatoes, eggplants, cucumbers, chilli, ganges amaranth and cabbages. However, these vegetables are unusually planted by native farmers.

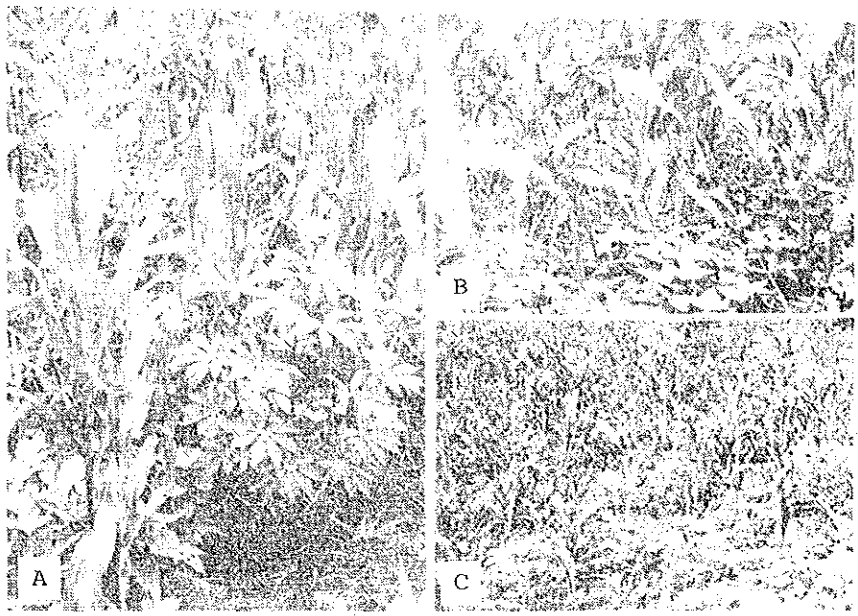

Fig. 25. Inter-cropping combined with herbaceous crops. Maize, sweet potatoes and cassavas (A), Maize and sweet potatoes (B) and *Maize and peanuts* (C).

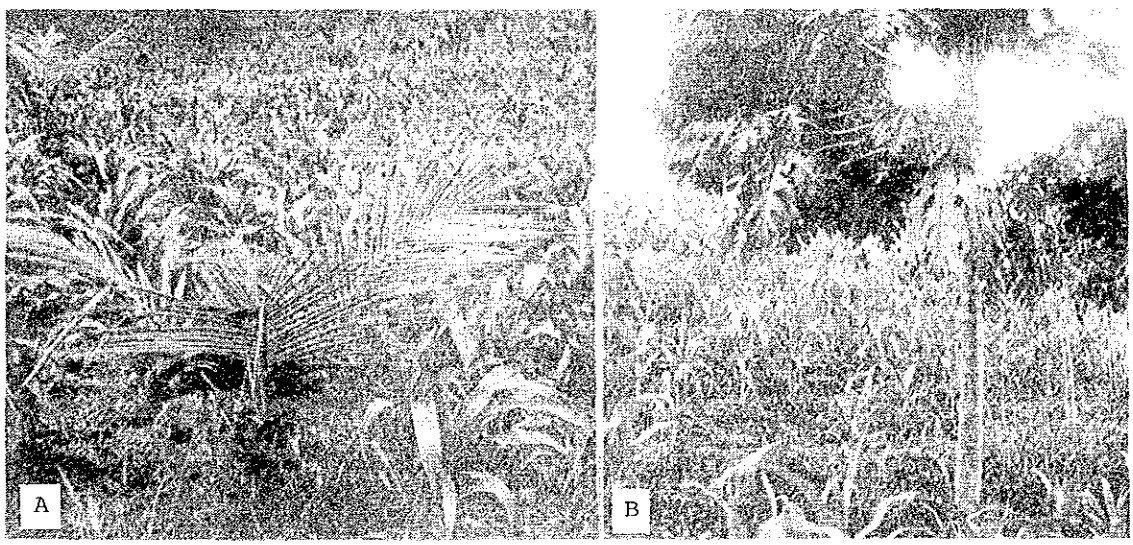

Fig. 26. Inter-cropping combined with herbaceous and perennial crops. Coconut and maize (A) and Papayas and maize (B).

2) Perennial Crops

In perennial crops, there are estate crops or industrial crops and fruit trees. They are as follows:

A. Estate Crops or Industrial Crops

Major estate crops cultivated differ by the farmer in the surveyed area. In Tenggarong district which the farmers are transmigrants coming from Java, the major estate crops are cloves, coffee, para rubber and coconut palms. In Loajanan, the farmers are Bugis who cultivated pepper in the area of 1,200 ha, while, in Muara Java, the major crops are coconuts which cultivated by local farmer, Banjar and Bugis.

