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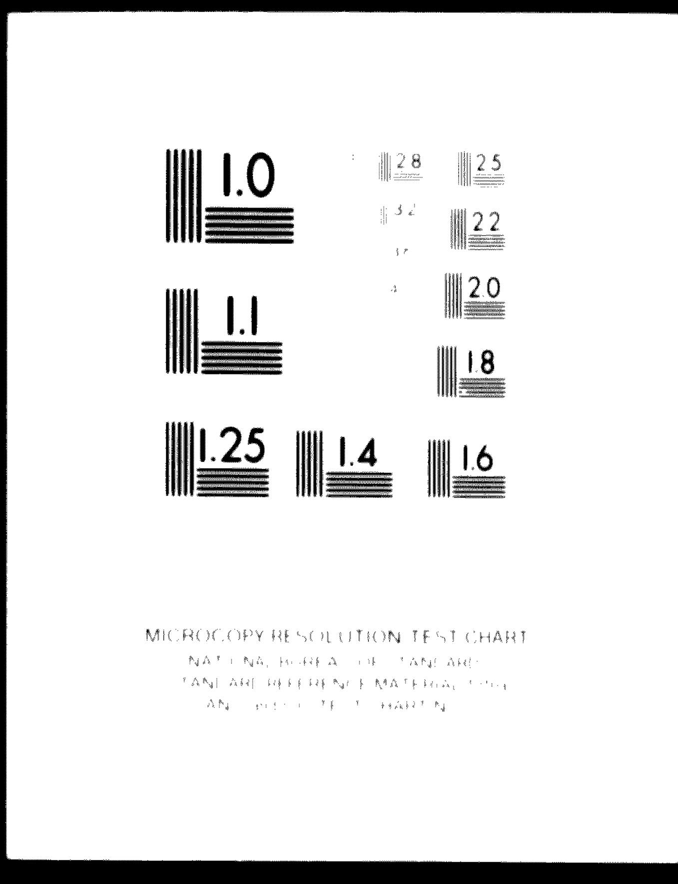

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FINAL REPORT

UNIDO THA-041-D (SIS)

THE CHEMICAL INDUSTRY IN THAILAND

by

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B A N G K O K
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BACKGROUND

The assignment of the adviser comprised a study of the existing chemical industries as well as advice on improvements and on steps to be taken to ensure the future development of the basic chemical industries. Within this scope the adviser was requested to start with an investigation of the troubles in the [illegible] fertilizer plant.

The work of assessing the existing industries and suggesting possibilities for chemical industries for Thailand has already been done by Dr. [illegible] in 19[illegible] and 1967 ([illegible]). In the [illegible] the adviser has pointed out [illegible] conditions which [illegible] of Dr. [illegible]'s conclusions [illegible] to the [illegible] foundation for a basic chemical industry [illegible] protection [illegible] government.

SUMMARY [illegible] RECOMMENDATIONS

In view of the results of the cost analysis of the [illegible] fertilizer plant the adviser suggests in his Investigation (12) that a suitable candidate [illegible] try to find a viable use for the industrial site and facilities of the [illegible] plant.

The [illegible] on Future Fertilizer Production in Thailand ([illegible] of this report) is an independent programme [illegible] with the aim of finding the [illegible] for providing the Thai agriculture with the necessary fertilizers at a reasonable cost.

For the rest of the chemical industry the adviser [illegible] by which [illegible] chemical industry including the petrochemical industry can gradually be built up.

The [illegible] of the [illegible] industry will [illegible] by the development of the fertilizer industry which [illegible] naturally [illegible] not need [illegible] quantities of sulphuric acid.

For the [illegible] industry the adviser suggests to utilize the [illegible], which is a [illegible] by-product, for producing ammonium chloride fertilizer.

[illegible] chlorine [illegible] vinyl chloride monomer [illegible] by-product, [illegible] ethylene dichloride [illegible] chlorine [illegible] vinyl chloride [illegible] by-product, viz. [illegible] acid. [illegible] for converting [illegible]. Thus the necessity of building [illegible] expensive [illegible] avoided.

[illegible] be applied to the petrochemical [illegible], [illegible] approach to the development of [illegible] preferred.

[illegible] question of appropriate [illegible] petrochemical project. [illegible] to [illegible] petrochemical industry.

[illegible] products appear to be [illegible] too diversified. [illegible] [illegible] polyvinyl chloride are produced from [illegible] [illegible] considerably [illegible] the polymerisation [illegible] [illegible] polyethylene [illegible] [illegible] polymerisation [illegible] [illegible].

[illegible] our [illegible] chemical industry in Thailand [illegible] the Government [illegible] follows:

1) [illegible] duty [illegible] imports [illegible].

2) [illegible] electricity [illegible] capacity.

3) [illegible].

4) [illegible] imported [illegible] pipelines [illegible] tank-car filling [illegible].

5) [illegible] petrochemical industry [illegible] definitely [illegible] import unit.

6) [illegible] fertilizer industry [illegible] petrochemical industry should in principle [illegible] protection [illegible] absolutely necessary it [illegible] definitely to [illegible] abolished.

7) [illegible] which [illegible] Government [illegible] protection [illegible] privi- [illegible] exorbitant price [illegible].

[illegible] the Government has [illegible] criticised in this report, [illegible] fertilizer [illegible] chlorination [illegible].

[illegible] ASRCT

[illegible] report [illegible] possibilities of manufacturing petrochemical products in Thailand written in 196[illegible] (1). This report is [illegible] by rather optimistic view of [illegible] availability of very cheap electric energy and can therefore be considered as obsolete now. The [illegible] treatise [illegible] written in 1967 (2) [illegible] chemistry [illegible] which [illegible] their [illegible] cheap electric energy. It [illegible] ought to be [illegible] in practice.

In [illegible] 1967 Dr. [illegible] wrote a report about the chemical industry in Thailand ( ). This report deals with [illegible] questions [illegible] problems of the chemical industry in Thailand. His conclusions [illegible] are still valid with the exception of those which arose from the myth of very cheap electric energy.

