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Land Management Patterns in Northeast Thailand 1/

John Kagland and Iain Craig 2/

INTRODUCTION

Northeast Thailand is a large flat to gently undulating plain rimmed to the west and south by small mountains or hills and to the north and east by the Mekong River. A folded range of small mountains divides the plain into two watersheds which both drain into the Mekong one of the worlds' largest rivers (Figure 1). A single crop of transplanted photo-sensitive glutenous rice, grown for subsistence under rainfed conditions, is the region's predominant activity. A number of field crops are grown for cash on the upland. Cassava is the most important one but its acreage is small compared to rice.

Since the mid-1950's the Northeast has made large and impressive gains in developing roads, regional trade centers, health services and educational capacity at the primary, secondary and higher levels. Agriculture has also increased rapidly but mainly as a result of forest land being brought into cultivation. Yields per hectare in the Northeast have not changed significantly over this period. Deforestation has averaged 7 percent per year. Since 1960 rice acreage has doubled and cassava and maize have increased by fourfold and fivefold, respectively, since 1970. Nationally Thai agriculture grew an average of [illegible] percent/year from 1960 to 1975 but since then growth has slowed to 3.7 percent/yr and is expected to slow even more (5). Production trends in the Northeast have followed the same pattern.

The Northeast contains 17,000,000, people, which is one third of the nation's total and 8.5 million hectare or 42% of Thailand's cultivated land. Consequently the government and the people of the region wish to continue a rapid pace of development but are confronted with formidable constraints. Intensifying agriculture production is proving to be much more difficult than increasing production by expanding the area cultivated. Poor soils and erratic rainfall are serious although not insurmountable constraints.

1/ Presented at International Conference on Soil Fertility, Soil Tilth and Post-Clearing Land Degradation In The Humid Tropics, July 21 - 25, 1985 University of Ibadan, Ibadan Nigeria.

2/ Professor and Assistant Professor of Agronomy, University of Kentucky, respectively. The authors have since 1982 been working in Northeast Thailand on a technical assistance team to a Thai Government/USAID sponsored rainfed agriculture development project. Mailing Address: Northeast Agriculture Center, Tha Phra, Khon Kaen, Thailand

Landforms and Climate

The Northeast Plateau was once covered by the sea but uplifted to approximately 200 meters as a part of the Indian and Chinese continental movements which caused the Himalayas to rise 3,000 meters. The ranges of small mountains (large hills) that formed in the process resulted in two basins (Figure 2). There are surprisingly small variation in elevation right up to the foot of the mountains. In the process of forming, there must have been massive slipping and sliding of the siltstone, shale, mudstone and rock salt that were the predominant parent materials. Apparently this accounts for the featureless landscape.

The fine sand and silt particles that predominate in the region's soils have a unique size distribution that causes close packing. The result is high bulk densities and extremely slow rates of rain water infiltration and slow movement of water in the soil, particularly vertical movement. This property keeps the water table at or near the surface in the rainy season and only 2-3 meters deep at the height of the dry season (February). Pearched water tables are common even in the uplands and the topsoil is water saturated after every heavy rain. Impermeable layers of laterite are common at 1-3 meters and contribute to keeping the water table high. With so much surface water it is understandable why rice is so predominant and the farmers have laboriously constructed small bunded fields that cover 70 percent of the agricultural land.

Generally rainfed rice needs 2000 millimeters of rainfall (3) for stable yields, but the Northeast produces it with 1100-1400 mm (Figure 3). The number of drought days is greater than 60 days for essentially all the region and greater than 100 days for much of it (Figure 4). Society's response to this has been to evolve patterns of land ownership that give a family some lower and upper paddy land. In years of excellent rainfall amounts and distribution, all paddies are transplanted to rice. When the rains are the poorest, only the lower paddy is transplanted and the upper paddies catch rainfall that seeps slowly down the slope to more or less keep the lower paddies continuously water saturated.

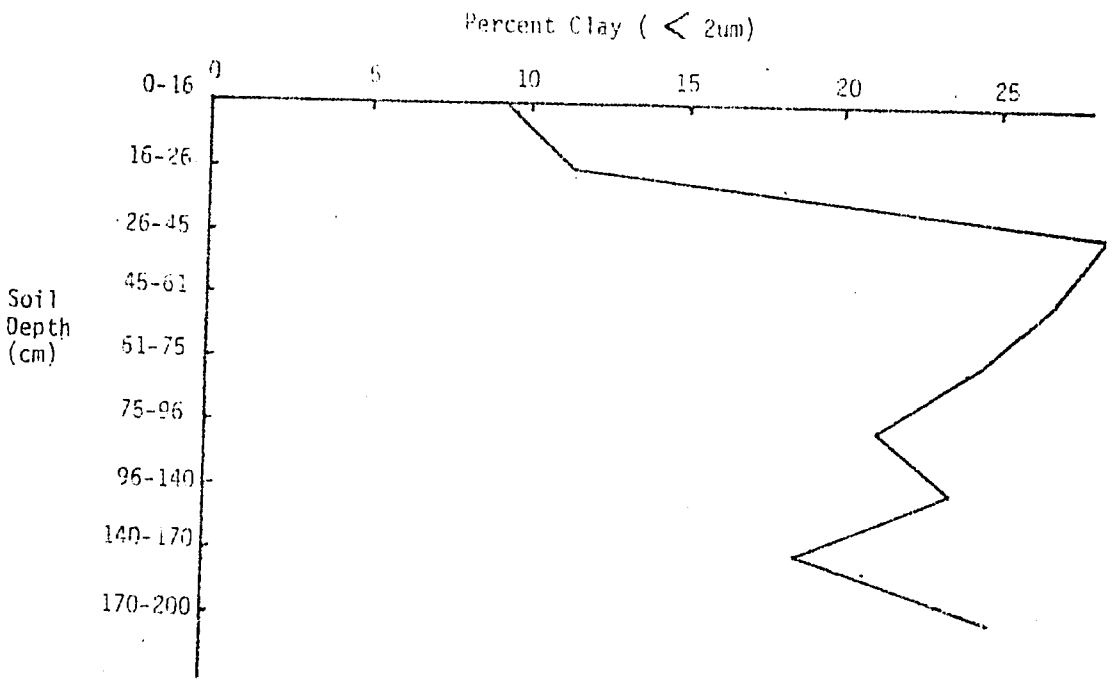
Soil Properties

There are 35 different soil types in the Northeast but the majority are low humic gleys, podzols and alluvial soils (Figure 5).