B. Fruit Trees

There are many kinds of fruit trees grown in the surveyed area i.e., jack-fruit, banana, avocado, mango, durians, rambutans, langsats, papaya, pineapple and others. Durian, rambutan, and langsats are the native trees that grow naturally. Breeding on these fruits are not done positively. Cultivation of the above mentioned fruit trees are done as a farmyard or orchard for plantation.

(2) Cropping System

Generally speaking, crops were raised without fertilizer application in East Kalimantan and besides no measures to control noxious pests were taken. Notwithstanding the fact that upland farming was made on the slope land of the hilly area, no erosion control due to rainfalls was provided.

The cropping systems practiced by the farmers in the area are as follows:

A. Monoculture

B. Inter-cropping

C. Mix cropping

Some crops are planted as monoculture by farmer i.e., rice, maize, cassava, vegetables, coconut, para rubber, cloves, coffee and pepper. Some farmers also practised inter-cropping system for some crops i.e. - Corn and cassava, sweet potato and peanut (Fig. 25). - Coconut,

coffee and papaya (Fig. 26) - Coconut and corn.

Mix cropping was very common which mostly in farmyard.

The cropping occurs between fruit trees and estate crops i.e. durian, rambutan, banana, and papaya are mixed with coconut. (Figs. 27, 28).

Fig. 27. Mix cropping combined with native durian and coffee

Mix and inter-cropping are good systems that should be practised in East Kalimantan.

These croppings between annual and perennial crops as well as between perennial and perennial crops can be called 'Agroforestry' system, which means the blending between agronomy and forestry concept.

The utilization of such a cropping system will be useful for the improvement of microclimate, to activate potential soil fertility by means of perennial crops, to supply of organic matter to the soil by fallen leaves, to prevent the reduction of soil fertility by nitrogen fixation using mycorriza and rhizobia depending on the tree, and to control the soil temperature by crown covering.

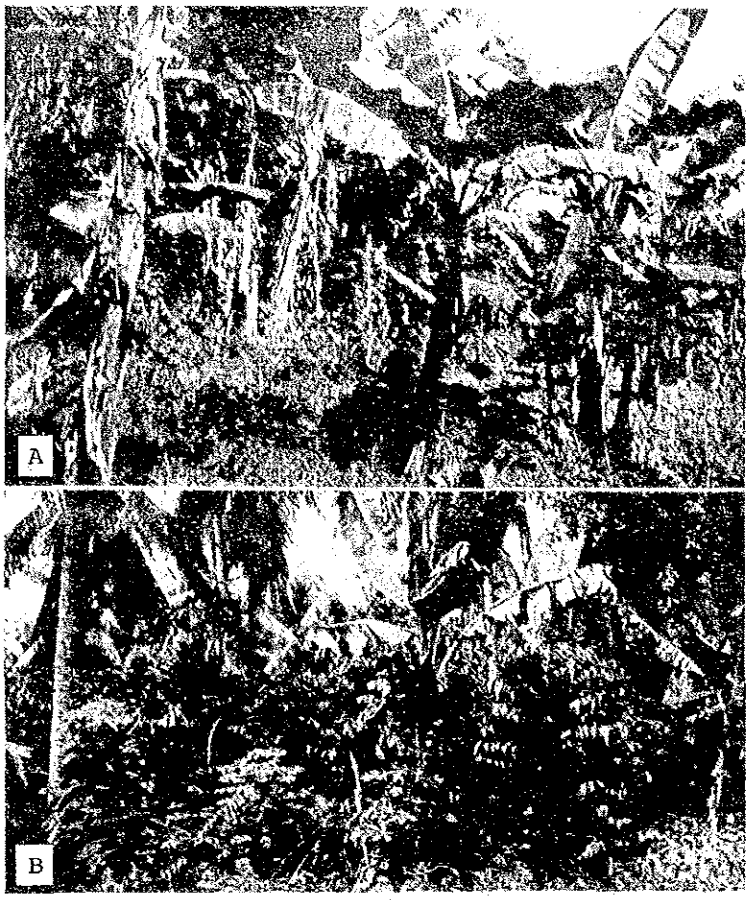

Fig. 28. Mix cropping combined with perennial crops. Bananas and cassavas (A) and Coconut, coffee, bananas and cassavas (B).

The inter-cropping and mix cropping developed in the tropical area are considered that they have the following advantages:

A. Control of soil erosion by cover crops.

B. Utilization of soil nutrients through the year.

C. Free from food deficiency by extending cropping season or dispersion of risk caused by natural disasters (droughts, floods, noxious pests, etc.).