Another [illegible] reports, written as contributions to the ECAFE seminar by [illegible] (4) and by [illegible] Bunn (5) point out the difficulties in the development of any chemical industry in a country where non-existent [illegible] reports [illegible] in the light of what has happened since.

Directory of Thai Chemicals by the [illegible] Group, ASRCT ( ) [illegible] for the [illegible] existing industries and the products [illegible].

A survey of the basic chemical industry is contained [illegible] 22-2[illegible] "A Brief Survey of Selected Industries" (7)

The reports on the fertilizer consumption [illegible] dealt [illegible] "[illegible] on Future Fertilizer Production in Thailand." (8), ( ) and (10).

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INTRODUCTION

Some of the enterprises in Thailand, which produce chemicals or related substances have run into serious difficulties. The main causes for these difficulties are: Faulty planning, obsolete processes, lack of suitable raw materials, marketing difficulties for the main products or for unavoidable by-products, too low capacity, operating at only part of the capacity either caused by marketing difficulties or by poor management and poor maintenance.

Outstanding exceptions are the manufacture of monosodium glutamate in the chemical field and cement factories, glass and ceramic factories, and rubber factories in related fields.

In addition to these there are mixing, emulsifying, and packing plants producing saleable products of imported more or less finished chemicals. They can hardly be termed chemical plants although most of them are doing much better than their unfortunate cousins. Such plants are not considered here.

The industries producing mineral oils, pulp and paper, vegetable oils, and metallurgic products are covered by other investigations and do not fall into the scope of this report.

One fundamental cause for the slow development of the chemical industry in Thailand is the market situation. There is on the one hand a practically undeveloped market for heavy chemicals, because industries which could use these intermediate raw materials do not yet exist, and there is on the other hand a limited but highly sophisticated and very diversified market for many things based on chemicals, such as plastic articles, textiles, coatings, detergents, pesticides, pharmaceuticals etc. Among all these things, the import of which adds up to large sums of foreign currency there is not a single item consumed in large enough quantities to support a viable production in Thailand.

The other alternative, i.e. to produce chemicals for export does hardly exist for Thailand owing to the complete lack of any of the more valuable raw materials which might give Thailand any advantage in producing chemicals for export.

There is no shortage of salt, gypsum, and limestone which can, however, hardly be termed valuable materials and the locations where these are found are not altogether favourable for heavy industry. There are also fair quantities of fluorite and ilmenite.

Thailand's wealth of metal ores is well known but these do not fall into the field of this report.

Fuel, chiefly mineral oils, has to be imported. There is lignite in Mae Moh but its use for ammonia synthesis has led to economic failure. Better lignite found in Li may be suitable for metallurgical use.

There are raw materials of agricultural origin, such as vegetable oils, starch, cellulose fibres, wood, and rubber. Their conventional uses, as mentioned above, are not covered by this report, which will limit itself to chemurgic possibilities for these raw materials.

FERTILIZER PLANNING

An investigation of the economic and technical difficulties of the existing fertilizer plant in [illegible] has been reported separately (1[illegible]). In view of the result of this investigation the adviser suggests that the future fertilizer production in Thailand should be planned without delay and [illegible] independently by a suitable team. This team should investigate the situation on a broad basis and then [illegible] into the solution of the various problems which is most favourable for Thailand's economy.

The adviser has laid down the requirements for such planning in a memorandum on future fertilizer production in Thailand of July 1971 which is attached to this report as Annex 1. [illegible] alternatives which [illegible] be investigated by the proposed team are given in this memorandum which is based on discussions with and information from the Soil Fertility Research Project of the [illegible] in Bangkok. A transcript of this information is attached as Annex 2.

BASIC CHEMICALS

All attempts to develop a basic chemical industry in Thailand have hitherto met with the greatest difficulties. A market for heavy chemicals is notoriously non-existent in developing countries to begin with.

Development of the chemical industry in general can, however, only be achieved after a viable production of the most important basic chemicals can be arranged.

Obviously it would not serve any purpose to deal in this report with the multitude of heavy chemicals which normally are produced in industrial countries. Consequently the adviser shall discuss in the following only those basic chemical industries for which there is any possibility of successful development in Thailand within the near future, viz. sulphuric acid, alkali, and some branch of the petrochemical industry.

Before doing so it is necessary to emphasize strongly that all heavy chemicals are primary materials for subsequent industries. Therefore they should be recognized as such and everything should be done to keep their production cost down as low as possible. Thus on the one hand their producers should be allowed to import the essential primary raw materials such as sulphur, naphtha, phosphate rock, potassium salts, coke, etc. free of duty. They should also be encouraged to build their plants as large as possible [illegible] to expand their capacity whenever feasible, since a number of small plants producing the same chemical would definitely be uneconomic.

On the other hand the heavy chemical industry should be given only a moderate tariff protection if this is considered necessary for a limited initial period. If any such producer will abuse his monopoly by maintaining unduly high prices [illegible] the protection which he may still enjoy should be cancelled. [illegible] for this possibility should be made part of the [illegible].

SULPHURIC ACID

The general market for sulphuric acid in view of the undeveloped industries "down the line" is yet much too small to support one sulphuric acid plant of viable size, let alone several miniature plants, whose only hope is protection for an indefinite period of time.

However depending upon the outcome of the thorough investigation recommended by the adviser in Annex 1 there may arise a necessity to build a large sulphuric acid plant in connection with the future fertilizer industry in order to make ammonium sulphate and to make fertilizers containing phosphorus.

In this case most of the sulphuric acid consumption will be captive to the fertilizer plant, but it would certainly not serve the Thai national economy if such a plant is compelled to abstain from selling sulphuric acid on the open market in favour of influential producers who have built unviable plants counting on eternal protection.

If on the other hand it is decided that the fertilizer industry in the near future will not need any sulphuric acid plant, e.g. because it might be better to make ammonium phosphate from imported phosphoric acid, the existing capacity of the sulphuric acid plant at Mae Mo should be more than sufficient for Thailand's present demand. Subject to a viability analysis it is assumed that this plant, operated independently after the shutdown of ammonia production in Mae Mo, will be able to produce sulphuric acid at a lower cost than the other existing small plants.