With the exception of some limestone areas in the hills, virtually all soils in the Northeast are derived from sandstone, shale or siltstone and are inherently low in calcium, magnesium, potassium and phoschorous. Being so highly weathered, they are extremely sandy and have low organic matter and clay (predominantly kaolinitic) contents. Low clay contents combined

with the low activity of kaolinite have resulted in soils of extremely low cation exchange and buffering capacities. Extremely low pHs are common, especially in the dry season.

Generally clay contents are least in the plow layer but are 2-3 times greater in the B-horizons. The Roi Et profile characterised by Brinkman (2) probably has higher overall clay content but otherwise may be typical:



At the time this profile was sampled (March 18), the water table was about 1.8 m. The CEC was found to increase from 1.1 meq/100 gm in the plow layer to approximately 5 for all layers below 26 cm. Organic carbon was 0.3 percent in the plow layer and declined to only trace amounts below 45 cm. The pH was 5.1 in the plow layer and decreased to approximately 4.5 for the deeper depths. This profile is not typical for pH because the plow layer is often the lowest in pH during the dry season.

By monitoring field plots, Ragland et al (9) found that the pH of rainfed rice paddies in the Northeast increases to 5.5 to 6.5 at the height of the rainy season but commonly declines to 4.5 in the dry season. The pH increase is due to reduction of ferric iron when the soil is flooded and the pH decrease due to

the oxidation of iron when the soil dries (2). These reactions may be written as:

$$\text{(I)}\quad Fe(OH)_3 + 3H^+ \text{------>} Fe^{+2} + 3H_2O$$

$$\text{(II)}\quad Fe^{+2} + 1/4\ O_2 + 2\ 1/2\ H_2O \text{------>} Fe(OH)_3 + 2H^+$$

Apparently these two reactions, and the associated consequences, are the major factors determining the crops grown in the Northeast and how the farmers manage them. Reaction (I) is a self-liming process that corrects the problems of soil acidity. Additionally, many workers (6,7,8) have demonstrated that the availability of phosphorus is increased when iron is reduced, presumably iron phosphates are dissolved. Reaction (I) has one negative consequence because the ferrous ion exchanges for base cations that tend to be leached away. However, the slow vertical movement of water is probably minimizing these losses under the present advanced state of weathering.

It is conventional wisdom in the Northeast that the greatest agriculture production problem is insufficient water, a statement with which this writer agrees. However, he does not believe that the lack of enough water to meet the direct needs of the crops is the first limiting factor. Rather it is the absence of the self-liming, self-fertilizing consequences of reaction (I) that occur when the soils are water saturated. Given the extremely low fertility of the soil and the low-input agriculture that is practiced, keeping the soil water saturated much of the time is a must in order to have nutrient availabilities high enough for even the low yields obtained (approximate rice yield, 1,200 kg/ha). The relative contributions of water in meeting the direct crop need and the indirect benefits of increasing nutrient availabilities deserve much more research and development emphasis.

A good perspective on the fertility status of Northeast soils is provided by Kyuma (4). He and colleaques from Asian countries have made comparison characterizations of rice soils from the four regions of Thailand, four regions of Bangladesh, two regions each of Sri Lanka and Malaysia and one region of India. The 410 soils in the study were rated by characteristics and grouped into three categories, i.e. Inherent Potentiality of the soil (IP)3/, Organic Matter and nitrogen status (OM)3/ and Available Phosphorus status (AP)3/. The 32 soils from the Northeast that were in the study ranked -1.18, -1.14 and -0.94 for IP, OM and AP, respectively. The next lowest values for

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3/ The IP values were determined primarily by the nature and amount of clay and base status.
The OM values were derived from total carbon, total nitrogen, ammonium nitrogen, total phosphorus and organic phosphorus.
The AP values were determined primarily from two different soil tests for available phosphorus.

soils of any region were, -1.07, -0.36 and -0.72. Soils that were at the average of the group of 410 soils were ranked 0 on the rating scale. Given these inherently poor soils and the small amounts of fertilizer use it is obvious why rice yields are so low. Large increases in nutrient availabilities must be occurring in association with reaction (I), otherwise the yield would not even be 1200 kg/ha.

Whereas reaction (I), and the associated soil changes, are so beneficial to rice yields, reaction (II), and the associated changes, are very detrimental to crops grown either in the dry season or on well-drained sites in the wet season. The H+ ion produced in reaction (II) lowers the soil pH (Figure 6) to the point that large amounts of aluminum are made soluble (Figure 7). Farmers traditionally cope with this problem by applying dry animal manure to all vegetable crops and tobacco, the major dry season crops. The manure is quite basic in its effect on the soil because it is usually air dry and most of the urea and other easily available nitrogen compounds have been lost by ammonia volatilization. The soil pH's are easily increased because the cation exchange capacities are so low. Ground limestone applied sparingly would be a more efficient way to raise soils pH's but it is not available despite abundant limestone deposits at the rim of the Korat plateau.

Beyond its implications for field crop production, reaction (II) is thought to have been a major, if not the major, soil forming factor for the soils in the Northeast. The H+ ion from the reaction is absorbed to the negative sites structurally embedded in the clay. However, hydrogen clay is unstable and partially decomposes, releasing aluminum and silica. Brinkman(2) concluded that this mechanism, operating over countless cycles of soil flooding and drying, reduced the clay content at the Kalasin site from greater than 20 percent to the present situation of less than 10 percent in the 0-16 cm. layer and 11.6 percent in the 16-26 cm. layer. Beyond destroying the clay, the soils have been further degraded by the aluminum dissolved from the clay forming ferrous-aluminum hydroxide interlayers in the 2:1 clays that are present. This chloritization process has further decreased the cation exchange capacity of the soils by permanently blocking exchange sites. Brinkman estimated that the Roi Et soil he studied probably had a CEC of 10 meq/100 gm at an early stage of deterioration.