D. Soil enrichment.

These systems with these advantages as mentioned above may have been made up to be maintained an ecosystem in the field keeping balance of various factors in relation to the crop cultivation. Accordingly, any cropping system which may break the maintenance of the ecosystem would be hard for agriculture development in the tropical rain forest zone with severe environment and the introduction of such agricultural

system without taking consideration of that conditions will be induced various problems. For instance, a large scale cultivation of maize single cropping in the State of Lampung was broken the ecosystem maintained by the inter-cropping or mix cropping in that area and it supposed that the spreading of downy mildew, one of maize diseases, occurred in 1973 was resulted by monoculture of herbaceous crop in large scale production. Consequently, it seems that the breaking of ecosystem may be induced a disastor by the natural action.

The inter-cropping or mix cropping system in the agriculture of East Kalimantan carried out under high temperature and humidity in the tropical rain forest zone is considered to be effective for preventing the high temperature of soil and an effective method of culture for controlling the rapid decomposition of organic matter contained in the soil and soil erosion. Besides, the keeping and increasing soil fertility, the supply of organic matter in the soil and introduction of leguminous plants as green manure to the fields should be made, and at the same time the studies on soil improvement, irrigation and draining systems, manuring and others on crop cultivations should be promoted for the agricultural development in the future.

(3) Growth of Crops and Soil

To study the relationship between soil and plant growth in the survey area, maize and pepper plant were used.

1) Maize

Survey of meize growth and soil relationship had been carried out in Maluhu and Bukitbiru. Farmers of both locations are transmigrant coming from central Java. In both districts, crops were grown without fertilizer and manures.

Maize crop that was used for study at Muluhu were located in sharp slope 18 - 22°. The crop was planted in monoculture using local cultivars. The maize, about 45 days after sowing, was measured according to contour line, and in order to know the relationship between the growth and soil nutrients , soil samples were taken.

The results was shown in Fig. 29. Big difference among individual plant was shown on the same level. It is considered that the condition of soil erosion due to rainfall was the same since the survey was made along the contour line.

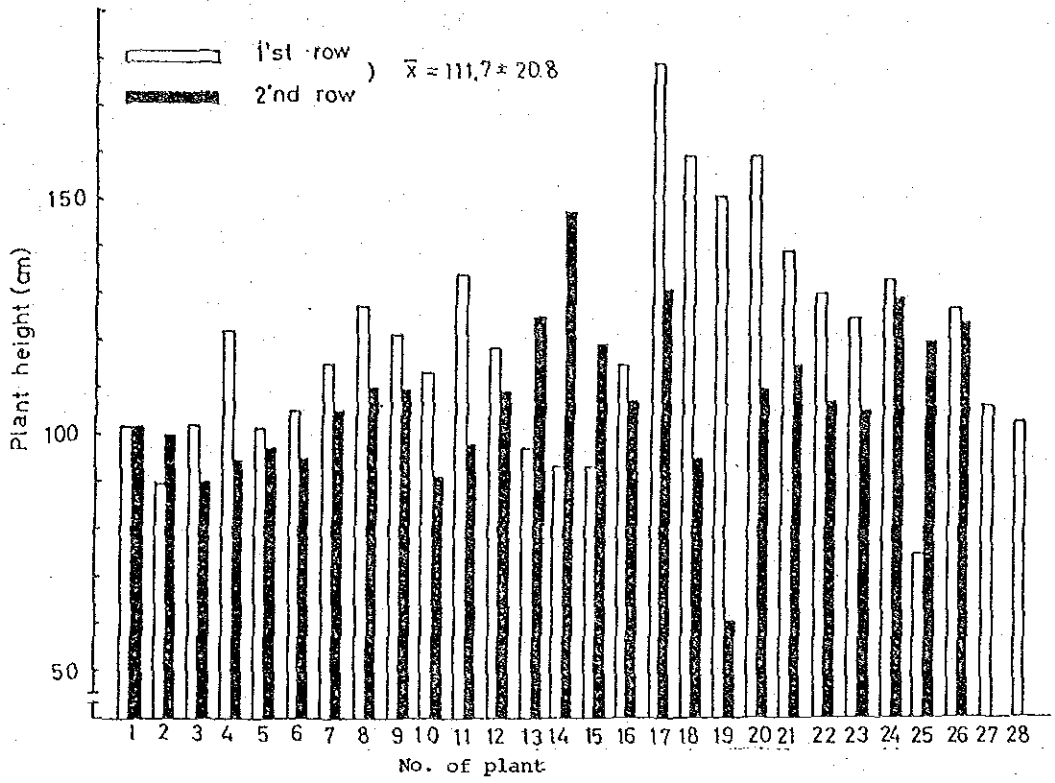

Fig. 29. Individual variation of maize growth (Plant Height) at Maluhu Field (Slope 18 - 22°).