ALKALI INDUSTRY

Alkalis being in good demand for many purposes, this industry should have had a fair chance to be developed into a production unit of viable size. Various factors described in Dr. [illegible]'s report ([illegible]) complicated this development

Raw material situation

Thailand has two sources of salt (sodium chloride), rock salt deposits of enormous size in the north-eastern parts of the country and sea salt made by solar evaporation in salt farms on the coast. At present practically sea salt only is recovered which traditionally is produced in large quantities. The population's own need is estimated to be 150,000 tons per year. The excess has been exported, chiefly to Japan. Normally this excess quantity would be ample as raw material for a sizable alkali industry. Untimely rains during the harvest season have recently washed away a good deal of this year's salt harvest. The price of salt has skyrocketed from [illegible] Baht per ton to 600 Baht per ton, which did not do much good to those salt farmers who had lost their salt, but put the alkali industry into an impossible situation. Long after this shock was reached the Government allowed salt imports, chiefly from [illegible], where salt can be bought for about 92 baht per ton [illegible]. In West Pakistan where salt farming is [illegible], a price of [illegible] per ton is considered normal for supply to the industry. This corresponds to about [illegible] baht per ton.

The adviser has recently obtained direct information on salt prices which the chemical industry pays in central Europe. In southern Germany and in Austria the price for refined salt, 99.8% pure, corresponds to 140 Baht per ton. This salt is suitable for electrolysis without further treatment. Crude rock salt containing 97-98% NaCl costs about Baht 120 per ton. In northern Germany, in the vicinity of the great potash mines, common salt is a by-product of the production of potash fertilizer salts and therefore considerably cheaper. It would obviously not be fair to use the depressed prices paid there for comparison.

The possibility of developing the rock salt deposits in northeastern Thailand is at present being investigated by the Department of Mineral Resources. The Railway Authorities demand a freight rate of 65-70 Baht per ton of salt merely for the transport from a tentative salt mine to the Bangkok region. There are tendencies to protect the salt farmer by raising the salt price. In this connection plans are being discussed of giving monopolistic mining rights for rock salt to one company only, the government setting the salt price arbitrarily. There is a risk that political rather than economic considerations may heavily influence this price setting. Thus it is to be feared that the future salt price policy may seriously handicap the alkali industry. This industry will have to provide the petrochemical industry with chlorine, one of its most important raw materials. As it will be shown below the alkali industry is at present the only chemical industry in Thailand, which might have a fair chance of becoming internationally competitive.

Under present market conditions a price for salt of about Baht 100 per ton f.o.b. Bangkok should be aimed at. If the rather impure salt available here will cost more than about Baht 150 per ton, the alkali industry will be at a disadvantage.

The cost of electric energy is a still more important factor. The present charges adding up to about 27 satang per kilowatthour are definitely too high for any heavy industry. The price should be not more than 15 satang per KWH including the demand charge if it is expected that the caustic soda industry shall become internationally competitive. Competitiveness, however, should be aimed at especially concerning the price for chlorine and the products made from it.

Choice of Process

There exist two different processes for the production of alkalis from common salt, the electrolytic process and the Solvay soda ash process.

For carrying out the electrolytic process only salt and electric power are needed but the electrolysis unavoidably produces an equivalent large quantity of chlorine gas as a by-product. The viability of an electrolysis plant hinges thus on a balanced market for both chlorine and caustic soda. To achieve and maintain this balance is or has been a problem in almost any country where this industry exists. In industrial countries with a petrochemical industry it is not uncommon that chlorine, formerly a troublesome by-product, has now become the main product, while caustic soda which is relatively easy to store and to transport is a by-product. This situation creates a desire to export caustic soda at very low prices. In exceptional cases some of the excess caustic soda is even converted to the normally lower priced soda ash.

Countries like Thailand in which caustic soda is the main or even the only desirable product are in a much less favourable position because chlorine is a troublesome poisonous gas which can only be stored and shipped in liquified form in pressure tanks. If the chlorine cannot be sold or converted to a salable product, the only way to dispose of it is to burn it with the hydrogen simultaneously produced, whereby hydrogen chloride gas is formed which dissolves in water as hydrochloric acid. Even the acid cannot be disposed of directly but must be neutralized by letting it react with crushed limestone. Thus the disposal is costly and even necessitates special equipment.

In 1963 the Ebasco Service Incorporated in their report (11) saw no hope for solving the chlorine problem and recommended therefore the errection of a Solvay soda ash plant. This soda ash process is based on salt, limestone, good coal or coke, and a considerable quantity of steam. Ammonia is used as an auxiliary agent which is recovered from the waste liquor and recirculated so that only the ammonia losses need be replaced.

Under an efficient management and with good maintenance the ammonia losses can be kept small but the viability especially of small soda ash plants can become completely upset by losses of ammonia from badly maintained equipment. In any case the operation of a Solvay soda ash plant is a difficult task and really good yields are usually not obtained during the first year or two of production. Owing to the nature of its operation a soda ash plant always will look messy which makes it psychologicially very difficult to persue good maintenance.

The minimum viable capacity of a soda ash plant is at present about 100,000 tons per year. It is also practically impossible to expand the capacity of an existing soda ash plant. It is thus rather fortunate that the recommendations of Ebasco were not carried out, because they may have led to another economic failure in the chemical industry.

At present all soda ash is imported into Thailand. The question is whether this situation should be allowed to persist and for how long. The possibility of producing low priced soda ash from generally more valuable caustic soda has been mentioned above and is discussed in the Ebasco report. It is hardly recommendable. If there will be an excess of caustic soda produced at any time in this country it should rather be exported.

No soda ash plant should be built in Thailand until the local consumption will have reached at least 75,000 tons per year, i.e. nearly 3 times the present imports. Even then it should be considered whether such a step is justified in view of the cheap natural soda ash available from Magadi.