In 1969 Brinkman (1) coined the term Ferrolysis for this soil forming process that occurs in alternately reduced and oxidized seasonally wet and dry soils. He does not deny that clays are physically transported down the profile but concluded that such mechanisms were not sufficient to explain the properties of gley soil so common throughout Asia. The iron reduction/oxidation cycle and related soil formation and soil management consequences are summarised in Figure 8 and Table 1.

Traditional and Present Cropping Patterns

The acreages of each crop in the Northeast and relative proportions of the Nation's total production are contained in Table 2. After rice, cassava is the most important crop. It accounts for much of the land clearing since 1970 and is the regions most important cash crop. In years of good rainfall rice sales may exceed cassava, but this is due to disposing of the surplus of a subsistence crop and is not consciously intended.

Cassava is an ideal crop for the Northeast. It can be grown in infertile, low pH, sandy soils with no cash inputs, has no major pests and is extremely drought tolerant. Harvesting dates can be delayed or advanced in line with farmers labor availability, cash requirements and the market prices prevailing. Cassava production is currently facing two major constraints. First, because it is so efficient at extracting nutrients from even an infertile soil, it rapidly accelerates the process of soil fertility decline. Second, because of recent export agreements between Thailand and the EEC, virtually the sole market for Thai cassava products, prices are falling to levels that are only just economically viable.

Alternative crops to cassava are being tested and in 1984 grain sorghum and mungbean were promoted. In some localized areas these were successful but both require relatively high inputs of cash and labour, are sensitive to intermittent water-logging and are prone to a wide range of pests and diseases.

Corn is successfully grown in the Northeast but production is restricted to the better limestone or volcanic soils found only in the hilly areas bordering the region where its cultivation can cause serious erosion on the steeply sloping land. Corn could be grown on the low fertility soils of the plateau but the high levels of fertilizer and lime required would make it economically unattractive.

Widespread cropping intensification in the paddy land is constrained by the high probability of serious water-logging in pre-rice crops and drought in post rice crops unless supplemental irrigation can be supplied.

Agronomically, rice is the most attractive crop for expansion in the Northeast. Much of the upper paddy which usually does not receive enough water for transplanting could be direct seeded and thus produce a crop. Enough labor to weed the crop is a major constraint. Rice prices will not support the cost of herbicides and the farmers wish to avoid them in favor of the frogs, land crabs and fish that grow in the paddies.

Agriculture Development Through a Farming Systems Approach

Faced with these constraints to any single crop solving the development needs of the Northeast, development projects are

increasingly emphasising a farming systems approach. The idea is to closely study existing production patterns, labor demands and market opportunities and, based on a good understanding of the current system, identify where appropriate improvements can be made. Acceptance of these changes is sought through on-farm testing done collaboratively with the farmer, extension officer and experiment station researcher.

An example of improvements coming from this approach is the NERAD 4/ project working in Roi Et province. There rice yields had declined to the point of alarm and farmers began searching for an alternative to reverse the decline. First they grew watermelons as a cash crop and noticed that the yields of rice following watermelons was much improved. The residual fertility from the manure and chemical fertilizers that must be applied to grow watermelons was carrying over to the rice. Subsequently, the farmers improved the system by adding a kenaf crop planted after watermelons and with the first rains of February or March. This crop is harvested whenever rainfall is sufficient for transplanting rice, usually late July or early August. The farmers have gone from a single rice crop to limited triple cropping which they rotate between fields to improve yields of their subsistence rice crop.

Widespread adoption of this system is currently limited by the high input costs for manure and fertilizer and its inherent risk due to variable prices for the watermelon and the build up of soil-borne root rot disease (Phytophthora nicotianne) in kenaf, which is frequently subjected to water logged conditions. NERAD's approach has been to test green manure crops as a low input alternative to watermelon to stabilize rice yields. The root rot problem in kenaf has been successfully overcome by the introduction of Cuban kenaf which is more resistant to the disease under water-logged conditions.

Introducing peanut and sesame grown before and after rice, constructing weirs to keep more of the soil water saturated, producing fish in the paddy with rice, village woodlots and livestock disease and parasite control are all parts of the NERAD project. These activities are not so dramatic as thousands of hectares of a new crop for export but they are more appropriate for the Northeast. The area is one of an inherently low yielding subsistence agriculture with cheap labor being its major competitive advantage. Even this production advantage is disappearing. Off-farm employment in regional trade centers, Bangkok and the Middle East has grown rapidly to augment the growing of subsistence rice. The upcoming five year plan is purported to emphasise rural industrialization. Certainly the large numbers of construction and other workers who are cycling in and out of the Northeast will improve the workforce for such industry, if it really grows.

4/ Northeast Rainfed Agriculture Development project currently being implemented by the Thai MOAC and USAID.

Conclusion

The Northeast is a large (170,000 km^2) semi-flat plateau. It is populated by 17 million industrious people left behind economically because of inherently poor land and isolation. The isolation problem has been solved and with it the exploitation of the land's meager store of fertility has been rapidly accelerated. However, it does not appear that the land will be exhausted and abandoned as in some parts of the world. Most farmers own their land and directly draw their food supply from it. When rice yields decline below approximately 1200 kg/ha they add organic and chemical fertilizers to reverse the trend. The land is greatly degraded by the ferrolysis process operating in seasonally flooded and dry soils, but this too is a self-limiting process. Thus it is reasonable to expect the region to continue producing indefinitely although yields will continue to be low. The pressing need is not to develop some large scale export crop, but to stabilize the subsistence rice yields and to gradually improve the various cash crop and other enterprises in a self sustaining manner, not only to meet family cash requirements for education and consumer goods, but also to supply agricultural inputs as subsistence farmers become more integrated into the market economy.