Moreover, the results of soil analysis show that there was no big difference in soil chemical properties (Table 5). Consequently, the ununiformity of maize plant height at this place is not caused by the difference of soil fertility but might be caused by ununiformity of seed quality. Because maize seeds that used by farmers in this location brought about inbreeding continuing several generation. Maize is an allogamy crop and, if the inbreeding was continued, the plant growth would bring about the declined vigor and the difference will become higher.

In Bukitbiru, survey was carried out to measure the growth of maize and root distribution. The cropping system in this location was inter-cropping combined with maize cassave and sweet potato. It was laid at slope 11 - 12°, which was lower than that at Maluhu. In upper part of this field, alang-alang grow vigorously. The plants that used for study is about 45 days after sowing, and the plant height was measured along the contour line and the slope.

Results of this study (Fig. 30) show that the height variation

among plants along the slope was to tend greater than that along the contour line. There was no difference in the soil chemical property between the upper and lower sites on the slope as the result of soil analysis (Table 6). Therefore, the difference in the degree of soil erosion depending on the place where the plant grew along the slope was considered to be influential on the plant growth in connection with the depth of top soil layer affecting th the distribution of roots.

The above mentioned fact was proved by the results of maize that had been surveyed in neighbour maize field at harvesting time (Table 7).

Table 5. Relative growth of corn and soil test results of top soil layer at Maluhu field

Degree of growth	pH		NO_2-N*	NO_3-N*	NH_4-N*	Available		Exchangeable			Al_2O_3*	Fe^{3+}*	Fe^{2+}*
	H_2O	KCl				P_2O_5*	K_2O*	Ca(%)	Mg*	Mn(ppm)			
Good	6.0	6.0	0.4	4.0	1.0	5.0	>30	<0.07	35	>50	5	25	25
Moderate	5.5	5.0	1.0	10.0	1.0	2.5	3	<0.07	35	>85	20	75	25
Poor	5.5	4.5	0.4	4.0	1.0	5.0	0	<0.07	35	>10	20	150	25

* mg/100 g.

Table 6. Soil test results of different site of the same maize field at Bukitbiru

Place of sample taken from field	pH		NO_2-N*	NO_3-N*	NH_4-N*	Available		Exchangeable			Al_2O_3*	Fe^{3+}*	Fe^{2+}*
	H_2O	KCl				P_2O_5*	K_2O*	Ca (%)	Mg*	Mn (ppm)			
Top-soil layer													
Lower part	4.5	4.5	0.4	1.0	1.0	5.0	0	<0.07	5	>25	10	75	<25
Higher part	4.5	4.0	0.1	1.0	1.0	1.0	0	<0.07	5	>25	20	25	<25
Sub-soil layer													
Lower part	4.0	4.0	1.0	1.0	1.0	2.5	0	<0.07	70	>25	20	25	<25
Higher part	5.0	4.0	0.1	1.0	1.0	2.5	0	<0.07	5	<10	20	<25	<25

