

THE EFFECT OF INCREASED FERTILIZER
ON RICE YIELDS AND FARM PROFITS
IN THAILAND

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ABSTRACT

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by Sirion Hongsanand

The primary objective of this study is to investigate the relationship of fertilizer inputs and output of rice in Thailand at the present prices. To find whether at the current price levels of inputs and outputs, output expansion might be achieved by adding more inputs to the present agricultural system.

Because of the importance of rice as a national crop which plays the most important role in the agricultural economy, and fertilizer as an important factor of the cultivating system, the relationship of fertilizer use to rice yields has been examined using production function analyses. The study is based upon the assumption that other factors are held constant while varying the amount of fertilizer used in the same area of cultivation.

Most of the analysis is based upon experimental data from the Rice Division, Department of Rice, Ministry of Agriculture, Bangkok, Thailand, from 1958-1962. The relationship of the paddy yield and different levels of

fertilizer use was measured by the use of the correlation analysis with log equation.

The study shows a strong relationship of paddy yield and fertilizer over the range of the data. Although the factor prices are high, the increased yield of rice after adding some factors of the production, will be worth much more than the increase in the factor costs. Farm budget analysis was used to determine that farmers would get higher profits by increasing fertilizer use on present varieties of rice.

Thus, finally the study shows that even though the price of factors of the agricultural production are unfavorable, one way to expand output is to use more factors of production in the present cultivating system.

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By
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CHAPTER I

INTRODUCTION

Agriculture plays an important role in the economy of the developing countries, and thus increases in agricultural production is necessary. T.W. Schultz¹ has said that the farmers in developing economy are in equilibrium given the present prices and technology. He said that although it is obvious that traditional agriculture is niggardly, it is not obvious that niggardliness is a function of a unique set of preferences related to work and thrift. He stresses that it is predominantly a consequence of farmers having exhausted the profitability of the techniques of production which are an integral part of the inputs and knowledge at their disposal, and that there is a little or no incentive to save and invest in order to increase the stock of reproducible capital farmers are employing. Thus, traditional agriculture brings a low rate of return to the investment in agricultural factors of the type that farmers have been using for generations. In order to transform this type of agriculture it will have to

¹ Schultz, W. Theodore, Transforming Traditional Agriculture New Haven and London, Yale University Press, 1964, pg. vii-viii.

develop and supply new factors of production. In order for farmers to learn how to use the new factors will require new investment - investment in human capital will be required.

Thailand is a country of traditional agriculture, so that if Schultz is correct, in order to develop the economy of the county it appears necessary to follow a policy of agricultural output expansion. Since the agricultural output is the most important source of the national income, agricultural output expansion will bring an increasing rate of growth in the national income, and per capita income. This is the goal of the national development policy.

According to Schultz's theory, the way to increase agricultural production is to make the farming systems by providing new and more productive factors. This will result in higher productivity and give more profit.

The purpose of this study is to find whether:

(1) Thai farmers are using less fertilizer inputs compared to other countries with higher agricultural productivity.

(2) High factor prices are preventing the use of fertilizer because fertilizer cost is higher than its marginal productivities.

(3) At current prices using current varieties, more fertilizer will substantially increase production.

(4) It would be profitable to apply more inputs of fertilizer than now used, with current prices of inputs and products.

In the following chapters, after showing the background of the economy of Thailand, which is in the Chapter 2 and 3, is a study of the relationship of the inputs and outputs of one major agricultural crop -- rice. The main input which is studied is the fertilizer, for it is one of the most important factors of production in a modern farming system. The output which is examined is "rice", since it plays the most important role in the Thai economy.

A simple production function relating fertilizer and the paddy field is computed. The raw data were collected from the experimentation of the Rice Division, Department of Rice, Ministry of Agriculture, Bangkok, Thailand, in 1962. This experiment shows the combination of the fertilizer tests and yields on farms in the different regions of Thailand.

Using production function showing the relationship of the fertilizer and the paddy yield, it is possible to compare the paddy production before fertilization and after fertilization. A comparison to farm budgets of the rice farms by regions in 1962 were compared with the revised farm budgets

computed using new input-output ratios, these included using an optimum level of fertilizer obtained from experiments in farmers fields. The comparison used the average price of fertilizer and the average price of the paddy yield in the region for the year of 1962.

These results are covered in Chapter 4. Chapter 2 is the discussion of the location and geography of Thailand, income and employment, per capita income, foreign trade, and then the agricultural situation which shows the importance of the sector in the Thai economy. Chapter 3 shows the significant factors in the economy of agriculture; those are rice, corn and jute. The farming system, resource use, and the agricultural marketing system, fertilizer prices and the fertilizer use are being shown in the chapter also. Chapter 5 is the conclusion of the study and some suggestions for improving the output expansion program.

CHAPTER 11

THE THAI ECONOMY

A. Location and Geography

Topography

The kingdom of Thailand covers 514, 000 square kilometers (almost 200,000 square miles), as large as France, of the Indochinese Penninsular between longitudes 6° and 20° North and latitudes 97° and 106° East. Listed clockwise, countries bordering Thailand are the Kingdom of Laos and Cambodia on the North and East, the Federation of Malaysia on the South, and the Union of Burma on the West and North.

There are four natural regions conveniently divided by the pattern of rivers and mountains in Thailand: 1) The North, 2) The central Plain, 3) The Northeast, and 4) The South. With the exception of the South and the Northeast, the political geography of Thailand is that of a nation oriented toward one major river system, Chao Phraya. The Thai gradually moved down the tributaries of the Chao Phraya and on the plain of the river itself, establishing the foundation of the modern state.

Northern Thailand includes the area drained by the upper reaches of the Chao Phraya tributaries. It is a 60,000 square-mile region of long, north-south mountain ridges and deep,

narrow, alluvial valleys. Villages and towns cluster in the valleys, making use of the alluvial rice soils that exist here. The political and economic capital is Chiangmai. The ridges of this area are thickly forested and yield many types of valuable woods. Southwest of Chiangmai, the ridges reach their maximum height of 8,400 feet above sea level.

The Central Plain is the heartland of the Thai nation, it is the great plain of the Chao Phraya, and covers 50,000 square miles. Its northern limit is the Uttaradit area, and it stretches to the slope of the Korat Plateau. Bangkok is the capital of the great city of the plain; it is the center of the economic, political and cultural activity. Today 40 percent of the people live on the lower Central Plain, in a space smaller than 25 percent of the country's area. These millions have stripped the plain of natural cover, replacing it with the rice plant. The area now is a vast rice paddy. Although divided by the rivers, crisscrossed by the canals, dotted heavily by small villages, the paddy is everywhere. From the heavily populated and the intensively cultivated fields of the plain comes one of the world's largest rice crop. This also points to the dominance of rice in the country, for rice is the staple food, principal export, and largest source of the foreign exchange.

The Northeast is the least favored region of Thailand, having poor soil and relatively scarce rainfall, and is isolated from easy communication by its position outside the Chao Phraya basin. About 70,000 square miles (one-third of Thailand) is included in this area, and it represents the most serious challenge to the economic hopes of the central government in Bangkok.

The fourth region, 20,000 square miles, is that of the South. Its economy is based on tin mining as well as tropical agriculture. It is mountainous with narrow valleys plunging to the coast; only the east offers exploitable soils and adequate harbor facilities.

The western most mountain range in Thailand is a series of elongated blocks, along which most of the Thai-Burmese border runs, forming the watershed between the Salween and the Chao Phraya. To the south this range of many names becomes the spine of the Malay Peninsula. There are many passes and gaps through the mountains, but there has never been unlimited access, primarily because of military rivalry between Burma and Thailand.

Climate

The climates in Thailand qualifies in the Koppen classification as a "Tropical Rainy Climate." The defining

Thailand: Physiographic and Administrative Regions



Changwats:

- 1 Chai-Nat
- 2 Singh-buri
- 3 Lopburi
- 4 Sara-buri
- 5 Ang-thong
- 6 Ayuthya
- 7 Nonthaburi
- 8 Pathum-thani
- 9 Thonburi
- 10 Phra-nakhorn
- 11 Nakhornayok
- 12 Prachinburi
- 13 Samutprakan
- 14 Cha-choengsao
- 15 Cholburi
- 16 Rayong
- 17 Chant-buri
- 18 Trat
- 19 Chayaphum
- 20 Nakhornratsima
- 21 Buriram
- 22 Surin
- 23 Srisaket
- 24 Ubonrathani
- 25 Nong-kai
- 26 Loei
- 27 Udonrthani
- 28 Sakonnakhorn
- 29 Nakhornphanom
- 30 Khon-kaen
- 31 Mahasarakham
- 32 Kalasin
- 33 Roi-et
- 34 Mae-hongsorn
- 35 Chiangmai
- 36 Chiangrai
- 37 Lamphun
- 38 Lampang
- 39 Phrae
- 40 Nan
- 41 Uttaradit
- 42 Tak
- 43 Sukhothai
- 44 Phitsnulok
- 45 Kamphaengphet
- 46 Phichit
- 47 Phetchbun
- 48 Nakhornsawan
- 49 Uthai-thani
- 50 Kanchanaburi
- 51 Suphanburi
- 52 Ratburi
- 53 Nakhornpathom
- 54 Samutsongkhram
- 55 Samutsakhorn
- 56 Phetburi
- 57 Prachuap-khirikhan
- 58 Chumphon
- 59 Ranong
- 60 Phang-nga
- 61 Surat-thani
- 62 Nakhornsri thamrat
- 63 Phuket
- 64 Krabi
- 65 Trang
- 66 Phatalung
- 67 Satun
- 68 Song-khla
- 69 Pattani
- 70 Yala
- 71 Nara-thi wat

characteristics of this classification are as follows:

(a) Warm temperatures throughout the year, with no month having a mean temperature less than 64°F.