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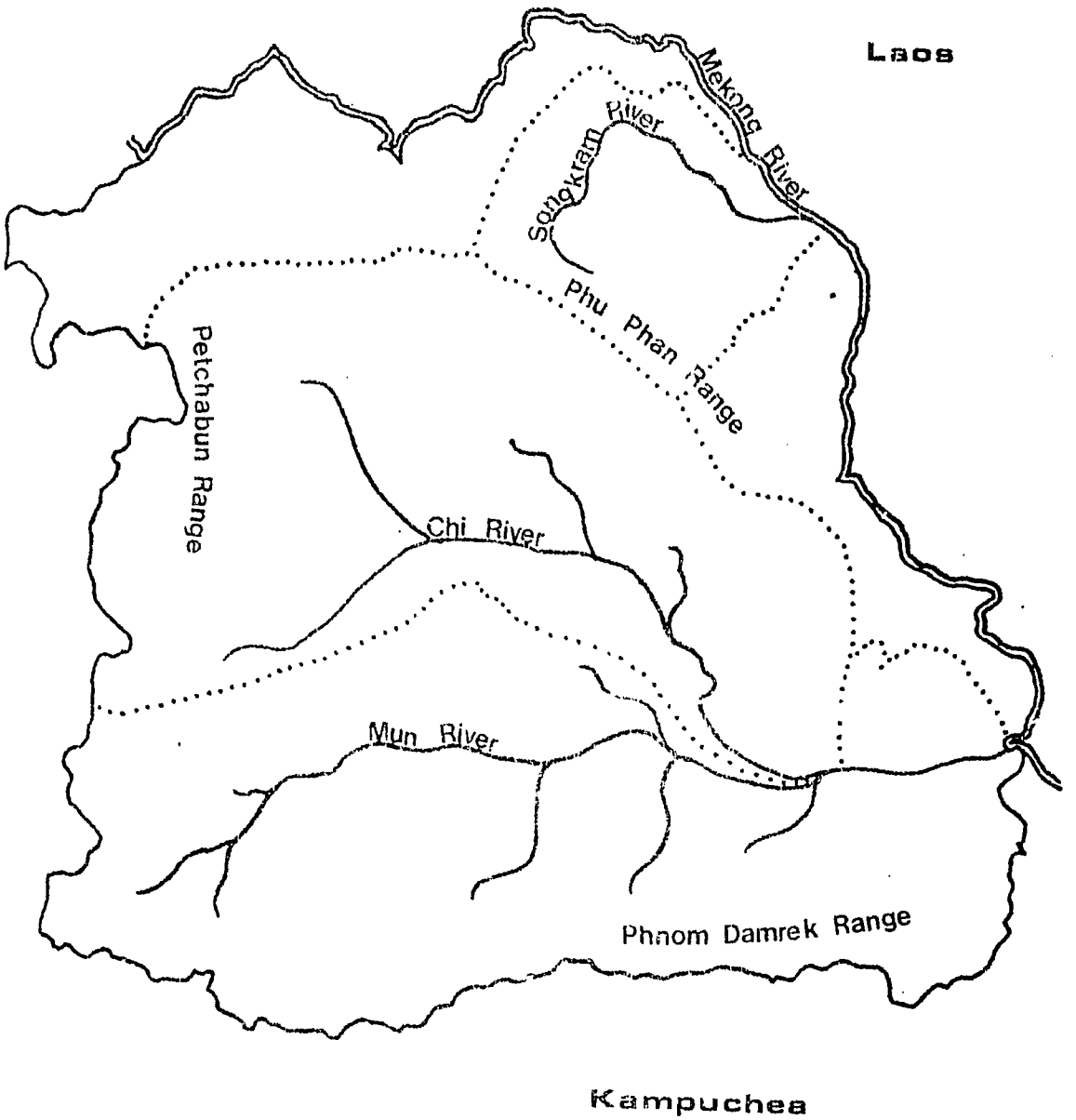