The Chlorine Problem

The existing independent plant for producing caustic soda of the Thai Asahi Caustic Soda Co. Ltd. is heavily handicapped by the impossibility of selling its chlorine. The firm was supposed to sell its chlorine in the form of hydrochloric acid to the Thai Plastics and Chemical Co. Ltd. for reaction with acetylene to produce vinyl chloride monomer. This production, being obsolete and unviable, was discontinued as will be discussed in the chapter on petrochemicals.

As a result of this Thai Asahi are now forced to destroy and waste the main part of their chlorine in the manner described above. Obviously the cost for making and destroying the chlorine must be covered by their sales of caustic soda which thereby becomes too expensive.

Even if one takes all this into account the sales policy of Thai Asahi does not appear very reasonable in many respects. As long as a major portion of the chlorine must be destroyed any customer for chlorine or hydrochloric acid should be met with a preference price. That this is not done for customers who wish to buy liquid chlorine may have its reason in having to depreciate costly compression, storage, and transport facilities for this commodity.

Such a policy will, however, no longer serve any useful purpose if it forces the prospective customer to set up his own electrolysis plant. If he needs primarily chlorine his caustic soda will be sold in competition with Thai Asahi.

The manufacturers of monosodium glutamate are prospective customers with balanced needs for both caustic soda and hydrogen chloride. If they are not given a special preferential treatment they find it more economical to set up and operate their own electrolysis plants.

It is well known that in the chemical industry normally it is much cheaper to produce on a large scale than on a smaller one. There are several reasons for this rule not applying in this particular case:

The investment cost of a chemical plant is a function of its capacity. If one plant has n times the capacity of a smaller one it will cost n^e times as much as the smaller one, the exponent e being smaller than 1, $(0 < e < 1)$. As a rule of the thumb e will equal 0.6 for most chemical plants. However an electrolysis plant will chiefly consist of a number of electrolytic cells, whose dimensions are more or less standardised by practical considerations which are dictated by the peculiarities of the transport of electric current through the cell. Thus the number of cells required is directly proportional to the rate of production desired, i.e. the exponent e becomes equal to 1, simply because n cells will cost n times as much as one cell.

Thus the large producer has, with respect to the cells required, no economic advantage over the smaller one. His advantage will only appear in connection with auxiliary equipment such as electric transformers and rectifiers, equipment for compressing, liquifying and storing chlorine, evaporation and flaking of caustic soda etc. At present caustic soda is not flaked at all in Thailand, the monosodium glutamate manufacturers need no auxiliary equipment at all with exception of a hydrogen-chlorine combustion unit of small design, and the pulp manufacturers are using the chlorine directly. Furthermore these producers for captive consumption have no additional overhead for their small electrolysis plants, whereas the caustic producer must cover his overhead from his sales proceeds.

Thus the caustic soda producer will be able to compete with these small captive plants only if he operates on a really large scale according to the most modern principles. He obviously cannot do so as long as there is no use for the byproduct chlorine. This becomes thus the cardinal problem of the alkali industry in Thailand.

Possibilities for Chlorine

Most of the products which could be made from chlorine have at present no market in Thailand or only a very limited one. Carbon tetrachloride and other dry cleaner solvents, bleaching products, chlorinated paraffin plasticizers are typical examples. Only PVC shows some promise as a chlorine containing plastic with a growing market.

There are, however, two great obstacles for using Thai-produced chlorine in making vinyl chloride, the mother substance of PVC. The one is the obsoleteness and unviability of the carbide-acetylene method mentioned above. The other is the unavailability of ethylene in Thailand, ethylene being the ideal raw material for producing vinyl, chloride. This problem will be discussed more in detail in the Petrochemicals chapter below.

As it will obviously take a number of years before any petrochemical project will eventually be established, another way must be found to relieve the grave situation of the caustic soda industry and to open the road to its further expansion.

Fortunately there is such a way: the chlorine instead of having to be destroyed can be converted to hydrogen chloride in existing equipment and subsequently neutralised with ammonia, whereby ammonium chloride is produced. According to Japanese investigations, ammonium chloride is an excellent fertilizer especially for rice. This has been corroborated in recent discussions with Messrs. [illegible] and J. Takahashi of the Soil Fertility Research Project, UNDP/SF, Kasetsart University Campus. Mr. Takahashi has investigated this question by practical experiments on Thai farms with very encouraging results.

The necessary know-how for producing ammonium chloride suitable as fertilizer should be available from Japan. Immediate steps should be taken to find out what kind of equipment will be necessary and what it will cost. Its capacity should tentatively be assumed to be large enough to take care of about three times the present output of chlorine which is 1[illegible],000 tons per year. The capacity of such a plant would be 5[illegible],000 tons of ammonium chloride corresponding to about 15,500 tons of nutrient which is only about 22% of the estimated minimum requirement for rice in Thailand (cf. tables attached to Annex 2).

The advisor must warn of a hazard which will be the result of the somewhat unusual combination of chemical reactions recommended here:

Before reacting the hydrogen chloride or its aqueous solution with ammonia every last trace of free chlorine must be meticulously removed. Chlorine and ammonia react with each other and form nitrogen trichloride, a heavy oil which detonates at the slightest friction. If the chemical engineer designing the plant is aware of this danger he can easily eliminate it so that the operation will be quite safe.

PETROCHEMICALS

The production of petrochemicals in Thailand has been under discussion for some time. The motive for the desire to have a Thai petrochemical industry is the same as in every country which spends a considerable amount of foreign currency on the import of goods made of petrochemical products. However if this vast expense is analysed it is found that it is divided up into a considerable number of different petrochemicals and that not any one of these is actually consumed in quantities which would justify its production.

This problem is not limited to developing countries. Many of the smaller industrial countries find themselves in the same position, i.e. that the home market cannot support a petrochemical production of a viable capacity. This situation is worsened by the usual demand from "the public" or from the Government that as many as possible currency consuming commodities should be produced locally.