(b) An annual rainfall of greater than 750 millimeters, which is largely convectional in origin with heavy showers often accompanied by severe thunder and lightning and cyclonic rains associated with weak tropical lows.²

There are three seasons in the general classification, the cool season is from November till the end of February, from March to May is what is called the hot season, and the rest is the rainy season. The southwest monsoon breaks over the whole country by June, bringing the season of heavy rains. The southwest monsoon blows steadily from May to September and then gives away to the cooler, drier northeast monsoon which continues into February. The Monsoon pattern is modified by local thunderstorms which arise in the Gulf of Thailand and by cyclonic storms which originate in the South China Sea and pass over North and Northeast regions in June and September. The return of the cyclonic storms in September often results in the heaviest rainfalls of the year in the areas which are affected.

²Nuttonson, M. Y. The Physical Environment and Agriculture of Thailand: A Study based on field survey data and on Pertinent Records, Materials and Reports. Washington: The American Institute of Crop Ecology, 1963, p. 12.

The variation of the rainfall over space is determined primarily by the topography. The major sources of rain are the Southwestern monsoon, local storms which arise in the Gulf of Thailand and which do not normally venture far inland, and the cyclonic storms which pass over north and northeastern Thailand. Heavier rainfalls are concentrated in the areas which are southwest of the mountain ranges, close to the Gulf of Thailand, and the cyclonic storms from the South China Sea pass over regularly. The Northeast does not receive substantially less rainfall than does the Bangkok Plain and much of the rest of the Central Region. The relative water shortage in the Northeast does not seem to result from either low annual rainfall or wide annual variance in rainfall so much as from the incapacity of the soils to retain much water and the torrential river system. In the Central Region, the rivers are not torrential and large areas, especially in the Bangkok Plain, benefit from runoff of rainfall which actually occurred in the North.

Soil Type

With the exception of the flood plains, the surface soil is generally of low fertility. Once the apparently luxuriant natural tropical vegetation is destroyed the organic material is quickly oxidized because of the higher temperature, and the heavy rains rapidly leach away the soluble organic

compounds, as well as any other soluble nutrients. Upland soils tend to be less fertile in the Northeast than in the Central Region because of the finer sandy loams of the Northeast are more susceptible to leaching and have a lower limestone content. The fine upland surface soils of the Northeast have little capacity for water retention and the underlying impermeable layers of laterite prevent substantial seepage into underground reservoirs. The upland soil structure of the Northeast is a major cause of the relatively torrential river flows and the associated alternation of flood and draught conditions in parts of that region.

The flood plain in both the Northeast and the Central Region are constituted of heavy clay soils which absorb water very slowly and which tend to be puddle when wet. Such soils do not permit adequate drainage for most crops, but are suitable for wet rice. The plains are usually overlaid with alluvial deposits. Because the rivers of the Central Region are much more sluggish and flood plains cover a much larger area, the deposition of sediment contributes more to the fertility of soils in the Central Region than in the Northeast.

B. Population

Size and Density

In 1965, the population of Thailand is estimated to have

been approximately thirty and a half million.³ The average density is about 114 persons per square mile.⁴ The most extensive concentrations, over 200 per square miles, are found in the Chao Phraya Valley and the Valley of the Chee and Mun Rivers on the Korat Plateau. The population is concentrated in the river valleys, where alluvial soils and adequate water allow the traditional rice culture.

Most of the people are classified in the agricultural sector, about 74.6 percent of the whole population of the country in 1960. Given the rapid growth of the population living in Bangkok in the post second world war period, presumable an even larger percent of the population lived in agricultural households in earlier years. Not all of those who live in the agricultural households receive all of their income from the agricultural production. Many of the agricultural residents work seasonally in the villages or in Bangkok or supplement their income through such activities as lac collection or forestry. The high percent of the total population which livest in the agricultural households is an indication of the

³Behrman Richard Jere, Supply Response in Underdeveloped Agriculture, A Case Study of the Four Major Annual Crops in Thailand, 1937-1963, Unpublished report submitted for Ph.D., University of Pennsylvania, Philadelphia, Pennsylvania, August 22, 1966, p. 39.

⁴Wendell Blanchard: Thailand, its people, its society, its culture. New Haven, HRAF Press, 1958, p. 49.

important role that the agricultural sector plays in the Thai economy.⁵

Growth Rate

The annual rate of the population growth in recent years has been approximately 3.2 percent. These growth rates suggest that in the Central Region, population is growing relatively quickly in the upper plains, in Choburi, and the Bangkok area. In the Northeast, population is growing relatively fast in the northern cities close to the Mekhong and in the western cities. In both regions, therefore, there is evidently some tendency for net migration out of the more densely settled flood plains.

Education Level and Social Structure

The government school in the rural areas became widespread only after the 1932 revolution. In the post World War II period, attendance has been required until the student has become fourteen or has passed the fourth grade (Prathom IV). There is some tendency towards higher literacy rates in the heart of the Central Region than anywhere. The highest literacy rates are in the Bangkok Plain and the lowest are in the Northeast and Western highlands.⁶ In the recent years,

⁵Behrman, Richard Jere, op. cit., p. 39a.

⁶Ibid., p. 49.

more informal educational programs associated with the community development and extension services are being expanded.

The dominant religion in Thailand is Buddhism, including 93 percent of the population. The other religions are Islam, Christianity, Bramanism and Touism; but these affect only small fractions of the population and none are expanding. The concept of the supernatural power affecting human relations, the arts, and even the economic organization are Buddhist religious beliefs and institutions that are changing, but many of the basic concepts remain unchanged.

The Thai economy, in general, is controlled by the Thai-Chinese people. They are still important to the agricultural sector, because they dominate the marketing system, the agricultural processing industries, and the agricultural export trade. They became predominant in commercial, financial and mining activities, while the Thai's concentrated in agricultural production and government services.

C. Income and Employment

National Income

The statistical data of the office of the National Economic Board, shows that Thailand's Gross National Product (GNP), or the value of all goods and services produced, reached

an all time high of 3.86 billion dollars in 1965. Growth rates of GNP since 1957, although fluctuating, have always been positive and have averaged over 7 percent a year, a rate which is more than double the estimated growth in population (3 percent per year, approximately). Per Capita GNP in 1965 was over 120.6 dollars, up from 86.8 dollars in 1957.

Agriculture is still the predominant sector of the national economy of Thailand. The value of agricultural output increased from 849 to 1,819 million dollars from 1957 to 1965, while the national income increased from 2,004 to 3,332 million dollars in the same period.

Fluctuation in the over-all growth rate ranged from a low of +0.8 percent in 1958 to +10.7 percent in 1960. Such variations were caused by the instability of agricultural output and its impact on other sectors of the economy. In the past few years agricultural output has stabilized at a high level and the growth rate since 1963 has been a little over 5 percent a year.

The basic activity of the Thai economy, or that from which most of GNP is directly or indirectly derived, is agriculture. Although only 37.3 percent of value added originates directly from this sector, over half of manufacturing involves the processing of agricultural products and a significant part of trade and transportation is devoted to the marketing of these

products. Consequently, when agricultural product varies, there is a direct income multiplier effect.

The structure of the Thai economy has changed considerably in the course of development, particularly during the first phase (1961-1963) of the First Economic Development Plan (1961-1966). Total output grew at over 5 percent a year in agricultural sector. During the second phase (1964-1966) of the plan, total output (GNP) grew at an annual rate of over 7 percent, while agriculture grew at only 2 percent annually.

Per Capita Income

A certain minimal level of income per person is considered an important factor for raising yields because where incomes are still at the subsistence level there is little capital available to purchase the yield-raising inputs such as fertilizer or improved seeds. The level of income per person is also the most commonly used indicator of the level of economic development, thus, establishing the fact that high income countries can raise yields rapidly may be to infer not only that these countries have a great deal of capital for investment in agriculture but also they are advanced countries, almost by definition, possess a much greater yield raising capability.

Most of the world's major rice producing countries are characterized by very low per capita incomes. Eleven of the thirteen leading rice producers have per capita incomes below \$150 per year (as shown in Table 1). The exception are Japan and the United States, where per capita incomes are \$350 and \$2,280 per year. Both countries have had much more success in raising rice yields than any of the low income countries.

The low income, rice producing countries had uniformly modest increase in yields during the 24 years from 1935-1939 to 1960-1962. Thailand, which experienced a decline in yields, was the only exception. Annual rates of increase in the other countries ranged from 0.3 percent per year in the Philippines to 0.9 percent in Taiwan.

In Thailand, the average per capita income shows a slight upward trend. It presently varies from \$60 in the Northeast area to \$168 in the Central Plains, which includes the Bangkok area. The national per capita income is estimated for 1965 at \$104 (Table 2).

Employment

Increases in the population throughout the nineteenth century and well into the twentieth century led neither to general overcrowding nor to an exodus from the land. The growing world demand for rice was an incentive for increased

Table 1. Per Capita Income (estimates) by Countries, 1959

Country	Annual Income
<u>North America</u>	
Canada	1,560
U.S.A.	2,280
<u>Latin America</u>	
Argentina	300
Brazil	170
Chile	440
Colombia	200
Guatemala	150
Mexico	310
<u>Western Europe</u>	
France	1,010
Germany (West)	1,020
Greece	330
Italy	510
Portugal	230
Spain	300
U.K.	1,100
<u>Africa</u>	
Algeria	230
UAR (Egypt)	120
Morocco	120
Tunisia	130
South Africa	350
<u>Asia</u>	
Burma	50
Ceylon	120
China (Taiwan)	90

Table 1, Continued

Country	Annual Income
<u>Asia, cont.</u>	
India	60
Japan	350
Korea (South)	100
Pakistan	50
Philippines	150
Thailand	80
Iraq	160
Turkey	140
<u>Oceania</u>	
Australia	1,100

Source: Brown, R. Lester, Increasing World Food Output; Problems and Prospects, Foreign Agricultural Economic Report No. 25, U.S.D.A.; Economic Research Service; Foreign Regional Analysis Division, April 1965, p. 47.