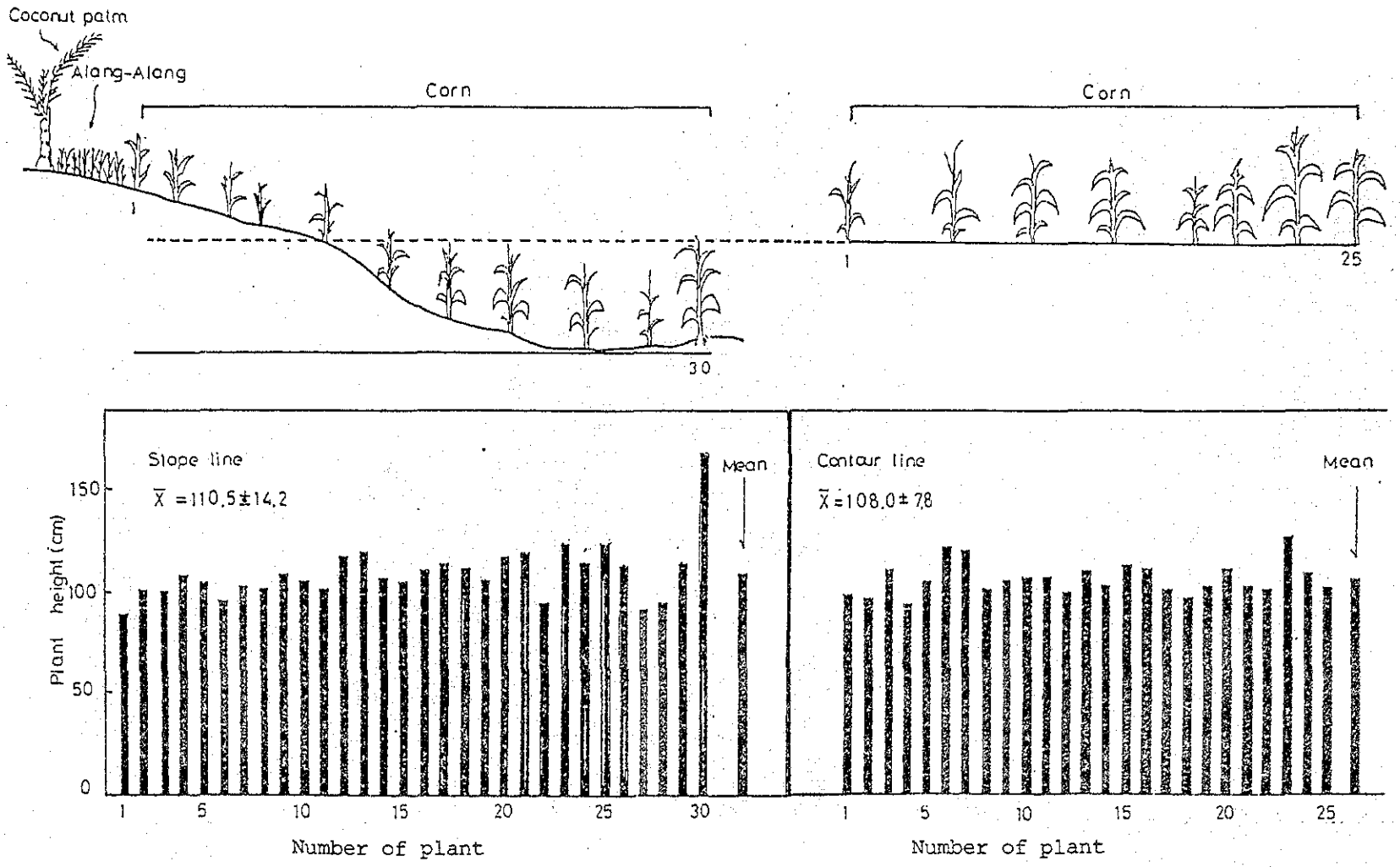

Fig. 30. Individual variation of maize growth (plant height) at Bukitbiru field.

Table 7. Relationship between depth of top soil layer and maize growth (plant height)

Place	Depth of top soil	Plant height	Depth of root penetration
Upper part of hilly field	10 cm	183.5 ± 20.1 cm	12 cm
Lower part of hilly field	32	263.7 ± 18.6	25

Soil survey was made on the soil profile (about 0.7 x 1 m) and observed on the soil layer differentiation and construction at Maluhu and Bukitbiru.

These results were shown in Fig. 31 and 32.

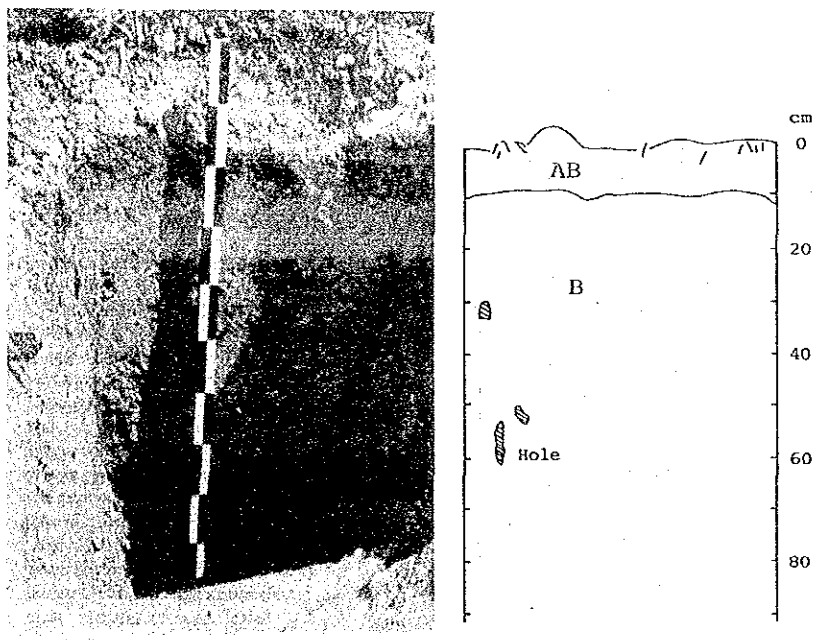

Fig. 31. Soil profile of maize field at Maluhu.