Figure 1. Topography of Northeast Thailand

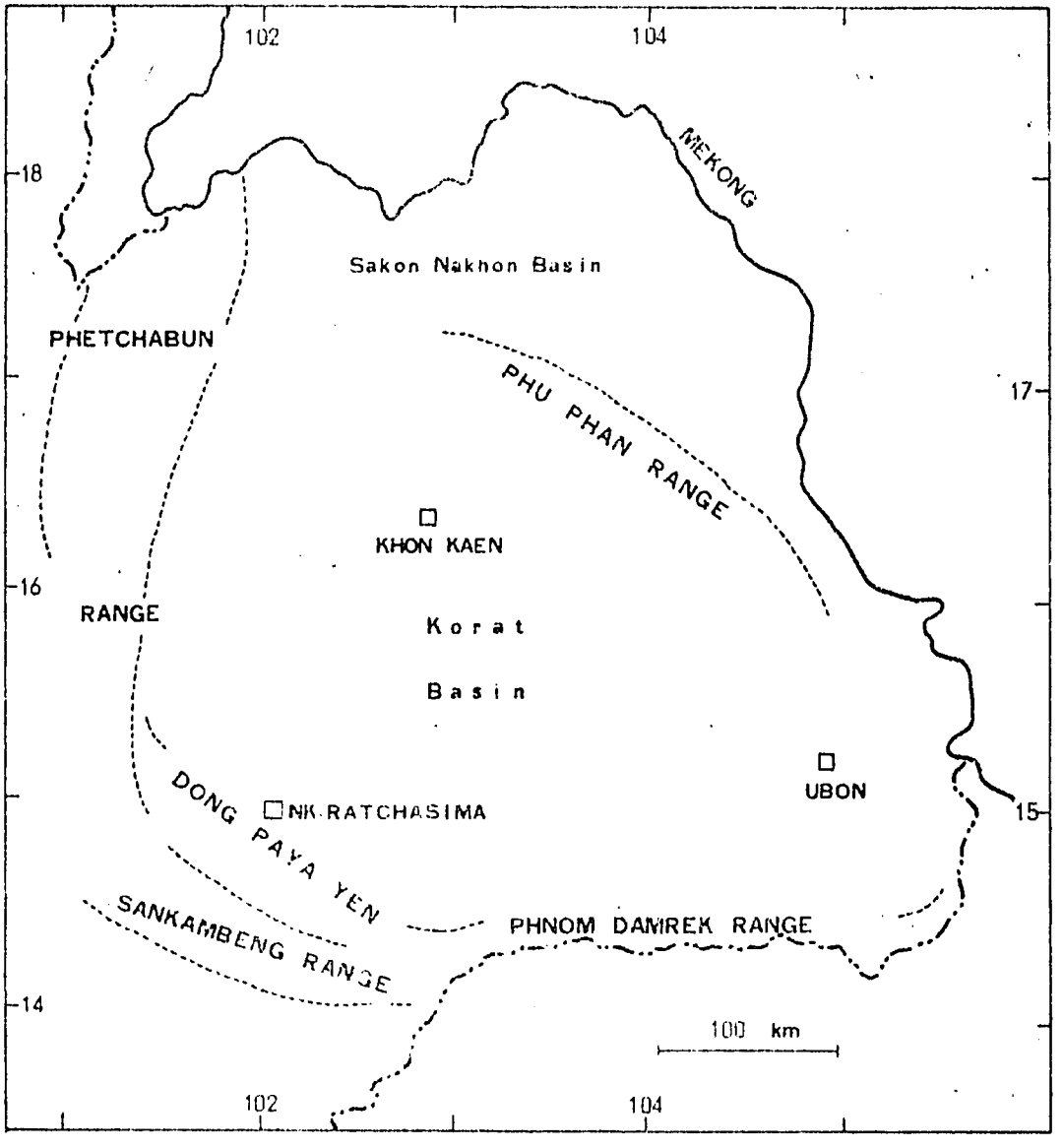


Figure 2. Korat and Sakonakhon Basins

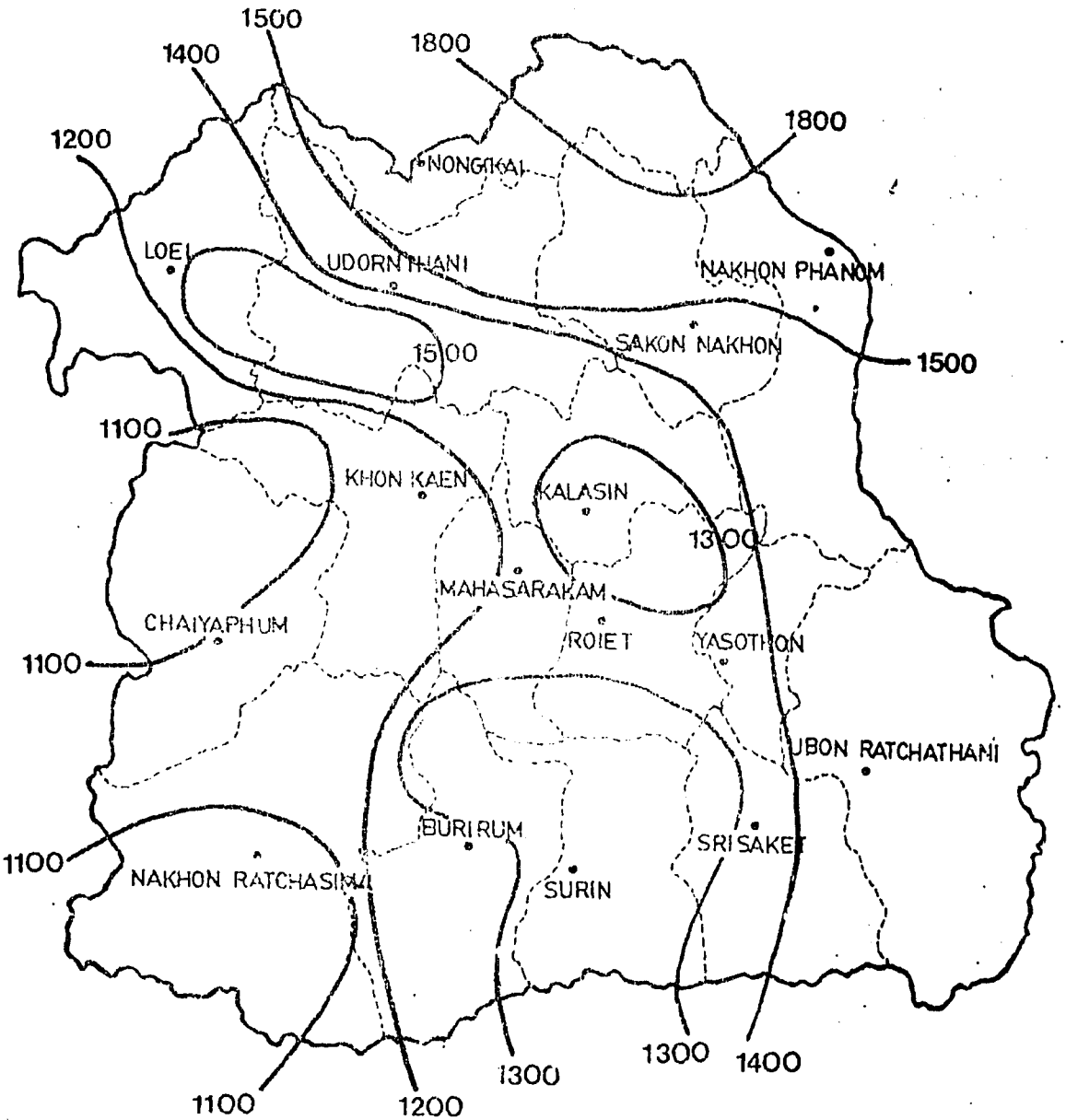


Figure 3. Rainfall isohytes and major rainfall regimes of Northeast Thailand. (Source: Khon Kaen University 1982)