Table 2. Per Capita Income of Thailand - 1957-1965

	<u>Population²</u> (1,000)	<u>National Income^b</u> (millions Baht)	<u>Per Capita Income</u> (Baht) \$	
1957	24,148	40,083.1	1,662	79
1958	24,873	41,579.1	1,670	79
1959	25,619	44,358.6	1,730	83
1960	26,388	48,910.6	1,854	88
1961	27,180	52,308.2	1,928	92
1962	27,995	56,863.5	2,032	97
1963	28,835	58,818.7	2,040	97
1964	29,700	63,010.8	2,125	101
1965	30,591	66,644.3	2,180	104

Source:

(a) Statistical Yearbook 1965, p. 41.

(b) Ibid: p. 456.

production, and new lands were brought under cultivation. Agriculture remains the Thai's preferred occupation, and no economic pressure developed to force him into others. New occupations coming into existence as a result of foreign investments in the extractive industries provided employment for Chinese rather than Thai labor.

The rice cultivator is generally a small operator working land which he owns or rents and which he farms with the help of his family. Farm wage laborers are not more than 6 percent of the agricultural labor force, yet, they represent more than one-third of all the wage earners in Thailand.

Recent reports indicate that there is, at the present time, little urban unemployment. Seasonal unemployment and underemployment, however, remain widespread in agriculture. In recent years government-sponsored road and irrigation projects have provided employment for many whose agricultural pursuits have several months of the year available for other work. Other agricultural workers, particularly from the North and Northeast, find jobs as unskilled laborers in Bangkok for a few months each year or two.

Foreign Trade

Thailand's foreign trade is extremely important to the economy. The export of raw materials provides foreign exchange for the import of manufactured products, including capital goods. Foreign trade represents a substantial proportion to the national income, and government economic policy has diverted a large part of this income to the treasury. Direct levies on trade, particularly exports, produce probably one-half of government revenue.

The three principal exports -- rice, rubber, and tin made up more than 70 percent of the exports in recent years. Rice represented more than 40 percent of the total. Imports consist primarily of textiles, machinery and transport equipment, fuel, food, and chemicals. With rare exceptions the yearly value of imports exceeds that of exports. The imports have been increasing at a higher rate than the rate of expansion in exports. This results in a negative balance of trade. Despite the negative balance of trade, there is no balance of payment difficulties, because of the significant inflows of international aids and private capital.

D. The General Agricultural Situation

Types of Farming Practiced and Location

Thailand is a part of monsoon Asia, lying entirely within the tropics. The present area has been held by the

Table 3. Exports, Imports, and Balance of Trade of Thailand, 1950-1963 (In US\$ millions)

Year	Exports			Total Imports	Balance of Trade
	Rice	Other	Total		
1950	79.6	85.8	165.4	125.0	+40.4
1951	86.8	123.3	210.1	176.4	+33.7
1952	125.2	94.7	219.9	263.1	-43.2
1953	178.4	96.4	274.8	308.2	-33.4
1954	147.0	147.1	294.1	334.4	-40.3
1955	149.2	189.9	339.1	357.3	-18.2
1956	136.2	193.5	329.7	364.5	-34.8
1957	172.5	187.5	359.0	406.3	-47.3
1958	141.3	165.7	307.0	392.2	-84.2
1959	122.7	137.3	360.0	429.0	-68.0
1960	122.4	287.8	410.2	458.2	-48.0
1961	171.3	304.7	476.0	489.9	-13.9
1962	154.3	299.5	453.8	547.8	-94.0
1963	163.0	297.8	460.8	609.7	-148.9

Source: Agricultural Statistics of Thailand, 1963
Tables 80, 81.

Thailand's for more than 100 years. Its physical features are varied and fall into four natural regions. The North (north-west) region toward the border of Burma is mountainous and forested. The Northeast region bounded on the east by the Mekong River (the Laos border) is a vast plateau. The Central Region is a well-irrigated and very fertile rolling plain. The South Region extends down the Malay Peninsula to the border of the Federation of Malaya and is mainly mountainous.

Of the total land area of 126.5 million acres, approximately 22 million are under cultivation and some 75 million are forested lands. There is no precise information available on the use of the remainder -- nearly a quarter of the land.

Agricultural techniques in Thailand have not changed substantially from those used a hundred years ago. It is a kind of traditional farming system. The methods varied according to the climate condition, the topography of the land, and the nature of the soil. Yield per rai (2.5 rai = 1 acre) is low. The tools are simple, such as a wooden plough, a wooden harrow, and a wood-handled sickle.

The average area per family is approximately 10 acres.

General Marketing System

According to theory, to induce higher output, the farm output prices must be suitable and stable, and provide an incentive for using productive inputs. Improvement in

productivity of farming is important. Farmers have low income because:

1. They have the contracts with the loaners to sell the products at the prices lower than the market prices;

2. No storage available for them. They have to sell the products after threshing and harvesting. This causes the lower prices during the harvesting time.

3. The purchasers who are the merchants, retailers and the loaners tend to cheat the illiterate peasants in measuring and pricing.

Rice farms in Thailand are large in number but small in the area owned. It is estimated that there are approximately 2.8 million farms with an average size of 26 rai (10 acres). These farms are scattered around the whole kingdom, but concentrated most in the Central Plain. The marketing system of rice is as simple as the other products. These are shipped from the villages to the mills, processed at the mills, shipped from the mills to the ports, and the arrangement for export is all done by separate groups of middlemen. Rivers are important in the transportation; railroads and highways are used where the water transport is not accessible.

Middlemen play an important role in the marketing of major crops. Some of them close to the farmers buy and sell paddy, and other farm products; sell imported merchandise and transport goods in both directions.

Relative importance of the Major Crops

Among the major annual crops of Thailand, rice plays the most important role, as is well known. It occupies the largest cultivated land area, produces the highest value among the crops, and provides employment opportunity for the majority of the people. It supplies more than enough staple food for the country, earns the largest amount of foreign exchange, and yields the most stable revenue for the government.

In 1963, agricultural products, which always has been the most important source of national income, was estimated at about 35 percent of the national income, while rice contributed 12 percent to the gross domestic product.⁷

The second major crop is maize, which is increasing in importance in exports, mostly in the recent years. It is the most important export of the grain crops, other than rice.

⁷National Income Statistics, Office of the National Economic Development Board, Thailand, 1964, pp. 90-91.

From 1951 to 1963, the quantity of corn exported increased at an average annual rate of 36 percent, and it ranked as the third export next to rubber in 1961 to 1963.⁸

Jute and kenaf are the fiber crops, which are the third major type of crop in the economy.

Summary

Among the Southeast Asian countries, Thailand is one of the major agricultural exporters. The climate and the soil type are suitable for growing crops, and crop production plays an important role in the economy of Thailand. About 37.3 percent of the national income comes from the agricultural sector, and the farmers represent the largest share of the population (74.6%) as a whole.

The rate of the population growth is approximately 3 percent a year, while the growth rate of the gross national product is 7 percent. Although agricultural development in Thailand has made significant gains, in certain respects it is lagging behind other countries in the use of improved seed and fertilizer. The rate of growth in Thai agricultural output has been significant but still remains lower than Japan and Taiwan. The rest of the study examines some of the implications of removing some of the obstacles to improve yields.

⁸ Behrman, Richard Jere. Supply Response in Underdeveloped Agriculture, A Case Study of Four Major Annual Crops in Thailand, 1937-1963. Unpublished material submitted for Ph.D., University of Pennsylvania, Philadelphia, Pennsylvania, August 22, 1966, p. 151.

CHAPTER III

SIGNIFICANT FACTORS IN THE AGRICULTURAL ECONOMY

A. Production and Output

Rice

The economy of Thailand is not only predominantly agriculture, it is primarily a 'rice economy'. Rice production has been the main economic activity of the people. It occupies 41.3 million rai (2.5 rai = 1 acre), or 13 percent of the land available for cultivation in 1963 (Table 4).

The area under rice cultivation expanded at breakneck speed from 9.3 million rai in 1907 to 41.6 million rai in 1962 (Figure 1). This increase in acreage is due to the rapid growth of population, limited opportunity for employment in the city, and the fact that rice is the main staple food of people.⁹

Rice can be cultivated everywhere in Thailand, but the heaviest concentration of rice production occurs in the Central Plain zone, averaging about 50 to 55 percent of the total production of Thailand.

⁹Division of Agricultural Economics, Ministry of Agriculture; Bangkok, Thailand, A Study of Rice Production and Consumption in Thailand, 1966, p. 5.