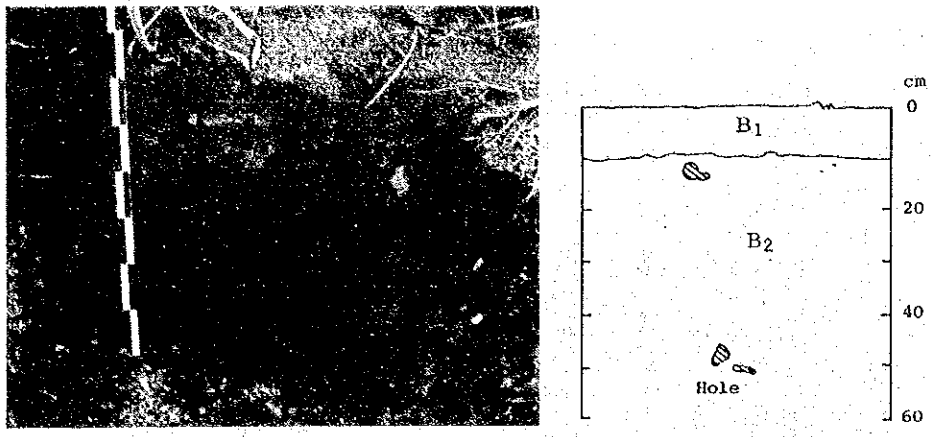

Fig. 32. Soil profile of maize field at Bukitbiru.

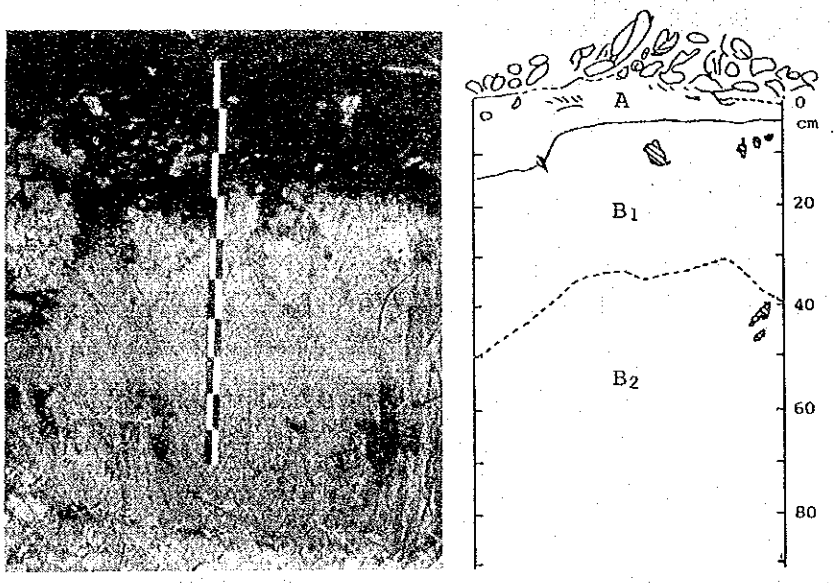

Fig. 33. Soil profile of selection cutting system forest at Sebulu.

From the survey of these fields, it is considered that the soil induced a decline of soil chemical and physical properties, because the soild in both field were not observed a layer containing humus in comparison with that of the selection cutting system forest at Sebulu (Fig. 33). However, in slope field on the mix cropping with durian and coffee at Maluhu, the available soil layer was deep (Fig. 34) and coffee plant was well growing.

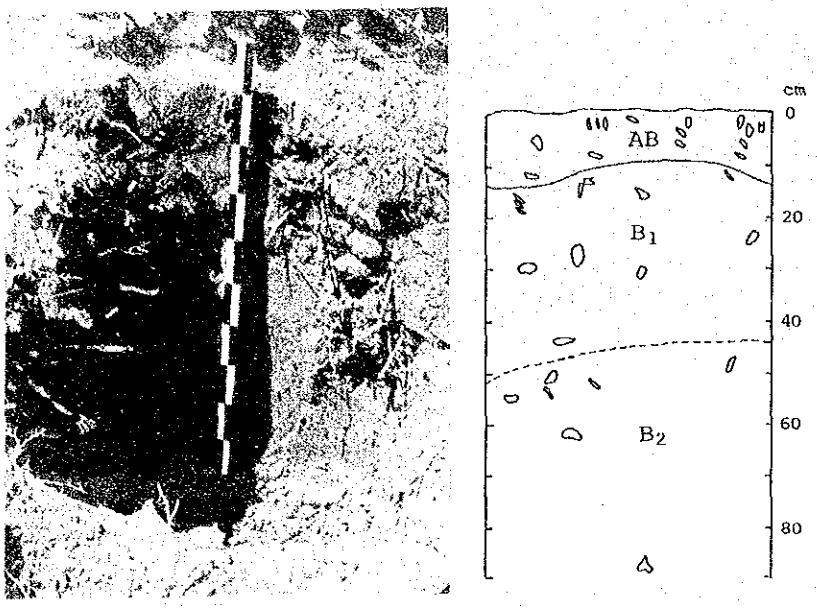

Fig. 34. Soil profile of mix cropping field (durian and coffee) at Maluhu.