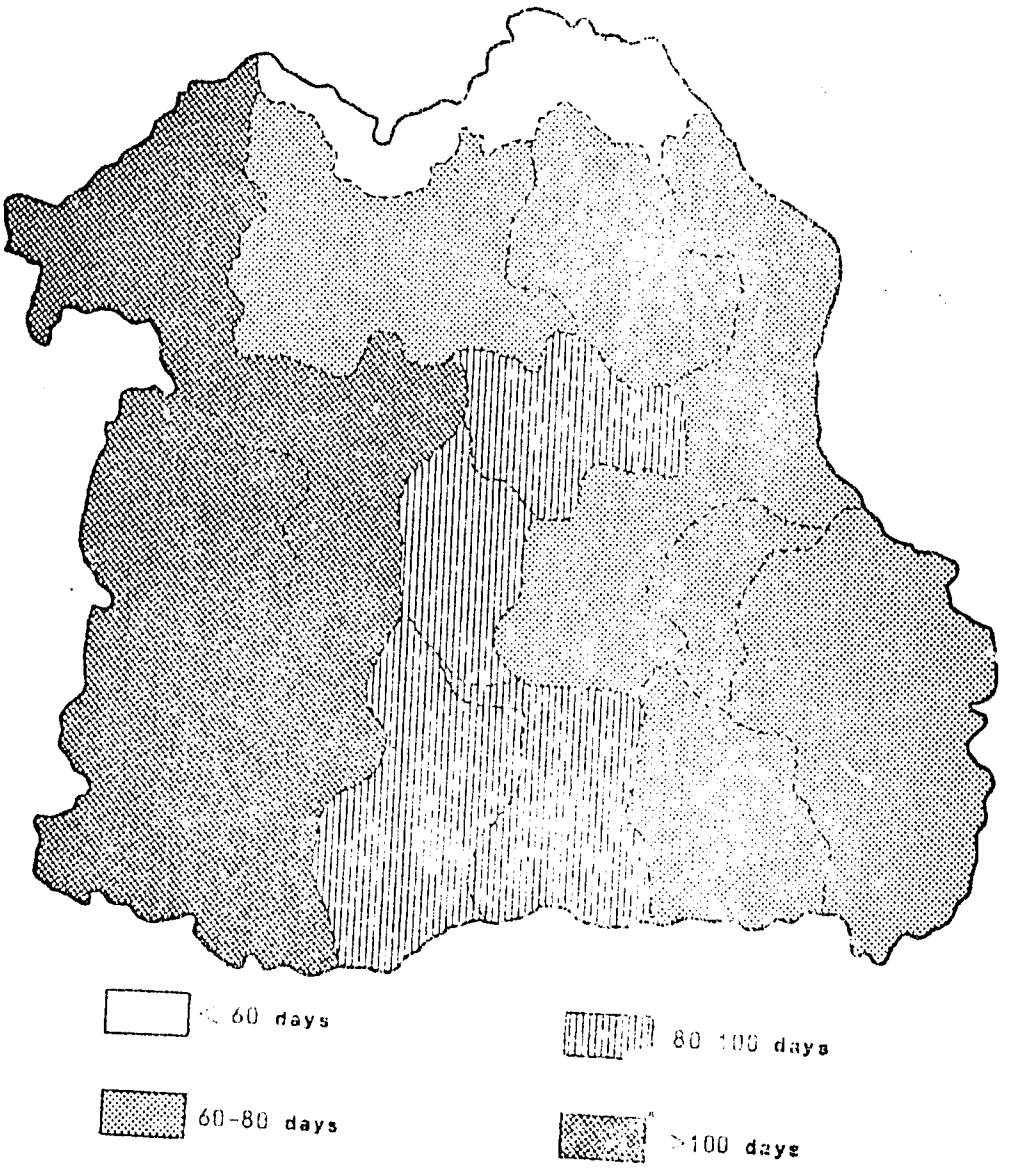


Figure 4. Number of drought days (calculated for paddy) for May to October period. (Source: TCAP 1974).