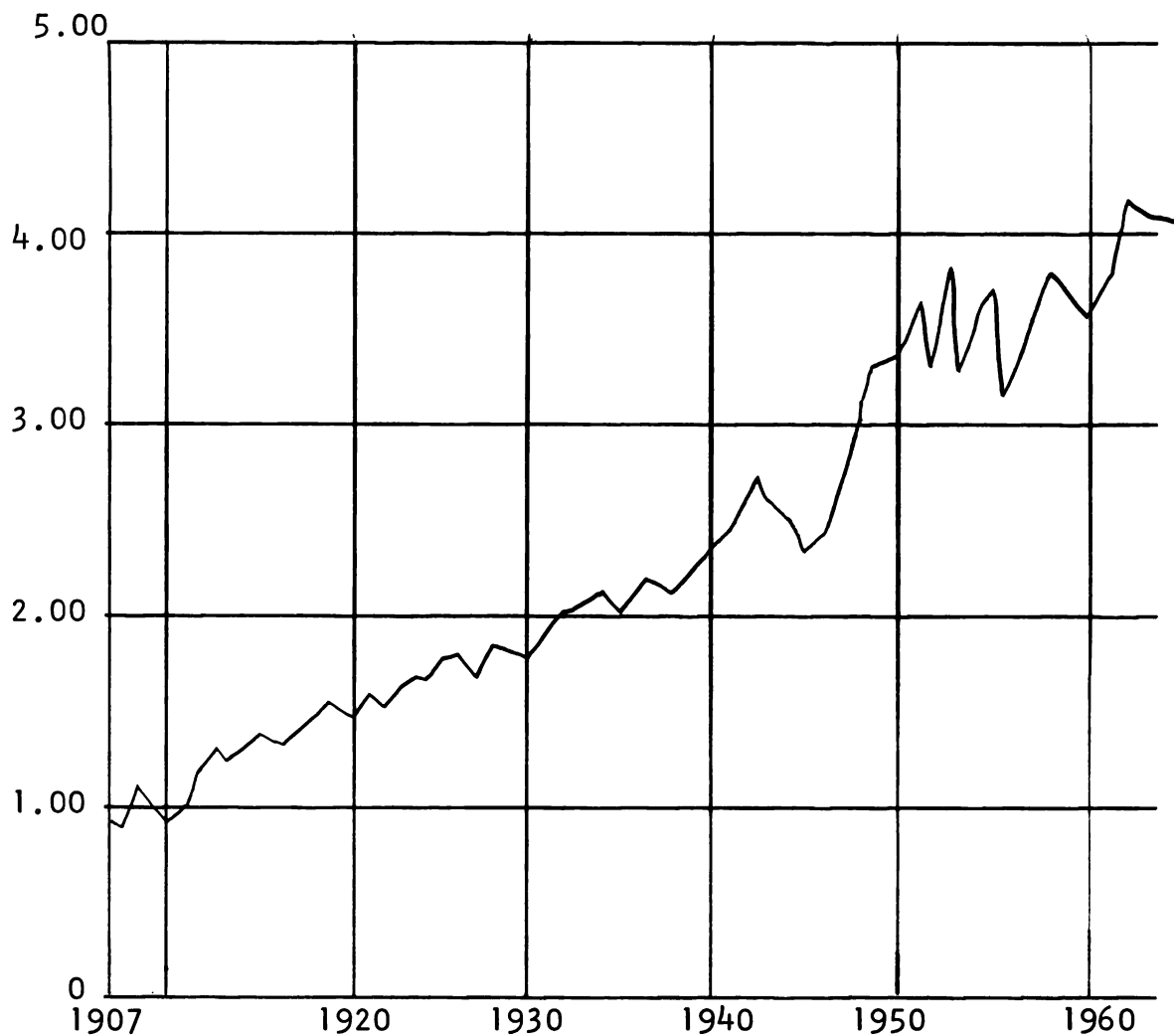
Table 4. Land Use in Thailand, 1963

Item	Rai (1,000)	% of Land Area Used
Rice	41,277	12.84
Tree crops	10,792	3.36
Upland crops	10,234	3.19
Farm woodland	4,224	1.31
Misc. farmland	3,968	1.24
Sub-total: All farmland	70,495	21.94
Forest and grazing land	165,443	51.50
All other (roads, rivers, urban areas, wasteland)	85,312	26.56
Total Area	321,250	100.00

Source: Division of Agricultural Economics, Ministry of Agriculture, Bangkok, Thailand, Agricultural Statistics of Thailand 1963, pp. 162.

Figure 1. Rice Area Planted in Thailand, 1907-1965.

Million Rai



Source: Division of Agricultural Economics, Ministry of Agriculture; Bangkok, Thailand; A Study on Rice Production and Consumption in Thailand, 1966, p. 6

Although more land has been used for rice growing and total production has in consequence increased, average yield per rai has exhibited a declining trend (Figure 2). From the report of the Division of Agricultural Economics, over the entire period there is a downward trend until the 1950's with many fluctuations. That may be due to the following causes:

- (1) The supply of land is fixed and as farming becomes more intensive, suitable land for growing rice is less available.
- (2) Land is not properly taken care of and insufficient fertilizer is used to maintain soil fertility, which has been reduced as a result of cropping practices and natural conditions.

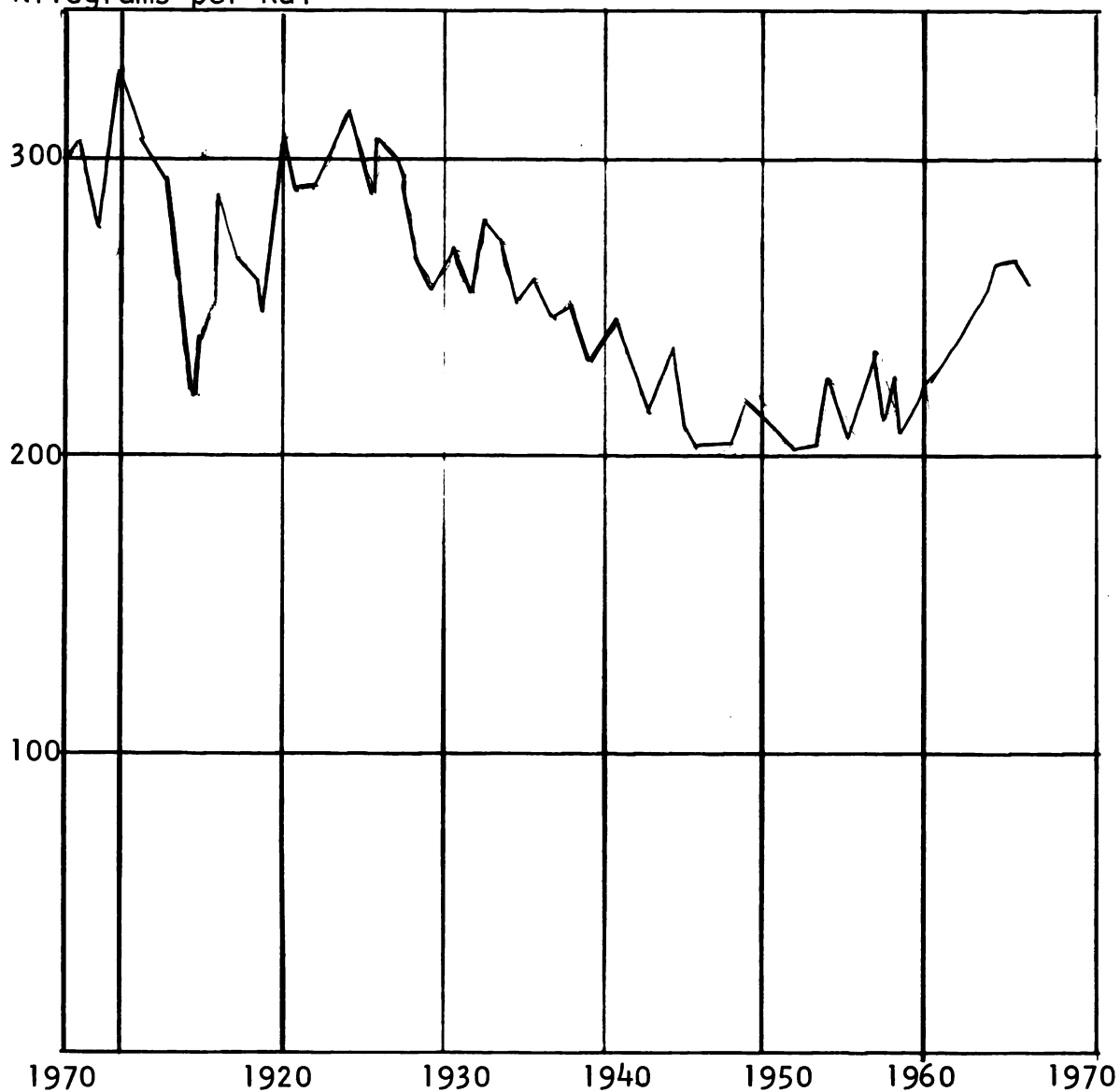
It appears that the declining yield per rai was arrested in 1959. Since then, yield has increased by approximately one-fourth -- from 206 kilograms in 1959 to 257 kilograms per rai in 1964. There are two reasons given to explain this rise in yield. One is the varietal improvement and an increase in rice under irrigation.¹⁰

Although Thailand is the first in the world rice exporters, it has one of the lowest yields (as shown in Table 5). From

¹⁰Ibid., p. 8.

Figure 2. Paddy Yield in Thailand, 1907-1965.

Kilograms per Rai



Source: Division of Agricultural Economics, Ministry of Agriculture, Bangkok, Thailand, 1966. A Study on Rice Production and Consumption in Thailand. 1966, p. 7

Table 5. Average Yield of Paddy per Acre in Selected Rice Producing Countries From 1961-1962/1964-1965

Country	Average Yield (pounds per acre)			
	1961-1962	1962-1963	1963-1964*	1964-1965
Australia	5,773	5,332	5,293	5,339
Spain	4,724	5,546	4,865	-
Italy	4,868	4,740	4,573	5,127
Japan	4,196	4,417	4,386	4,510
U.S.A.	3,411	3,726	3,962	4,082
Portugal	4,161	4,203	3,897	3,812
Peru	3,708	3,184	3,527	-
Taiwan	3,130	3,186	3,361	-
Pakistan	1,484	1,351	1,537	-
Thailand	1,297	1,339	1,420	1,422
India	1,361	1,224	1,378	1,378
Philippines	1,097	1,099	1,090	1,126
Cambodia	974	1,040	1,073	-

Source: U.S. Department of Agriculture. Rice Situation, Washington, D. C., January 1964, pp. 28-29 (*1963-1964, 1964-1965 data are preliminary).

the table we can see that in 1963-1964, the productivity of rice per acre in Australia was 3.7 times as high as that of Thailand; in Japan 3.1 times as high, and in the United States, 2.8 times.¹¹

Corn

Corn or maize can be grown under high temperatures, high rainfall and a fairly long growing season. The degree of concentration of corn production has been increased because of the improvement of transportation, which increases returns to producers. The second reason is that because of the comparative soil characteristics, high corn yield can be obtained in the north of the Central Region where corn has become concentrated.

In cultivating corn, sometimes three bean crops are interplanted among them, since these kinds of crop will increase the nitrogen organic material, which replenishes the soil fertility and makes the second crop of corn more productive. This kind of practices are being followed for the other crops also.

The cultivation techniques which are used for corn in Thailand are simple. Even so, corn production has been

¹¹Krisnamis Phriach, Paddy Price Movements and Their Effects on the Economic Situation of Farmers in the Central Plain of Thailand, June 1967, p. 10. Unpublished report submitted for Ph.D., Indian University, Indiana.

increased in both acreage and yield (in Table 6), because of the improvement of the transportation to market, the development of new varieties, and also the improvement of soil fertility.