The petrochemical plans for Thailand comprise at present such a number of different "downstream" plants, that the viability of the whole project appears very questionable. It is obviously for this reason that the negotiations with the tentative Japanese counterparts have been delayed and that it recently was announced that the whole project is being postponed until 1976. The setup of the TPC upstream project is criticized in the Summary.

The adviser is of the opinion that the Thai national economy would be served better by a more gradual approach to the establishment of a petrochemical industry. One valid objection to such a gradual approach is the fact that the minimum viable size of a modern naphtha cracker for producing polymerization grade ethylene is in the neighbourhood of 100,000 tons per year and that therefore the downstream plants must use up this quantity.

While this statement is true, it must be pointed out that it refers specifically to the production of polymerization grade ethylene. This type of ethylene suitable for producing polyethylene must be extremely pure. The complicated fractionation and purification equipment necessary for purifying the ethylene to this high degree is by far the most expensive part of the naphtha cracker. This equipment determines the minimum viable capacity of the whole operation.

For chlorinating ethylene to ethylene dichloride, from which vinyl chloride monomer is very easily made, we do not need such specially pure ethylene. We can therefore dispense with the expensive fractionation and purification plant and instead provide one cracking unit with a much simpler, old-renowned but by no means obsolete, separating equipment based upon oil absorption and stripping. This method is still in use in most oil refineries and in natural gas plants for separating byproduct gases.

The cracking unit referred to above is the same as those used in a modern naphtha cracker of full capacity. If a large cracker comprises say 5 such cracking units and we need only one to begin with, that part of the plant will only cost one fifth of the cost of the cracking units in a large naphtha cracker. To this we have to add the cost of the simplified separation equipment referred to, which should, however, from the beginning be laid out large enough to handle the product of say three cracking units, Thus the plant may gradually be expanded as need arises.

One cracking unit of this type will have a capacity of about 20,000 tons of ethylene per year. This quantity will take care of 50,000 tons of chlorine, i.e. much more than is produced in Thailand now. Until such a quantity of chlorine will be produced we can resort exclusively to converting the chlorine to ammonium chloride as recommended in the previous chapter, or we can import ethylene to make ethylene dichloride locally. The decision what should be done will obviously depend upon the relative prices of vinyl chloride monomer, of ethylene dichloride and of ethylene and of course upon the price of the locally produced chlorine.

If and when the time is ripe to make vinyl chloride locally by decomposing ethylene dichloride, it must be borne in mind that this decomposition will yield hydrogen chloride as a byproduct. For taking care of this troublesome byproduct modern technology has provided the so-called oxychlorination process by which hydrogen chloride is reacted with ethylene and air over a catalyst to form more ethylene dichloride.

While this solution of the problem sounds ideal it has the great disadvantage of demanding a very expensive plant. This in turn limits the use of the oxychlorination process to very high capacities. The high cost of this process has also led to the conclusion that it will only be viable if there is no cost for the hydrogen chloride which is assumed to have zero value because, as shown in the chapter "choice of process", it would cost money to destroy it. However if, as proposed by the adviser, the hydrogen chloride is converted to ammonium chloride and sold as a fertilizer, the hydrogen chloride will earn the equivalent of the cost of the sulphuric acid in ammonium sulphate. As this will also obviate the high investment cost for an oxychlorination plant, the adviser believes that his suggestion may offer substantial advantages.

Attentive readers of this report and especially petrochemical enthusiasts among them will wonder how one can possibly suggest a petrochemical industry with the most important petrochemical, polyethylene, left out. They may rest assured that the expert, himself a petrochemical enthusiast of long standing, has some very good reasons for recommending to omit polyethylene to begin with. Polyethylene is composed 100% of ethylene. Its cost is entirely a matter of plant size. All the really large chemical companies in the world have been and are still erecting polyethylene plants of ever more gigantic size. The price of polyethylene is more depressed than that of any other chemical on the world market and only the giant producers are continuing making money with it.

In contrast to this vinyl chloride contains 56.5% chlorine, which with low priced salt and not too high cost of electricity should become available in Thailand at about the same cost as in industrial countries, which have an excess of caustic soda to worry about.

For reasons explained above 43.5% of the vinyl chloride monomer will have been made of the considerably less expensive ethylene of less purity than polymerization grade. It is very probable that PVC made in Thailand will not be more expensive than that made in any other country and that Thailand therefore may be able to export it.

It should also be remembered that the physical properties of polyethylene cannot be varied much. There are of course two types, low density and high density, which differ greatly in rigidity but these two types cannot be made in the same plant.

PVC on the other hand has a much greater versatility of its use pattern than polyethylene, because by itself it is hard and rigid but can be modified over a wide range of properties with suitable plasticizers.

It must be emphasized that leaving out polyethylene production to begin with will in no way hinder the future development of the petrochemical industry in Thailand. Quite on the contrary, as has been pointed out above, the cracking unit to be installed to begin with is identical with the cracking units used in a full size naphtha cracker. More units can be added successively and eventually, when the market has grown sufficiently, the plant can by addition of fractionation and purification equipment be converted to a plant which will produce polymerization grade ethylene.

The usual byproducts of ethylene, such as propylene, butylenes and butadiene are available from the simplified naphtha cracker without difficulties. Whether the quantities available, the market conditions, and the cost of investment will justify the erection of such downstream plants, and when they should be erected, must be subject to careful investigation and viability analysis from case to case. It is an additional advantage of the gradual approach that none of this must be done in a hurry, while the flood of enormous quantities of ethylene and byproducts will start at a certain date and simply must be used up if a full size cracker is built from the beginning.

CHEMURGIC PRODUCTS

There are only two kinds of chemurgic productions in Thailand. The one is the production of mono sodium glutamate which is very successfully carried out by 4 companies. The largest one, the Ajinomoto Co. (Thailand) Ltd., was visited. Like the others it has its own production of caustic soda and hydrochloric acid which are both consumed captively. The capacity of the electrolysis plant is nearly half that of the Thai Asahi Caustic Soda Co. Ltd. Tapioca flour and urea are used as chief raw materials for the fermentation. Although the capacity for mono sodium glutamate, 600 tons per year is considerable in view of high value of the product, the impact on the abundance of tapioca flour is of course negligeable.