Under the above-mentioned things, it is considered that soil fertility in the field under humid tropic condition such as East Kalimantan was quickly reduced by the decomposition of organic matter and heavy soil erosion. Accordingly, it must be maintaining and increasing soil fertility in the crop cultivation of upland field in East Kalimantan. In order to maintain the soil fertility, it is necessary that the slope field need a terracing, introduction of cover crops effectively for the control of soil erosion and of perennial legume trees for the increasing and utilization of potential fertility, and to foster or maintain hill top forests or water conservation forests.

2) Pepper

The growth of pepper was surveyed at Loajanan. The cultivation of pepper in this region is carried out by the farmers from Bugis and the cultivated acreage is about 1,200 ha. They are cultivated during 12 years from planting to replanting. As a succeeding crop of pepper, perennial crops such as cacaos and coffee were often used.

The fields were located on slope land of the hilly area, and soil erosion induced heavily by clean cultivation. The crops are managed with no fertilizer and control of pests in this area.

For this reason, the field decreased soil fertility had been abandoned, and some of them are becoming the grasslands of alang-alang (Fig. 35).

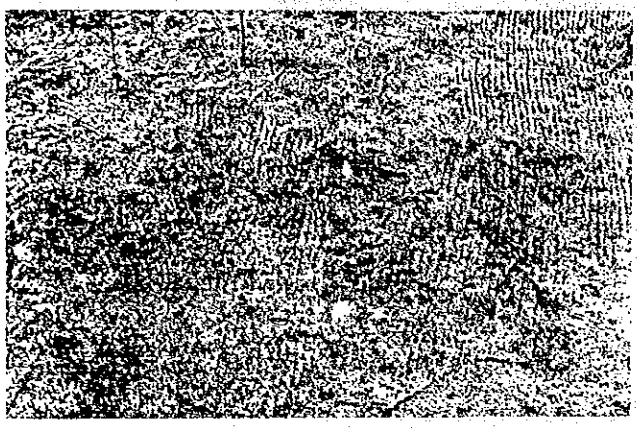

Fig. 35. Alang alang (Imperate cylindrica) invaded into the abandoned pepper field.

Results of the survey are shown in Fig. 36. As in the case of maize, individual variation of growth among plants is a big. In addition, many missing plant by diseases and other injuries were observed and the rate of them in the whole field reaches 27 %.