The recent rate of increase of the corn production and corn export has been very high. In the period of 1951-53 through 1961-63, corn production has increased at an average of annual rate of over 27 percent and the quantity exported has increased at an average of annual rate of almost 36 percent.

Jute and Kenaf

Jute and kenaf are produced mostly in the north-eastern region of Thailand. Farmers are concentrating more on the production of kenaf than jute because of the market demand. As shown in Table 7, the production increased from 181,000 tons to 339,000 tons from 1960 to 1961, resulting from an expansion in the area planted. Production declined in 1962 since the world price dropped extremely. Sometimes the kenaf and jute yields have dropped in some areas reflecting a reduction in soil fertility.

Next to India and Pakistan, Thailand is one of the most important fiber crop exporters. The government is trying to improve and support the production of jute and kenaf, also stressing the quality of the products.

Table 6. Maize: Area, Production and Market Value. 1928-1964

Year	Area Planted	Area Harvested	Average Yield	Production	Wholesale Price	Value
A.D.	1,000 Rai	1,000 Rai	Kg. per Rai	1,000 Tons	Baht per Kg.	Million Baht
1928-36	42	41	124	5.1	0	0
1937-46	67	64	128	8.2	0	0
1947	144	136	126	17.2	0	0
1948	137	132	130	17.2	0	0
1949	218	202	127	26.7	0	0
1950	296	211	197	26.9	1.08	29.1
1951	259	256	163	41.7	1.50	62.6
1962	281	271	165	44.8	1.03	46.1
1953	298	295	173	51.1	1.50	76.6
1954	331	326	191	62.3	1.30	81.0

Table 6, Continued

Year	Area Planted	Area Harvested	Average Yield	Production	Wholesale Price	Value
A.D.	1,000 Rai	1,000 Rai	Kg. per Rai	1,000 Tons	Baht per kg.	Million Baht
1955	347	345	196	67.5	1.20	91.0
1956	514	510	225	114.8	1.46	131.2
1957	606	597	229	136.8	0.90	191.3
1958	792	783	238	186.8		193.3
1959	1,249	1,241	256	915.		149.
1960	1,785	1,779	306	845.9	1.01	149.
1961	1,910		331		1.12	879.1
1962	1,050		331		1.06	872.1
1963	2,612		353		1.06	909.2
1964	3,449	3,381	376		1.08	1,009.9

Source: Division of Agricultural Economics, Ministry of Agriculture, Bangkok, Thailand, Agricultural Statistics of Thailand, 1964. p. 55.

Table 7. Kenaf: Area, production and market value, 1950-1964

Year	Area planted	Area harvested	Average yield	Production (washed)	Wholesale price	Market value
A.D.	1,000 Rai	1,000 Rai	Kg. per Rai	1,000 tons	Baht per kg.	Million Baht
1950	31	30	156.7	4.7	1.91	9.0
1951	88	85	235.3	20.0	1.75	35.0
1952	67	66	198.5	13.1	4.41	57.8
1953	60	60	233.3	14.0	1.00	14.0
1954	37	36	227.8	8.2	1.87	15.3
1955	53	52	188.5	9.8	2.85	27.9
1956	109	108	157.4	17.0	3.04	51.7
1957	78	78(r)	228.2 (r)	17.8 (r)	2.58	45.9 (r)
1958	127	127	233.1	29.6	2.30	68.1
1959	278	277	180.5	50.0	2.24	112.0
1960	877	870	208.4	181.3	3.17	574.7
1961	1,720	1,681	201.8	339.3	3.61	1,225.9
1962	712	700	192.0	134.0	2.33	312.2
1963	957	950	222.9	211.7	2.73	577.9
1964	1,365	1,346	225.2	303.1	2.75	833.5

Table 7, continued

Year	Area planted	Area harvested	Average yield	Production (washed)	Wholesale price	Market value
A.D.	1,000 Rai	1,000 Rai	Kg. per Rai	1,000 tons	Baht per kg.	Million Baht
1950	18	17	147.0	2.5	1.25	3.2
1951	22	21	142.9	3.0	1.92	5.8
1952	7	7	142.9	1.0	4.41	4.4
1953	11	10	180.0	1.8	1.00	1.8
1954	8	8	162.5	1.3	1.87	2.4
1955	10	10	130.0	1.3	2.26	2.9
1956	16	14	178.6	2.5	3.08	7.7
1957	12	12	233.3	2.8	2.53	7.1
1958	13	13	223.1	2.9	2.29	6.6
1969	17	17	229.4	3.9	2.25	8.8
1960	26	26	238.5	6.2	3.24	20.1
1961	66	63	184.1	11.6	3.64	42.2
1962	48	44	150.0	6.7	2.97	20.4
1963	34	33	208.0	6.9	2.73	18.8
1964	36	32	200.0	6.5	2.85	18.5

Source: Division of Agricultural Economics, Ministry of Agriculture, Bangkok
Thailand, Agricultural Statistics of Thailand, 1964, p. 85.

B. Resource Use

The traditional farming system in Thailand is being developed. Since the farmers have to pay the high rate of interest to the loaners, the Thai Banker Association offers a low rate of interest loan to the farmers to buy fertilizers and improve their mechanical use. Besides, the government is providing the policies of double cropping system, new strains, and different kinds of fertilizer to the farmers. Along with the improving in the storage facilities, that will prevent the high wastage of the grain to be spoiled through insects and pest damage.

Fertilizing is the first thing that should be done. In the past, fertilizer was imported and was so expensive compared with the other countries (as shown in Table 8), that farmers believed only crops such as sugar cane, tobacco, and vegetables could return enough to pay for its use. From a government survey, it was reported that only 20 percent of the cultivated land was under fertilizer in 1965. The prevailing high prices of fertilizers for a time defeated efforts to increase their use. The government is working on a program of subsidization of fertilizer. It has been shown by experimentation that certain fertilizers can increase rice yields from 25 to 200 percent.¹² A West German consortium

¹²Wendell Blanchard: Thailand, Its People, Its Society, Its Culture, New Haven, HRAG Press, 1958, p. 319.

Table 8. Fertilizer Applications and Cost in Selected Far Eastern and Asian Countries

Country	Average application, 1958-59 ^a (Kilograms per hectare)			Kilograms of Rough Rice Equivalent in Value at Local Prices to one Kilo- gram of Nitrogen ^b
	Nitrogen (N)	Phosphates (P ₂ O ₅)	Potash (K ₂ O)	
	(1)	(2)	(3)	(4)
Burma	.15	.10		9.53 ^c
Cambodia	.12	1.33	.12	
Ceylon	25.20	1.45	15.92	
India	1.23	.20	.12	4.40
Indonesia	1.57	.73	.28	5.39
Japan	132.90	58.30	85.30	1.44
South Korea	76.16	68.10	2.16	
Malaya	7.67	1.53	3.19	3.98
Pakistan	.63	.04	.00	
Philippines	3.54	1.24	1.24	4.83
Taiwan	104.80	39.97	30.73	4.10
Thailand	.19	.25	.41	6.70
South Vietnam	5.67	.44	.69	5.98

^aBrown [V-8, p. 14]

^bVon Vexkuell, "Obstacles to Using Fertilizers for rice in Southeast Asia," World Crops, March, 1964, as presented in Bachman, et al. [VI-3, p. 41].

^cAverage for all crops.

constructed a fertilizer plant which began operating in Northern Thailand at the beginning of 1967. Working at full capacity, this plant could product half the ammonium sulphate and urea needed by the country.

C. Fertilizer Use in Thailand

The use of the chemical fertilizers in Thailand started after the World War II and still is in the initial stage.

Of importance to Thailand and other Southeast Asian countries with developing economies is the fact that most of the increased fertilizer use is needed in the countries where the present level of usage is quite low. Ideally, it would be advantageous if countries which must increase fertilizer use on a large scale were also those countries which would and could construct the additional productive capacity needed. Even in developing countries such as Thailand, with a present low level of fertilizer use and no food deficit problems, the tremendous increases in estimated population growth indicate a close scrutiny of the potential for fertilizer production and use should be made.

A rather substantial growth in the use of fertilizers is occuring in Thailand (Table 9). In terms of total fertilizer used on a country basis, Thailand compares favorably with its close neighbors -- Burma, Cambodia and the Republic

Table 9. Consumption of Total Plant Nutrient (N,P₂O₅,K)
in Selected Southeast Asia Countries
(1,000 metric tons)

Country	1957-58	1962-63	Percent Increase
Burma	1.8	4.6	177
Cambodia	.1	.9	800
China (Taiwan)	172.3	105.2	-4
India	224.6	555.4	147
Indonesia	40.3	149.4	271
Japan	1240.4	163.8	32
Korea	218.6	316.1	45
Pakistan	3.3	53.1	1509
Philippines	26.1	105.1	302
Thailand	7.9	21.8	176
Vietnam	17.6	22.5	28
Total	1953.0	3033.9	55

Source: Present State and Future Plans for the Development of the Fertilizer Industry in the Region; Kiev, Ukrainian, USSR, FCAFE ECACE

of Vietnam. The use of fertilizer in these countries is quite low especially when compared to Taiwan, Japan and Korea. In terms of the fertilizer growth rate, only Indonesia, Pakistan, Cambodia and the Philippines have surpassed Thailand. However, because of the extremely low base levels of use in Thailand and other countries in 1957-1958, the fertilizer growth rates are relatively unsatisfactory measures of progress for country comparison.¹³

In a country which has never had a scarcity of food and is presently exporting large quantities of food in the world market, it is difficult to present a case to farmers for increasing fertilizer use. But, the data indicate that a tremendous untapped potential for expanding agricultural production exists in Thailand. Should the need develop for an increased rate of agricultural output, changes in the agricultural policies with regard to internal pricing of agricultural commodities and fertilizers might quickly alleviate the problem. The data also indicate that Thailand has the potential to increase its share of the world market for agricultural products.