The other chemurgic production is that of industrial alcohol by the Ayutthya Alcoholic Spirits Distillery, Ministry of Finance. The plant is quite old and in bad shape for lack of proper maintenance. As there is very little market for industrial ethyl alcohol and a good portion of this market is being taken away by methanol which is a byproduct of polyester fibre production, the plant is at the present time not at all producing industrial alcohol of which there is a large quantity in stock. Instead it takes a raw first distillate from fermented molasses. This distillate is shipped to Bangkok as an intermediate to the production of potable alcoholic spirits.

Future Possibilities

Unfortunately there are hardly any really promising chemurgic outlets for Thai agricultural products. The Weizmann process of fermenting molasses or starch to a mixture of acetone and butanol has already been mentioned by Dr. [illegible] (1). There is practically no market for acetone in Thailand. Acetone can be converted to diacetone alcohol and further to methyl isobutyl ketone, the latter undoubtedly a solvent occurring in some of the paints imported into Thailand. This, however, does not help at all. This ketone can even be replaced easily by other solvents in the respective paint formulations.

Butanol itself has practically no market at all anywhere. It is an intermediate for production of esters which serve as lacquer solvents and, more important, for making an octanol which in turn is reacted with phthalic anhydride to produce DOP, the most important plasticizer for PVC. The price for DOP is very much depressed now, because, to make things worse, both butanol and acetone are petrochemically made on a huge scale from propylene, which is a necessary byproduct of ethylene and therefore available at a very low price.

It is thus quite impossible to make a success of the Weizmann process nowadays.

More interesting is the possibility of chlorinating rubber. Chlorinated rubber is used in protective paints. Its disadvantage is bad adhesion on metals. This can be improved by combining it with alkyd resins, but such an addition decreases the chemical and weather resistance of the chlorinated rubber, which otherwise is its main advantage. There are indications in the literature that its adhesion to cement is satisfactory. The adviser has no personal experience with chlorinated rubber, but if this is true, there may be a very promising use for chlorinated rubber in this country for coating concrete. It could then replace the expensive epoxyresins in such coatings. This possibility is certainly worth looking into.

From the production side chlorinated rubber also looks attractive because both rubber and chlorine are readily available, so that the costs of raw materials should be low. This may induce some foreign manufacturer who possesses the necessary knowhow, for instance the Du Pont Co., to produce chlorinated rubber in this country for export.

MISCELLANEOUS

Fluorite, which usually is only thought of as a metallurgical raw material, would have potentialities as a chemical raw material if its upgrading to " acid grade" fluorite could be organized.

The same is true for ilmenite, but for titanium oxide chemicals the possibilities are much less attractive, because the products are pigments which must be made by very special methods, most of them jealously guarded as trade secrets.

Rubber chemicals have also been looked into. Here the usual pattern repeats itself, many different chemicals being used by the Thai rubber industry but none of them in outstanding quantities. Even carbon black is divided up into about 10 different types of which about 4 are dominating. Mr. S[illegible] Sangsun-[illegible] of the Economic Evaluation Group of ASRCT has recently made a survey by visiting the major rubber factories in Thailand. The total consumption of carbon black was found to approach 9,000 tons per year.

If carbon black is produced by modern methods from hydrocarbons with high aromatic content, a plant producing about 10,000 tons per year of carbon black might be feasible if the raw material is cheap. However Thailand lacks these raw materials. The heavy ends of the products of naphtha crackers are such materials, but the quantity even from a large cracker will be quite insufficient.

A summary of conclusions and recommendations is found on page 2 of the report.

ACKNOWLEDGEMENTS

The adviser wishes to express his gratefulness to Dr. Pradisth Cheosakul for the interest he has taken in this work, to Dr. Sancha Udomsakdi for arranging many useful contacts and especially for advice and constructive criticism concerning the subject matter and the sort of the reports, to Dr. C.L. Wrenshall for valuable advice, and to Mr. Norman L. [illegible] and members of his economic evaluation group for an inexhaustible wealth of information and help in every respect. The adviser's thanks are further due to Dr. G. Schütz and particularly Mr. John W. Lewis of [illegible] for valuable agronomic information, and especially to Mr. Thomas F. Porter, Jr. and Mr. F. Ramm-Ericson for their active support.

Bangkok, 8 August 1971

H. P. A. Groll

H.P.A. Groll

ANNEX 1 TO THE FINAL REPORT ON THE CHEMICAL INDUSTRY IN THAILAND
UNIDO THA-C41-D (SIS)

Bangkok September 1971

MEMORANDUM ON FUTURE FERTILIZER PRODUCTION IN THAILAND

(Second Expanded Edition)

By

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Background

That Thailand, a predominantly agricultural country, will need much more fertilizer than is consumed at present is beyond doubt. The only plant for production of synthetic fertilizer is that of the Chemical Fertilizer Co. Ltd. at Mae Mo. This plant is unviable as shown by the adviser in his "Report on an Investigation of the Mae Mo Plant of the Chemical Fertilizer Co. Ltd."

Summary

If the government will refrain from maintaining high price levels for fertilizers in Thailand conditions for a very essential growth of the agricultural produce are quite favorable. This growth can only take place if the necessary quantities and types of fertilizers are readily available. An estimate of the minimum and optimum requirements of fertilizers by the UNDP/SF Soilfertility Research Project is attached to this memorandum.

Problems connected with providing the necessary raw materials and with choosing the most suitable approach to producing the fertilizers needed are discussed in some detail. The adviser recommends a comprehensive investigation by a suitable team for solving these problems.

FERTILIZER NEEDS

Anyone who is expected to make suggestions on the manufacture of fertilizers in Thailand must ask how much and which kinds of fertilizer will be needed in the future. This question is not easily answered. Mr. Tate in his "Report on the Possibilities of Manufacturing Petro-Chemical Products in Thailand" gives up in despair and states on page 40 of his report: "As the application of fertilizer is dependent on the government policy regarding the use they desire to make of the Country's most important national resources, i.e. the arable land, no attempt could be made to estimate the future fertilizer consumption." This sardonic statement made in 1965 appears still valid. The policy of the government is not clear cut and appears for the time being to be heavily influenced by a desire to cover up the failure of the Mae Mo venture.