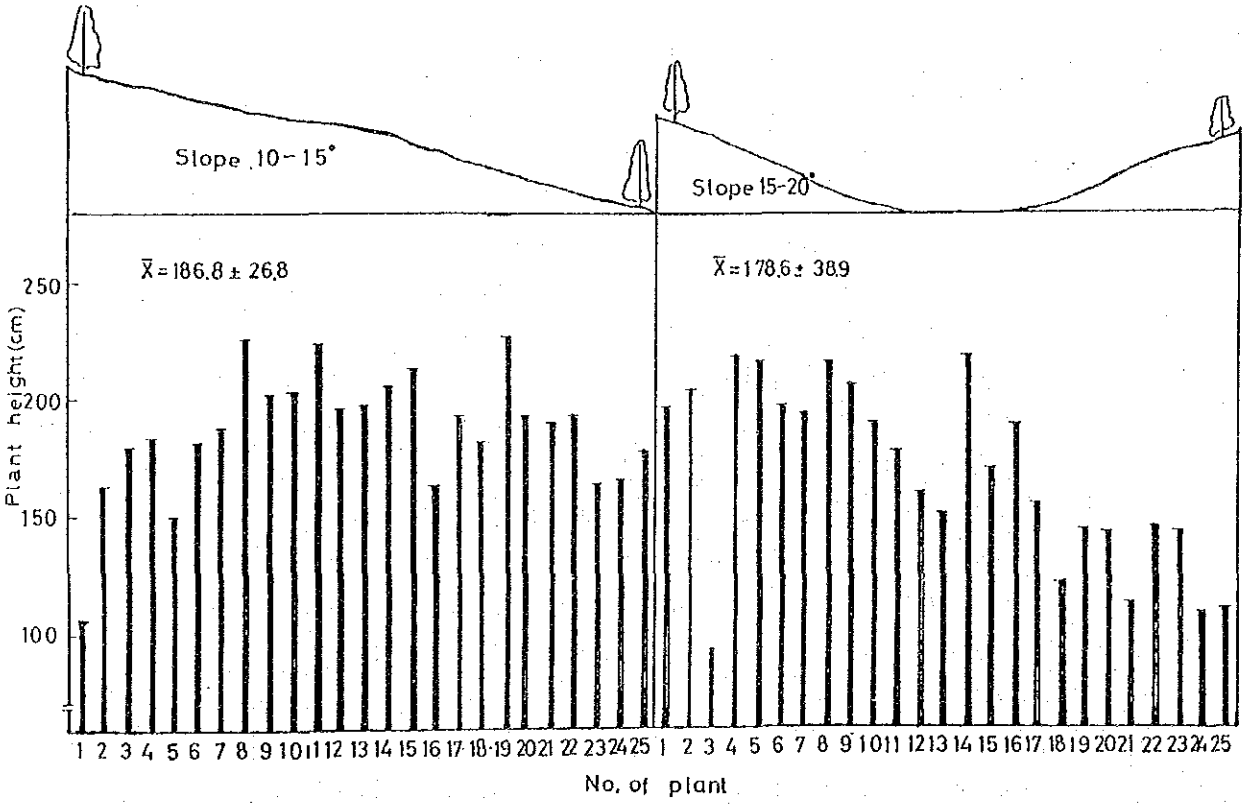

Fig. 36. Variation of pepper plant height at Loa Janan field.

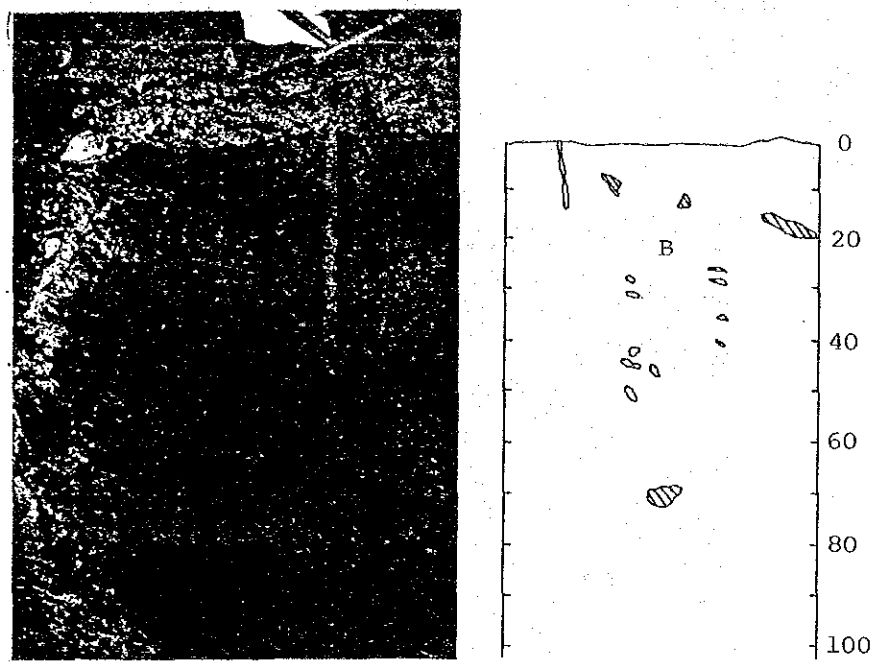

Fig. 37. Soil profile of pepper field at Loajanan.

In soil profile, a layer containing organic matter was not observed, and the top soil had almost already been eliminated by soil erosion. In addition, because of inferior soil physical and chemical properties, the development of the root system was extremely poor. This fact would make it clear that the poor growth of pepper cultivated in the Loajanan had been caused by the decline of soil fertility due to the deterioration of physical and chemical properties of the soil (Table 8). Consequently, it is most important for the development of pepper cultivation in the Loajanan to maintain and increase soil fertility. In order to maintain and increase the soil fertility, soil erosion must be prevented in the first place. For that purpose, the mulch or sod mulch method instead of clean cultivation as agronomic control should be adopted to the slope field and the terraced fields. Moreover, importance should be attached to increase soil fertility by application of the organic matter and improvement of the physical properties in subsoil.

It is also very important to establish the control methods of the pests. However, in view of the present situation in which no fertilizer and control of the pests have been taken, it is rather important to develop the researches on cultural practices and control of the pests, and to establish the extention system to secure the agricultural development.

Table 8. Soil test results of pepper field at Loajanan

Position of sample	pH		NO_2-N*	NO_3-N*	NH_4-N*	Available		Exchangeable			Al_2O_3*	Fe^{3+}*	Fe^{2+}*
	H_2O	KCl				P_2O_5*	K_2O*	Ca (%)	Mg*	Mn(ppm)			
Upper layer	5.5	4.0	0	0	1	-	8	-	5	<10	30	0	0
Middle layer	5.0	4.0	0	0	1	-	8	-	5	< 2	20	0	0
Lower layer	5.5	4.0	0	0	1	-	15	-	5	< 2	20	0	0

* mg/100 g