Since 1948, the annual growth rate in total crop production in Thailand has been 4.4 percent (Table 10). This is about the average for other Southeast Asian countries. In Thailand, the increase in crop production has been equally accounted for

¹³Bond J. Billy, Kelso M. Thurman, Woodward O. Robert: A Report on the Thailand Fertilizer Situation and Potential: Agency for International Development, May 10, 1966, p. 39.

Table 10. Compound Annual Growth Rate in Total Crop Production and Changes in Crop Area and Crop Yield, Selected Southeast Asian Countries, 1948-63

Country	Compound annual growth rate in Crop Production	Change In	
		Crop Area	Crop Yield
	(percent)	(percent)	(percent)
China (Taiwan)	4.5	12	44
India ¹	3.1	26	14
Japan	2.8	1	31
Philippines	5.2	67	13
Thailand ²	4.4	30	31

¹1948-1962

²1948-1961

Source: Economic Research Service, U.S. Department of Agriculture

by increased the land devoted to crop production and by increase in crop yields from improving the production techniques. As the acreage of land available for cultivation in Thailand is brought into production, greater emphasis must be shifted to increasing crop yields as a means of increasing agricultural production. At such a time, the need for increased fertilizer use should become an important factor in Thailand's agriculture.

In summary, Thailand has an extremely low level of fertilizer use. Although fertilizer use is increasing, the present rate of growth must be greatly accelerated if the output is to be increased to any significant degree.¹⁴

Fertilizer Prices

As shown in Table 11, there are variations in the pricing of fertilizer to both dealers and farmers. The relationship in summary is:

Average Price per Ton to dealers		Average Price per Ton to farmers	
Cash	Credit	Cash	Credit
1,948 baht	2,093 baht	2,211 baht	2,531 baht

¹⁴Ibid., p. 43.

Table 11. Fertilizer Prices in Thailand, 1962.

Type of Fertilizer	Dealer Price		Interest Rate to Dealers ^a	Farmer Price		Interest Rate to Farmers ^b
	Cash	Credit		Cash	Credit	
16-20-0	2,150	2,300	10.5	2,400	2,800	23.4
20-20-0	2,150	2,350	10.5	2,400	2,800	23.4
13-13-21	2,050	2,200	10.7	2,300	2,800	24.4
13-13-13	2,300	2,500	13.0	2,600	3,200	46.1
14-14-14	2,200	2,350	10.2	2,600	3,200	46.1
15-15-6-4mg	2,250	2,400	9.9	2,550	3,100	43.2
12-12-20	2,350	2,500	9.6	2,650	3,000	26.4
12-24-12	2,300	2,450	9.7	2,500	2,900	32.0
15-10-10	2,350	2,500	9.6	2,600	3,000	30.8
Sulphate of Ammonia	1,400	1,500	10.6	1,550	1,700	19.4
Calcium Ammonia Nitrate (21%)	1,450	c/	--	1,650	c/	--
Urea (45%)	2,650	c/	--	2,800	c/	--
Superphosphate (20% P ₂ O ₅)	1,155	1,255	12.8	1,400	1,600	27.0
Hyperphosphate (30% P ₂ O ₅)	1,200	1,300	12.5	1,500	1,700	26.6
Potassium Chloride (60% K ₂ O)	1,470	1,600	13.4	1,700	2,000	35.2

Source: Pricing information from distributors and dealers; USOM reports.

(a) Interest per annum, credit terms 8 months; (b) interest per annum, credit terms 6 months; (c) sold for cash only.

The average mark-up from the dealer to the farmer for cash sales averaged 263 baht or 13.5 percent per ton. Assuming a dealer purchases on credit from distributors and sells to farmers on credit, the normal practice, the average mark-up is 438 baht or 20.9 percent per ton. These computations do not reflect the tons sold of each material, compound or mixture. A weighted average would probably show that the average mark-up is slightly lower. The higher volume sale products in general have the narrower margins. Since most fertilizers are currently sold on a credit basis, the data indicate that dealers are operating on about a 20 percent margin.¹⁵

Farmers have to pay high prices for fertilizers largely as a result of weaknesses in the present dealer marketing arrangements:

- (1) Most local dealers are the operators of the small stores, have no storage, thus the delivery service to the farmers is slow.
- (2) Most dealers have little information about fertilizers and therefore cannot give the farmers help on agronomic matters.

¹⁵Ibid., p. 51.

- (3) Many dealers by necessity operate on a high cost, low volume basis.

Summary

According to Schultz, the economic equilibrium is relevant in underdeveloped economies; and for the peasant economies, it is in equilibrium at present prices and technology. He argues that in traditional agriculture, the crucial feature is the low rate of return to investment in available inputs. Thus, he says, the way to transform this type of agriculture is to develop new, more productive inputs.

Thailand is a country of traditional agriculture, which needs more modernization in technology, more factor supplies, in order to increase the returns to the farmers. However, it is not clear that farmers in Thailand actually are using inputs at the current prices at optimum levels or what effect so doing would have upon output and returns to farmers.

The following Chapter is an analysis of the relationship of paddy yield and fertilizer use. Rice is the most important crop in the economy of Thailand, and fertilizer is the most important factor available to increase output. This study assumes current prices and current rice varieties.

CHAPTER IV

FERTILIZER USE, RICE YIELD, AND FARM PROFIT

It is widely known that yields of paddy can be increased substantially and sometimes spectacularly by the application of fertilizer. However, in spite of the large amount of experimental work done in this field, there remains a great deal to be learned about the kind and amount of fertilizer required to produce a paddy crop, and about the magnitude of the yield increase which can be expected from applying a given quantity of the required nutrient.¹⁶

A. Sources and Nature of Data

The rice area in Thailand is divided into four regions: The Central Plains, Northern region, Northeastern region, and the Southern region.

Extensive trials on cultivators' fields in these zones have provided much useful information regarding the fertilizer requirements of rice in Thailand. Data on response to fertilizer are shown in the Appendix A.

¹⁶Ibid., p. 9.

The experimental trials were done by Lusanandana P., Technical Division, Department of Rice, Ministry of Agriculture, Bangkok, Thailand from 1958 to 1962. The experimentation indicates that with the higher levels of fertilizer use, higher yields will result.

For the whole test, it is found out that the response to nitrogen was higher than to potassium. The response to the fertilizer in the northern region was substantially lower than in the northeastern region. The single application of each nutrient gave average increase in yield of paddy of 28 percent for nitrogen, 25 percent for phosphorus, and 18 percent for potassium.¹⁷

B. Methods of Analysis to be Used

It is a fact that a farmer's output of products depends upon the quantities of inputs used in production. For example, a farmer might get a yield of 350 kg. of paddy if he sows a given amount of seeds without fertilization on one rai of land. But, if he applies 20 kg. of fertilizer in the production in the same condition, the yield might be 400 kg. of paddy on the same rai of land. These two inputs and outputs indicate yield might vary as the fertilizer input is varied.

¹⁷Ibid., p. 50.

This physical relationship between input and output can be described by a mathematical expression called a production function, which in turn, describes the 'response surface'.

Theory of Production Function¹⁸

A production function estimates the quantity of output that may be expected when particular inputs are combined in a specified manner. The chemical, physical, and biological properties of inputs determine the kind and amount of outputs which will be received from particular combinations of inputs. There are many possible combinations of inputs. Obviously, not all production functions are known. It is the job of research and experimentation to discover the production functions which are chemically, physically and biologically possible. The production function provides very useful information for making decisions by farmers as to input combinations and levels.

One of the simplest production decisions involves questions concerning the effects of varying the quantity of one input on the amount of product or output produced. Consider the letter y , to stand for the product which is produced and the letter f before the parenthesis to stand for the phrase 'depends upon',

¹⁸Wagner M. Melvin., Chaverot Praphun, Tosunthorn Suphan, A Method for Estimating Fertilizers Need of Thai Rice Production Based on the Most Profitable Level of Application per Rai, Faculty of Economics and Business Administration. Kasetart University, Bangkok, Tahiland, January 31, 196.

i.e., 'is a function of'. Let the letter x_1 stand for an input used in the production of y_1 . The production function $y_1 = f(x_1)$ and tells decision makers that the amount of product y_1 , depend upon, or is a function of, the amount of input (x_1), used in the producing y_1 . For example, the amount of paddy (y_1) depends upon the amount of fertilizer applied, x_1 ceteris paribus.

The symbolic expression, $y_1 = f(x_1)$, does not explain the amount by which y_1 changes as x_1 changes. In order to be more useful to decision-makers, information must be available concerning not only the kinds of inputs but also the quantities of inputs used to produce particular quantities of products.

When a farmer is considering the question of how much nitrogen to use in paddy production he may consider the other inputs as given or fixed in specified kinds and quantities. In this case, we say that $y_1 = f(x_1/x_2, x_3 \dots x_n)$; that is the amount of y_1 (paddy) depends upon the amount of x_1 (nitrogen), given the amount of the other inputs ($x_2, x_3, \dots x_n$) which might be phosphoric acid, potassium oxide, land, seed rice, labor, rainfall, temperature, cultivation practices, etc.

In the following analysis, a simple linear regression in logs was used to fit data:

$$\log y_1 = f \log (x_1, x_2, \dots, x_n)$$

C. Results of the Regression Analysis

Applying the theory of correlation to the input-output data, the relationship of paddy yield and fertilizer operation in the four regions were found. They were as follows:

Northern Region

$$\begin{aligned}\log y &= a + b \log N + e \log P + d \log k \\ &= 3.4203 + .0375 \log N + .0326 \log P + .0119 \log k \\ &\quad \text{SE} = .0034) \quad (\text{SE} = .0035) \quad (\text{SE} = .0038)\end{aligned}$$

$$R^2 = 0.9510$$

$$R = 0.9747$$

$$\text{The standard error of estimate} = 0.0157$$

Northeastern region

$$\begin{aligned}\log y &= a + b \log N + e \log P + o \log K \\ &= 3.1006 + 0.0631 \log N + .0712 \log P + .0502 \log k \\ &\quad (\text{SE} = .0093) \quad (\text{SE} = .0096) \quad (\text{SE} = .0104)\end{aligned}$$

$$R^2 = .08504$$

$$R = .0922$$

$$\text{The standard error of estimate} = 0.0428$$

Central Region

$$\begin{aligned}\log y &= a + b \log N + e \log P + o \log k \\ &= 3.2775 + .0515 \log N + .0504 \log P + .0163 \log k \\ &\quad (SE = .0037) \quad (SE = .0038) \quad (SE = .0044)\end{aligned}$$

$$R^2 = 0.9634$$

$$R = 0.9815$$

The standard error of estimate = .0135

Southern Region

$$\begin{aligned}\log y &= 3.3106 + .0487 \log N + .0706 \log P + (-.0050) \log k \\ &\quad (SE = .0090) \quad (SE = .0093) \quad (SE = .0116)\end{aligned}$$

$$R^2 = 0.9108$$

$$R = 0.9544$$

The standard error of estimate = 0.0244

These show the degree of the relationship of the fertilizer and the paddy yield by varying the amount of nitrogen, P_2O_5 , and K_2O . The return to the paddy yield when changing the amount of fertilizer is effected most in the Central Region, and next the Northern Region, Southern Region and Northeastern Region, respectively (Table 12).