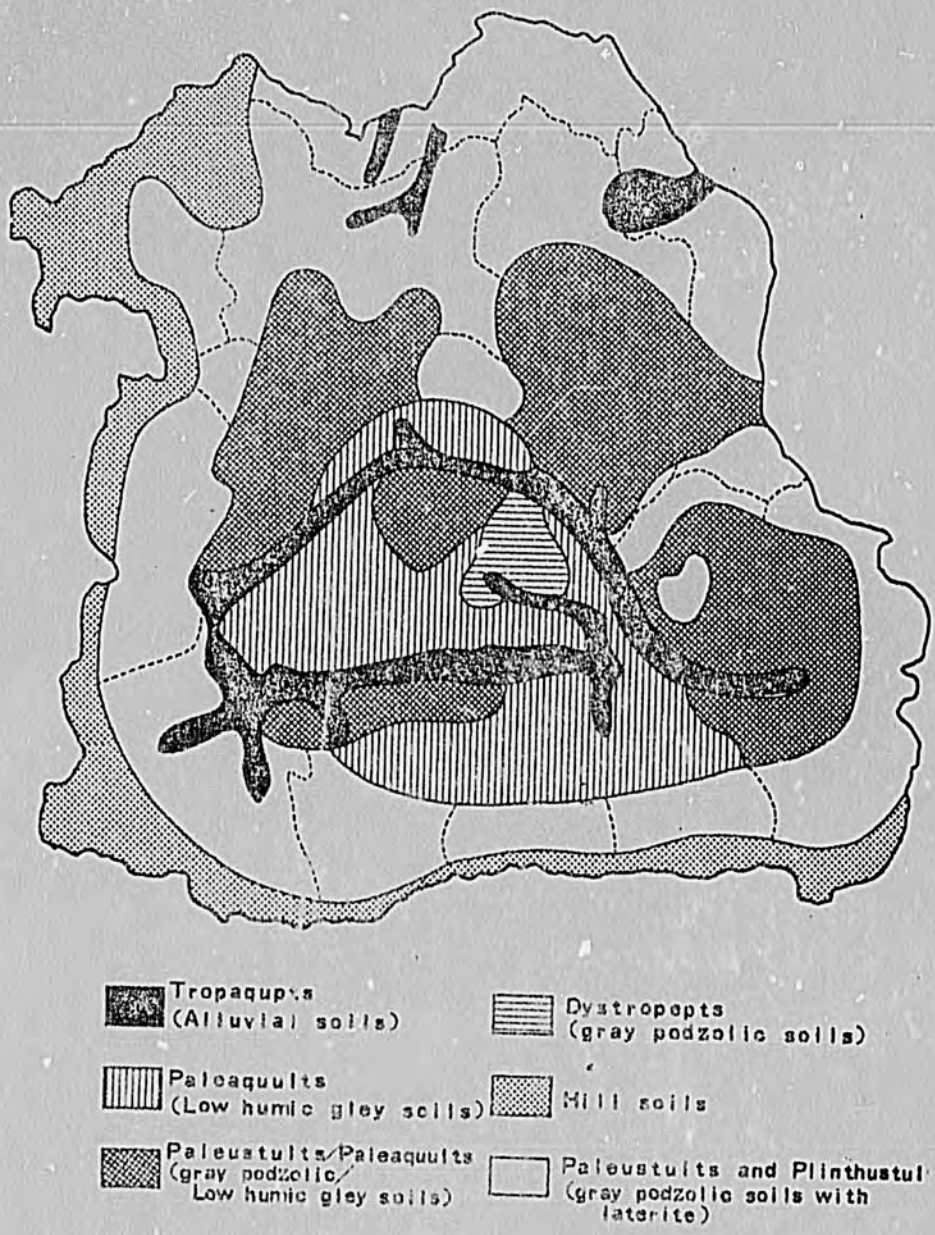


Figure 5. Simplified soils map of Northeast Thailand
(Source: Department of Land Development 1979).

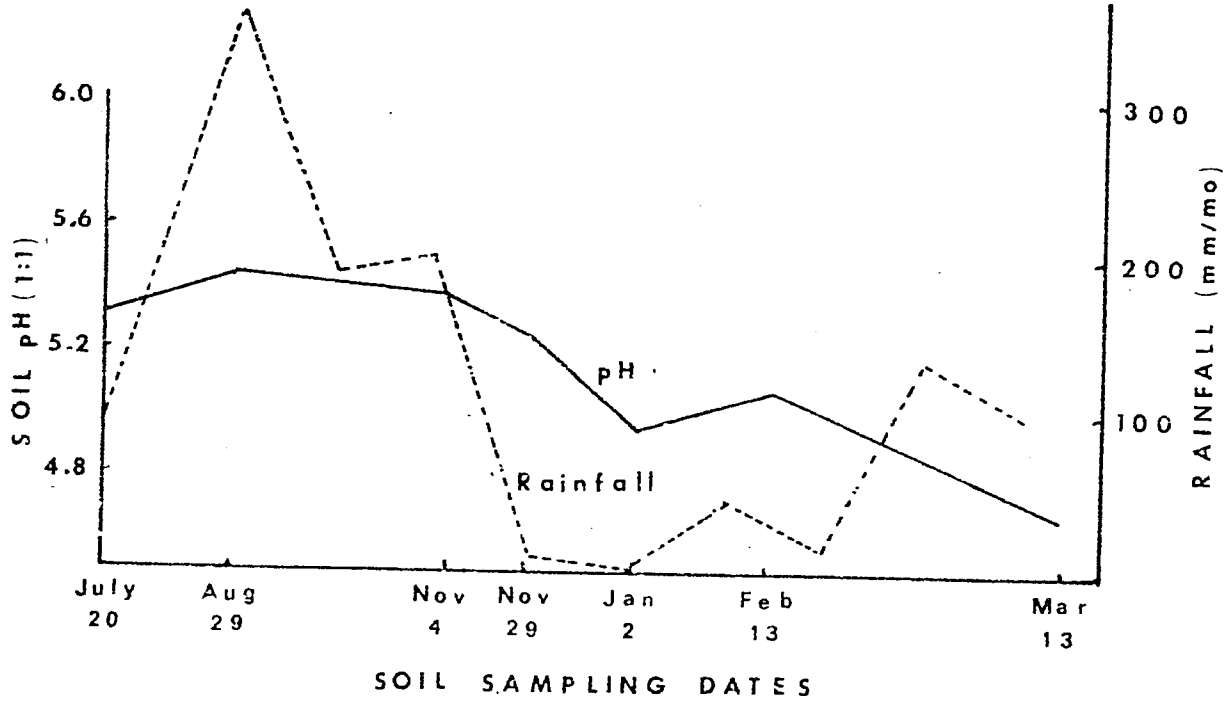


Figure 6. Decline in pH of rainfed paddy soil, Khon Kaen 1983/84, resulting from the oxidation of ferrous iron. (Source: Ragland, et al. Literature Cited Ref. No. 91)