The following table taken from an FAO report of Dr. Donner and Mr. Barlu (10) shows most convincingly the unfortunate situation into which the supply of nitrogen fertilizers to the Thai farmer has been maneuvered as a result of the "Mae Mo syndrome".

Table 1: Farmers' Price of Fertilizer (100 kg of Nutrient) in US$

Country	Ammonium Sulphate	Urea
Pakistan, East	17.1	13.8
Ceylon	21.1	15.8
Pakistan, West	21.7	21.9
Korea, South	23.1	18.9
Japan	25.6	22.5
India	27.1	20.9
Burma	31.1	34.2
Thailand	33.8	29.2

It must be kept in mind that even with the exorbitant prices in Thailand the plant operates at a heavy loss.

Thus it appears necessary to summarize briefly the factors to be considered for drawing up a government policy on fertilizers.

Fertilizers are, together with the soil and the rain and the sweat of the farmer, raw materials for all agricultural products which feed the nation and constitute the major part of the export of this country. Any increase of the cost of fertilizers will necessarily decrease the quantity of fertilizers used because the farmer cannot afford to spend more than he can earn. Consequently the yield of agricultural produce will be reduced and the export potential will suffer a considerably greater percentage loss because only the excess of produce, after deduction of the population's own needs, can be exported.

Considering these facts it appears reasonable to assume that the government will eventually refrain from artificially upholding a high price level for fertilizers. If we are allowed to assume this, the prediction of fertilizer needs will become a little easier.

Several attempts have been made to predict the future consumption of fertilizers in Thailand. Some of them, like the comprehensive "Report on the Thailand Fertilizer Situation and Potential" by S.J. Bond, F.M.

Kelso, and R.O. Woodward of the Tennessee Valley Authority, May 10th 1966,(8) are rather obsolete now, while others are based on insufficient data or lack a sound, critical assessment.

The "Appraisal Report No. 24, Fertilizer Situation in Thailand by Tolgay Cavusoglu, Economic Evaluation Group, ASRCT, 1970 (9) looks quite comprehensive. Mr. Cavusoglu has since left this country and could therefore not be consulted concerning the sources of his information and their presumable reliability. Thus the adviser made inquiries with Dr. Siribongse Boon-Long of ASRCT and with Dr. Schütz, Country Representative of the FAO in Thailand and upon their advice with Mr. J.W. Dewis, Dr. W. Donner, and Dr. C.H. Robinson, all of FAO. A wealth of information could obviously be obtained from all these gentlemen, but in order to make proper use thereof, the adviser would have been busy for the greater part of his assignment. It appeared that a critical survey of the general situation could most readily be obtained from UNDP/SF Soil Fertility Research Project whose Manager, Mr. Dewis has his office at the Kasetsart University in the immediate neighbourhood of ASRCT. Thus the adviser concentrated on this source.

On July 22 Mr. Dewis provided the adviser with 3 Tables comprising estimates of present minimum as well as future optimum requirements of fertilizer nutrients for the main crops in Thailand. These tables complete with comments by Mr. Dewis give a concise and comprehensive picture of the probable fertilizer needs. Copies are therefore attached to this memorandum as Annex 2. The total present needs of fertilizer nutrients add up to approximately 272,000 tons per year corresponding to probably 840,000 tons of fertilizers of all kinds. The corresponding figures for the optimum requirements are 1,044,000 tons of nutrients and 3.2 million tons of fertilizers. Mr. T. Cavusoglu arrives at 1.85 million tons of fertilizer as the optimum which is little more than one half of Mr. Dewis' estimate. Some major errors have been discovered in Mr. Cavusoglu's sources.

The question as to which kinds of fertilizers will be needed was discussed in some detail with Mr. Dewis and others. While it would theoretically be best if every farmer would have the knowledge for composing his own fertilizers according to the type of soil, the crop intended, and the climatic conditions, such a sophisticated approach cannot be expected to become feasible in Thailand for many years. Therefore it appears best to supply the farmer with suitable ready to use mixed and single fertilizers and instructions how much to use for the different crops. This is being done and it appears thus necessary to manufacture the types and quantities recommended.

When planning for the manufacture of mixed fertilizers flexibility with respect to proportion of ingredients is essential because much research work is currently done on questions connected with fertilizer applications to various crops in tropical countries. Changes of recommendations may be expected as the result of this research. A typical picture of the many factors playing a role in fertilizing can be obtained for instance from 2 articles on rice growing by Georg Kremmler in the magazine Der Tropenlandwirt, viz. "Die Düngung von Sumpfreis", November 1968 and "Fortschritte der Reisdüngung in Ostasien 1958-1968" April 1971.

FERTILIZER PRODUCTION

RAW MATERIALS

Before dealing with the question as to how the various kinds of fertilizers needed shall be produced it is necessary to look into the raw material situation. We find that all raw materials for fertilizers must be imported into Thailand because none of them is available in this country in sufficient quantity.

The raw materials are:

a) Potassium salts.

b) Phosphoric acid or some phosphate.

c) Hydrogen for making ammonia, i.e. some suitable material for producing hydrogen at low cost.

d) Probably sulphur for making sulphuric acid. This may become necessary for making phosphoric acid or superphosphate. It may also be used for producing ammonium sulphate, but it should be considered to utilise also the hydrochloric acid available from the excess of chlorine for producing ammonium chloride as a fertilizer for rice.