Table 12. Amount of Fertilizer Use and Yield of Paddy by Regions.

Regions	a	b ₁	b ₂	b ₃	log y	$\frac{dy}{dn}$ =MPP	log MPP	log x	x	Y*
Northern	3.4203	.0375	.0326	.0119	3.3487 + .0820 log x	.0820 3.3487 (10 ⁻) -.9180 x	2.26251- .9180 log x	2.0311	107.4	3275
North- eastern	3.1006	.0631	.0712	.0502	3.0347 + .1845 log x	.1845 3.0347 (10 ⁻) -.8155 x	2.3007- .8155 log x	2.33	215.3	2918
Central	3.2775	.0515	.0504	.0163	3.1745 + .1182 log x	.1182 3.1745 (10 ⁻) -.8818 x	2.24712- .8818 log x	2.0970	125.0	2815
Southern	3.3106	.0487	.0706	-(.0050)	3.2403 + .1143 log x	.1143 3.2403 (10 ⁻) -.8857 x	2.29835- .8857 log x	2.525	139.8	3059

Note: Set MVP = MPPxPy=Px
 =MPPx1.2=3
 log MPP =MPP³ =3/1.2 - 2.5
 log 2.5=.39794

*For an illustration of the computation
 of optimum fertilizer use see
 Appendix C

From the computation, we can find the yields of paddy with zero level of fertilizer comparing with the yield at the maximum level of fertilizer as computed.

For computation of estimated yield with zero level of fertilizer, see Appendix B.

Northern region, at 0 kg/ha. of fertilizer yield = 2652 hg/ha
 107.4 " " " " = 3275

Northeastern region, at 0 kg/ha of fertilizer yield = 1263.33 hg/ha
 215.3 " " " " = 2918.00 "

Central region, at 0 kg/ha of fertilizer yield 1895.67 hg/ha
 125 " " " " 2815.00 "

Souther region at 0 kg/ha of fertilizer yield = 2047.00 hg/ha
 139.8 " " " " = 3059.00 "

D.. Profitability of Using Fertilizer on Rice: Farm Budget Analysis

It appears that using fertilizer at the maximum level would increase yields of rice very substantially and that the optimum yield by increasing present fertilizer use above current levels (as reported in the Statistical Year Book 1965, National Statistical Division, Bangkok, Thailand) would be increased by 70 percent. In order to find the profitability

of using more fertilizer, it is necessary to examine farm budgets (Table 13).

In the theory of production function, the variables are fixed - except the one that varies. Thus, by increasing the cost of fertilizer until the maximum level is reached, the other costs are assumed constant. Therefore, the maximum return that was calculated assumed that only fertilizer will be varied in the production process.

But, in the real world when more fertilizer is used in the field, some other costs also must be changed. The human labor must be increased since when the production increases the farmers need more harvesting, weeding, and threshing. Also the animal use will be increased in the threshing, but not as much as the human labor. The same is true of mechanical use.

The interest cost also will be increased since the farmers are assumed to buy fertilizer on credit.

The seed, insecticides, rent, tax, depreciation, are constant for they are not affected by the change in the rate of fertilizer use.

Only one thing that is left now is 'the others' that will be changed a little since it causes oil, gas, tools, etc. Those are possibly affected by the increasing cost of fertilizer.

Table 13. Costs and Return of the Rice Farmers in Regions Under Actual and Assumed Levels of Fertilizer Use

Items	Actual baht/ha	Computed baht/ha	Actual baht/ha	Computed baht/ha
<u>Northern Region</u>				
Yield	1975 kg/ha	3275 kg/ha		
Price	1.20 b/kg	1.20 b/kg	1175 kg/ha	2918 kg/ha
Value of output	2270 b/ha	3930 b/ha	1.20 b/kg	1.20 b/ha
Costs:				
Labor:				
human ^a	346.16	394.38	603.04	693.04
animal ^b	115.50	147.65	234.87	295.47
mechanical ^c	-	16.05	1.69	31.99
Seed:	15.79	15.79	40.79	40.79
Insecticides	.02	.02	.12	.12
Fertilizers	.75	322.20	9.02	615.00
Others ^d	5.30	37.45	7.86	68.46
Fixed Costs:				
rent	84.15	84.15	9.14	9.14
taxi	8.02	8.02	4.66	4.66
depreciation	75.30	75.30	64.60	64.60
intereste	9.81	106.25	8.91	190.71
Total Cost	660.20	1207.26	984.70	2013.98
Total Profit	1603.20	2722.74	413.30	1487.62

Table 13, cont.

Items	Actual baht/ha	Computed baht/ha	Item	Actual baht/ha	Computed baht/ha
<u>Central Region</u>			<u>Southern Region</u>		
Yield	1643.75 kg/ha	2815 kg/ha	Yield	3059 kg/ha	1525 kg/ha
Price	1.20 b/kg	1.20 b/kg	Price	1.20 b/kg	1.2 b/kg
Value of output	1972.50 b/ha	3378 b/ha	Value of output	3670.8 b/ha	1830 b/ha
Costs:			Costs:		
Labor:	1034.79	1086.08	Labor:	1074.13	1013.20
human	325.99	360.18	human	625.80	585.18
animal	15.75	32.83	animal	23.14	2.83
mechanical	-	-	mechanical	-	-
Seed	162.43	162.43	Seed	63.14	83.14
Insecticides	2.66	2.66	Insecticides	.02	.02
Fertilizers	33.10	275.00	Fertilizers	419.40	13.23
Others	9.78	43.97	Others	50.16	9.54
Fixed Costs:			Fixed Costs:		
rent	282.18	282.18	rent	41.95	41.95
tax	17.56	17.56	tax	5.05	5.05
depreciation	81.19	81.19	depreciation	54.63	54.63
interest	42.90	145.87	interest	135.63	13.78
Total cost	2008.33	2589.55	Total cost	2429.91	1802.55
Total profit	135.83	788.45	Total profit	1240.89	27.45

Note: Actual costs are computed from "Research on Agricultural Economics" Agricultural Economics Division, Agricultural Dept., Dec. 6, 1966, Table 3.

The yield of the actual one is computed from Statistical Year Book, 1965.

Price of fertilizers is 3 baht/kg

- Estimated by increasing 15% over levels where no fertilizer was used.
- Estimated by increasing 10% over levels where no fertilizer was used.
- Estimated by increasing 5% over levels where no fertilizer was used.
- Estimated by increasing 10% over levels where no fertilizer was used.
- Estimated by average interest rate to the farm is 30%.

For the discussion of the farm budget as shown in Table 18, it shows that in the Northern Region the total cost will be increased 44.8 percent after increasing fertilizer used, while the yield increases 39.8 percent and the total income increases by 42.25 percent using the average price of paddy. Thus, the profit to farmers goes up 42.70 percent.

For the Northeastern Region, the total cost increases 51.20 percent, when the increasing in yield is 59.80 percent, and total income is measured 60 percent. Then the total profit goes up by 72.30 percent.

In the case of Central Region, with the 22.40 percent increase in cost will make the yield increase by 41.60 percent and the total income 37.2 percent. This results in the total profit increase of 104.5 percent.

For the last region, Southern, the total cost increases 25.80 percent making the yield increase 50.2 percent, and the income increases 50.2 percent. So that the total profit goes up to 97.90 percent.

Summary

The purpose of the study of the relationship of fertilizer and paddy yield is to show that the yield could be increased by a great deal by using more inputs at present input prices.

Given the limited time, it was not possible to study the relationship of the paddy yield that might be achieved by varying every kind of inputs, or with new varieties. Also, it was not possible to vary every input at the same time to find the relationship of all inputs to the yield. Thus, all that could be done with the data available was to take all other things as given varying only fertilizer.

In this case, by using the experimental data observed in Thailand, in the different regions, measuring the relationship of the fertilizer which is varying while the others are assuming constant, with the paddy yield, it shows that the relationship of the fertilizer to yield is significant. From the relationship obtained it was possible to compute the maximum amount of fertilizer that could be profitably used at current prices of fertilizer and rice. Indications are that much higher fertilizer use would be profitable.

To check this computation, budget data was used comparing costs and returns to farmers of the computed level of the paddy yield after fertilizing at the optimum level with actual budget data from Thai farms. This showed the difference in the total costs and total returns using the current varieties and the current price levels.

It indicates that the profitability of using fertilizer would be high in most regions and that farm income would be increased substantially by higher fertilizer use. This, in turn, suggests that lack of profitability probably is not the major deterrent to higher fertilizer use and improved rice yields. Instead, other factors relating to fertilizer use need to be examined.

CHAPTER V

SUMMARY AND CONCLUSION

A. The Importance of Rice to Thailand

As a crop, rice occupies the largest area of cultivated land, produces the highest total value among the agricultural crops, provides the best employment opportunity of the majority of the people, supplies the more-than-ample staple food for the Kingdom, earns the top amount of the foreign exchange, and yields the most stable revenue for the government. Rice can be grown everywhere in Thailand, and is especially concentrated in the Central region.