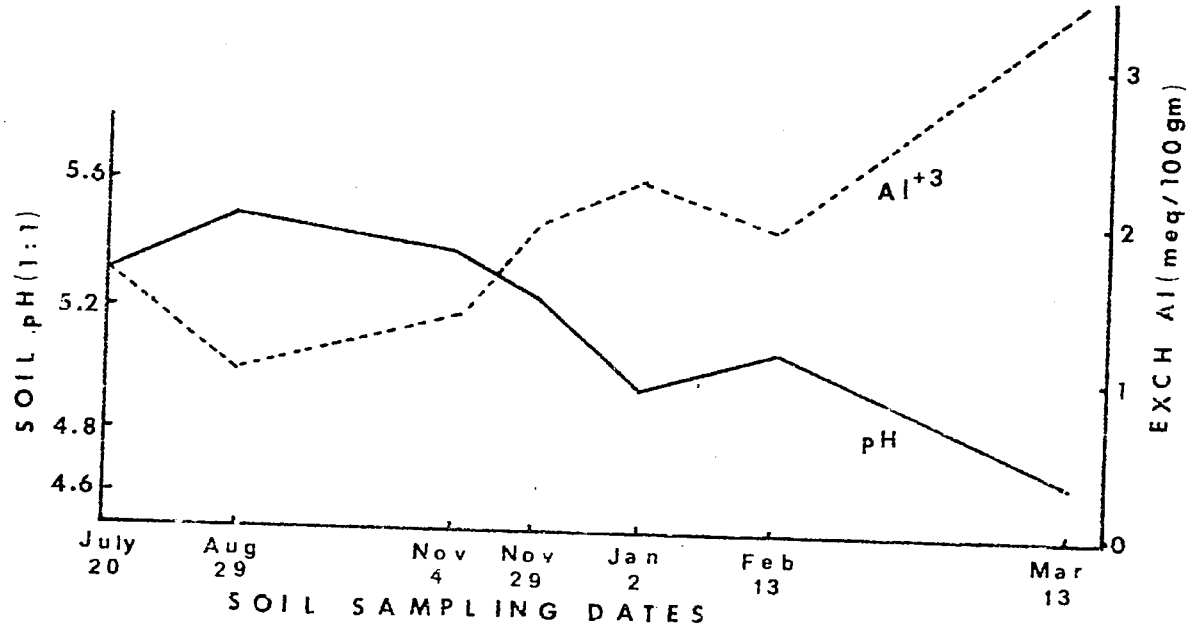


Figure 7. Decline in pH with concurrent increase of exchangeable aluminum in rainfed paddy soil, Khon Kaen 1983/84, resulting from the oxidation of ferrous iron. (Source: Ragland, et al. Literature Cited. Ref. No. 9).

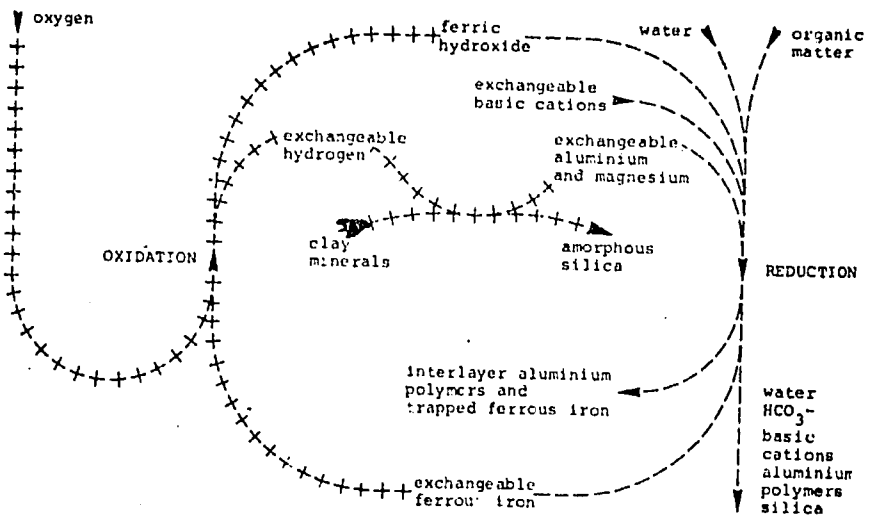
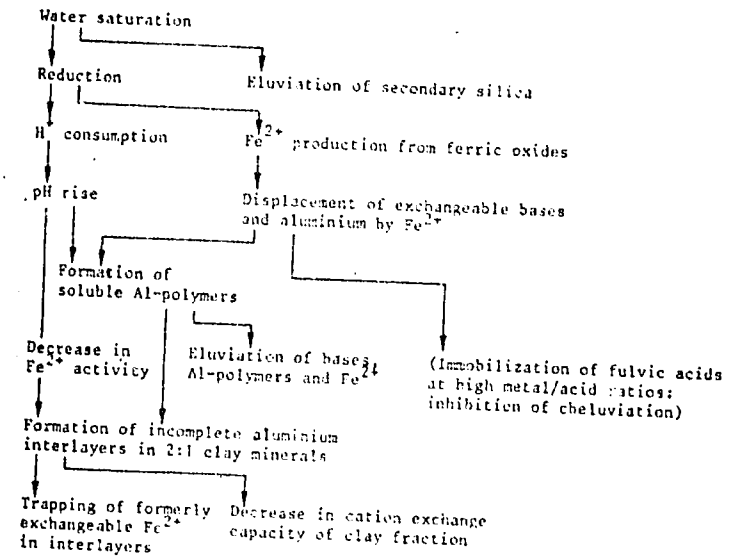


Figure 8. Schematic model of ferrolysis process operating in seasonably wet and dry soils. (Source: Brickman, Literature Cited Ref. No. 1)

Table 1. Schematic model of the genesis of eluvial horizons in seasonally wet, acid soils; ferrolysis. (Source: Brickman, Literature Cited Ref. No. 1, Table 51).

WET SEASON



DRY SEASON

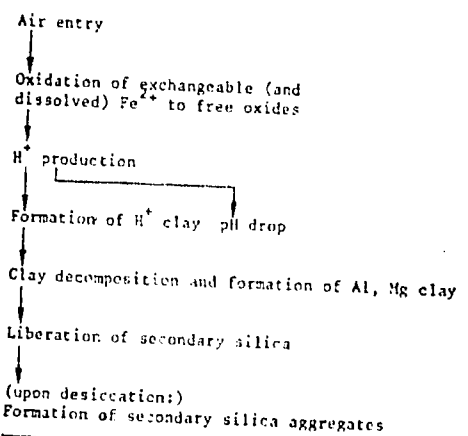


Table 2 Crop Production in Northeast Thailand

	Land Use		Production			
	Planted Area (Ha. x 10^3)	Change in Planted Area 1978-1983 (%)	N.E. as Percentage of National Production	N.E. Mean Yield 1978-83 (kg/Ha)	National Mean Yield 1978-83 (kg/Ha)	N.E. **Yield** as **Percentage** of **National** Average
Rice	4,257	± 9	36	1,200	1,660	**73**
Cassva	726	± 15	59	13,400	13,900	**96**
Maize	501	+ 53	22	1,780	1,990	**90**
Kenaf	217	- 31	100	1,040	1,040	**100**
Sugar cane	104	+ 124	11	39,800	40,600	**98**
Peanut	28	+ 25	19	1,020	1,190	**86**
Cotton	25	+ 13	25	1,270	1,150	**110**
Mungbean	18	+ 55	4	664	594	**112**

Source: OAE, 1983