The rice farming system is mostly traditional. The trend in national average rice yield from 1924 to 1950 slowly downward. Since 1960 it has gone up resulting from the improvement in the varieties and use of fertilizer, water and other inputs. But the level of yields is one of the lowest among the major producing countries. Improvement of the rice yield is necessary for the economy of Thailand. Price production can be increased by making the farming system more intensive. To do so, the new factors of the production are required.

Because the importance of rice, this study focuses on the relation between paddy yield and fertilizer assuming no new varieties or changes in technology.

B. Hypothesis Investigated

The average yield of rice production is relatively low, due to the low use of fertilizer. The farmers use less inputs because the price of inputs are higher than the farmers' income will afford. The study shows that with the current prices of inputs and outputs, yield could be increased.

C. General Summary of Results

We conclude that if the farmers buy the fertilizer on credit and use the optimum level of fertilizer at present prices, the rice yield will be increased much above present levels -- perhaps as much as 70 percent. However, I would like to emphasize that this study was the affect of fertilizer use on the paddy yield only. Comparison of the yield of rice before fertilization and after fertilization at optimum level, using farm budget shows that the total profits increased three fold. The price of the fertilizer, the price of the paddy, rent, taxes, interest, depreciation, etc., were all held constant. Thus, price does not appear to be preventing increased fertilizer use.

This study did not include data for the total production function, to the point where yields reached a maximum. Thus some of the optimum results are based on extrapolation of the data using the fitted curves.

D. Conclusion and Implication

The study shows that with the current prices and current varieties, farmers can get a higher paddy yields, higher profit by using more fertilizer. We conclude that it can be expanded by using more fertilizer without changes in prices or technology. The study does show that farmers will have to use more capital to increase their input purchases. It should be remembered that if the supply of paddy increases a great deal due to increase in the fertilizer use, prices can be expected to decline and, therefore, the farmers may not get returns which were computed. This portion also suggests that the government should continue to examine the international market for rice.

In a program of rice expansion the government should also consider the following points:

- (1) Establishment of a credit union for the farmers at the low rate of interest, so that they could decrease the cost of production.

- (2) Assure the greatly increase availability of the factor of production so that the price of the factors will decrease throughout the country. This is another way to lower the factor costs of farmers.
- (3) Explore ways in which the marketing costs may be decreased so that the farm prices of output will be higher, while the prices at the consumers are constant.
- (4) Determine whether the government might undertake action to stabilize the interest price to insure farmers against world price instability.
- (5) Mount a widespread information program on the profitability and techniques of fertilizer use on current varieties of rice.

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APPENDIX

APPENDIX A

Response of paddy to fertilizer at two locations in 1953^{1/}

Fertilizer treatment (kg/ha)		Field of rough rice (kg/ha)		
N	P ₂ O ₅	K ₂ O	Northern region	Northeastern region
0	0	0	1,850	1,452
75	0	0	2,516	1,828
0	75	0	2,355	1,855
0	0	75	2,149	1,635
75	75	0	2,947	2,471
75	0	75	2,581	2,028
0	75	75	2,539	2,052
75	75	75	3,004	2,892
Number of tests			35	15
Least significant difference: 5%			101	151

^{1/} Lusanandana, 1963.

Response of paddy to fertilizer at three locations in 1959^{1/}

Fertilizer treatment (kg/ha)			Yield of rough rice (kg/ha)		
N	P ₂ O ₅	K ₂ O	Northern region	Central region	Northeastern region
0	0	0	2,397	1,774	1,137
37.5	0	0	2,724	2,221	1,436
0	37.5	0	2,663	2,197	1,493
0	0	37.5	2,617	2,095	2,311
37.5	37.5	0	3,101	2,580	1,924
37.5	0	37.5	2,787	2,324	1,649
0	37.5	37.5	2,627	2,280	1,726
37.5	37.5	37.5	3,027	2,661	2,337
					1,587
					1,968
					1,949
					1,843
					2,374
					2,106
					2,098
					2,549

Number of tests	9	53	38	-
Least significant difference: 5%	268	120	191	-

^{1/} Lusanandana. 1963.

Response of paddy to fertilizer at four locations in 1960 & 1961^{1/}

Fertilizer treatment (kg/ha)	Yield of rough rice									
	Northern region		Central region		Northeastern region (kg/ha)		Southern region		Mean	
	1960	1961	1960	1961	1960	1961	1960	1961	1960	1961
N	P ₂ O ₅	K ₂ O	1960	1961	1960	1961	1960	1961	1960	1961
0	0	0	2,751	2,556	1,735	1,974	1,167	1,238	2,466	1,678
12.5	0	0	2,974	2,896	2,004	2,299	1,334	1,468	2,587	2,054
0	25	0	3,084	3,084	2,162	2,360	1,477	1,673	2,717	2,405
12.5	25	0	3,206	3,131	2,397	2,614	1,707	1,941	2,874	2,910
25.0	25	0	3,214	3,189	2,532	2,719	1,839	2,078	3,132	2,973
37.5	25	0	3,443	3,248	2,582	2,792	1,936	2,253	3,252	2,958
50.0	25	0	3,498	3,354	2,755	2,911	2,075	2,273	3,129	2,943
50.0	25	25	3,736	3,391	2,849	2,852	2,176	2,573	3,260	2,860
Number of tests			7	16	31	57	38	31	7	6
Least significant difference:										
5%			186	220	170	127	125	79	183	69
									74	124

^{1/} Lusanandana. 1963.

Response of paddy to fertilizer at four locations, 1962^{1/}

Fertilizer treatment (kg/ha)		Yield of rough rice (kg/ha)			
N	P ₂ O ₅	K ₂ O	Northern region	Central region	Southeastern region
0	0	0	2,654	1,855	2,072
12.5	0	0	2,936	2,151	2,321
0	25.0	0	3,085	2,262	2,561
12.5	25.0	0	3,169	2,506	2,892
25.0	25.0	0	3,292	2,626	3,053
37.5	25.0	0	3,346	2,688	3,105
50.0	25.0	0	3,427	2,834	3,036
50.0	25.0	25.0	3,564	2,851	3,060

Number of tests	23	88	63	13	-
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^{1/}Lusanandana. 1963.

Source: The Response of Rice to Fertilizer, by J. J. Doyle, FAO Rome, 1966.

APPENDIX B

Computation of the Zero Level of Fertilize Yield (a)

By the procedure, the paddy yield with zero level of fertilizer -- a, are found by regions in the years of 1958-1962. For the simple computation, the average of the last three years are used. Examples of the Northern Region:

Year	Constant	+	Coeff. of Dummy variable	a
1960	3.3150		0.1170	3.4320
1961	3.3150	+	0.0892	3.4042
1962	3.3150	+	0.1098	3.4248

The average of the three years = 3.4203.

Use the same way to the other regions so that:

Northeastern Region	a = 3.1006
Central Region	a = 3.2775
Southern Region	a = 3.3106

APPENDIX C

Example of Computation of Optimum Fertilizer Level

Let x = amount of average mixed fertilizer kg/ua

x_1 = amount of N, kg/ua

x_2 = amount of P, kg/ua

x_3 = amount of K, kg/ua

P_x = price of x = 3.0 baht/kg^a

y = amount of output, kg/ua

P_y = price of y = 1.20 baht/kg^b

The average mixed fertilized that is being used has an analysis of 14 percent nitrogen, 14.5 percent P_2O_5 and 10.7 percent K_2O . Thus, the amounts of the three nutrients applied per ua can be expressed as,

$$x_1 = .140x$$

$$x_2 = .145x$$

$$x_3 = .107x$$

Substituting these expressions into the production function we can write a simplified production function where output is a function of one variable, the amount of mixed fertilizer used per ua.

$$\begin{aligned}
\log y &= a + b_1 \log x_1 + b_2 \log x_2 + b_3 \log x_3 \\
&= a + b_1 \log (.140x) + b_2 \log (.145 x) \\
&\quad + b_3 \log (.107x) \\
&= a + b_1 \log .140 + b_2 \log .145 + b_3 \log .107 \\
&\quad + (b_1 + b_2 + b_3) \log x
\end{aligned}$$

By inserting the estimated b_1 for each Northern Region we obtain,

$$\begin{aligned}
\log y &= 3.4203 + .0375 (\log .140) + .0326 (\log .145) \\
&\quad + .0119 (\log .107) + (.0375 + .0326 + \\
&\quad .0119) \log x \\
&= 3.4203 + .0375 (-.85387) + .0326 (-.85863) \\
&\quad + .0199 (-.97062) + .0820 \log x \\
&= 3.3487 + .0820 \log x \\
y &= 10^{3.3487} x^{.0820}
\end{aligned}$$

To write an expression for the marginal physical production of fertilizer we differentiate:

$$MPP = \frac{dy}{dx} = .0820 (10^{3.3487}) x^{-.9180}$$

Converting again to logarithms we have,

$$\log MPP = 2.26251 - .9180 \log x$$

Assuming that the price of the output is constant at 1.20 baht/kg. we can write,

$$MVP = MPP \times P_y = MPP \times 1.20$$

To maximize returns, we set the marginal value product of fertilizer equal to its price, 3.0 baht/kg. Substituting the MVP into the preceding equation and rearranging we find that MPP will be 2.5 at the optimum:

$$\text{MPP} = \frac{3.0}{1.20} = 2.5$$

To find the corresponding level of x we substitute 2.5 into the marginal physical product equation and solve for x.

$$\log 2.5 = 2.26251 - .9180 \log x$$

$$.9180 \log x = 2.26251 - \log 2.5$$

$$\log x = \frac{2.26251 - .39794}{.9180}$$

$$= 2.0311$$

$$x = 107.4$$

The corresponding level of output is obtained by substituting this value of x into the production function:

$$\log y = 3.3487 \log 10 + .0820 \log x$$

$$= 3.3487 + .0820 (2.0311)$$

$$= 3.5133$$

$$y = 3275$$

So that the amount of fertilizer use at maximum level in the Northern Region is 107.4 kg/ha

And, the amount of output is 3275 baht/ha.

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