The potassium salts and the phosphate must be imported in bulk in very large quantities, i.e. several hundred thousand tons per year. Hydrogen could theoretically be produced by electrolysis of water. In this case the electric energy is the raw material. This is done in Norway where an enormous quantity of hydroelectric energy is available at the sea coast from rivers coming from the high mountains only a short distance away. Glaciers and snow fields make the most effective water reservoirs and man-made dams are only necessary to direct the rivers into the intake tubes of high pressure turbines and to provide some settling space for the boulders, the gravel, and the sand brought along by the swift rivers. Norways population of less than 4 millions cannot possibly consume more than an insignificant portion of the energy available. Therefore Norway can afford to use electric energy for purposes which would be quite unthinkable in any other country, not even in neighbouring Sweden, where also much hydroelectric energy is available. The suggestion of Dr. H. Thate in his report on possibilities of manufacturing petrochemical products, 1965, that electric energy will be available from the Mekong project at costs low enough to make hydrogen by electrolysis for ammonia synthesis is rather overoptimistic. The power stations of the Mekong river must convert several relatively moderate altitude drops of enormous quantities of water to electric energy as against falls of many hundreds of meters in Norway. The Mekong power stations will therefore require a many times greater investment for the same energy production than those in Norway. To this we have to add thousands of kilometers of power lines for distribution. To pay for all this, the price of electric energy can in the opinion of the adviser never be as low as to justify production of hydrogen for ammonia synthesis at least not as long as the sources of crude oil do not show signs of exhaustion. However this question should be checked carefully by accurate estimates.

Thus Thailand will almost certainly have to resort to imported petroleum hydrocarbons as source of hydrogen. Natural gas not being available, the choice will be between naphtha and heavy fuel oil. As long as there is a surplus of naphtha the oil companies are of course interested in getting long-contract customers for this commodity. It should, however, be borne in mind that this market condition may change at a very short notice if and when other, more profitable uses for naphtha can be found. Such shifts have occurred in the past, but they can be very much more swift in this age of advanced technology.

METHODS OF PRODUCTION

By far the cheapest and simplest method for producing pure hydrogen for the ammonia synthesis is by reforming natural gas by catalytic reaction with steam. Natural gas occurs in enormous quantities in Indonesia. It has therefore been suggested to locate the production of all fertilizers for South East Asia in Indonesia. This may in fact be the best solution from a technical and economic point of view. However it is questionable whether such a technocratic solution of the fertilizer production problems will be acceptable to the countries concerned.

Nevertheless the question should be given careful consideration, whether it will be better for Thailand to produce ammonia from imported fuel oil or naphtha and to pay for the foreign loans and interest necessary for building a very expensive large ammonia synthesis plant or whether it might be better, at least to begin with, to import the ammonia made at the lowest possible cost in Indonesia and to convert the ammonia together with the other imported ingredients to the mixed fertilizers required in this country. It should be borne in mind that a fertilizer plant built for using imported ammonia as raw material can at any time without any loss of equipment be integrated backwards by adding an ammonia synthesis plant based on imported fuel oil or naphtha or even on natural gas, should such be found in the country or in the continental shelf.

If it is decided that ammonia should be produced in Thailand instead of being imported, the economics of two alternative methods for producing the hydrogen-nitrogen mixture should be assessed. In countries where cheap natural gas is available it is best as mentioned to produce hydrogen by catalytically reforming natural gas with steam, enhancing the hydrogen content of the reformate by conversion, and adding an exact quantity of air whose oxygen content is removed by burning it out with some of the hydrogen. This method (I) will even be economical if sufficiently cheap naphtha is used instead of natural gas.

The other alternative is method (II) using the cheapest type of fuel oil which is burned with insufficient oxygen, so called partial combustion. The resulting gas mixture is converted and the resulting hydrogen is treated with liquid nitrogen for simultaneous purification and producing the mixture of nitrogen and hydrogen suitable for ammonia synthesis. A rather expensive air fractionation plant is necessary for this method and the question is how high the price of naphtha can be allowed to rise above the price of fuel oil before method (II) will become more economical than method (I).

B.J. Bond et al. (8) recommend to import urea, diammonium phosphate, and potassium chloride into this country and to blend them in suitable blending plants. The authors themselves point out that it is essential that all components must have the same particle size. The adviser doubts whether this prerequisit can be met when all shipments come from sources many thousands of miles away so that rejection of a shipment may cause a complete shutdown for some time. It may therefore be more advisable to prill the various ingredients together with at least one locally produced ingredient.

The adviser suggests that a suitable team of consultants make an unprejudiced investigation of all the alternatives indicated, to show their advantages and disadvantages, and to make viability calculations so that the best methods and the most favourable approach can be chosen. Close cooperation with the agricultural experts is imperative.

H. P. A. Groll

(Transcription)

Food and Agriculture Organization

UNDP/SF Soil Fertility Research Project

Bangkok, Thailand.

Fertilizer Requirements for the

Main Crops of Thailand.

Some Comments on the Attached Tables

The requirements have been estimated in two ways.

1) By considering the minimum amounts of nutrients required at present to maintain productivity and, to a certain extent, the fertility of the soil.

2) By considering the optimum amounts of nutrients which would produce profitable increases of yields and go a long way to improve soil fertility.

The estimates used are not entirely wild guesses and have been based on Project experience and on figures in the literature, including those for other countries. The amounts of Kg per hectare are averages for Thailand, it being recognized that some soils may require more than others. Nitrogen is naturally required more than other nutrients for most crops (except legumes).

Some of the optimum estimates may seem high for a developing country and it is of course reckoned that it will take years for Thailand to reach such rates of fertilizer use. But these rates and even greater ones in some cases are not uncommon in Japan and Taiwan and of course in more highly developed countries. They must at least be aimed at by agriculture in Thailand.

The nutrient requirements per year have been obtained by multiplying the estimates per hectare by the area devoted to each crop, using the most recent approximate figures for these areas, wherever possible. This assumes overall application of fertilizers and, in the case of the optimum rates, a high standard of farming.

Even the minimum requirements for all crops (excluding rubber) are greater than the amounts of fertilizers now used. The nutrient total requirement (NPK) is 272,050 metric tons per year whereas the amount consumed in 1969 has been estimated as 10[illegible] 700 tons (Project Working Paper No. 4), a little less than 10 Kg nutrients per hectare.

The picture of fertilizer consumption and requirement is dominated by rice. This crop should take 54 per cent of the N, 70 per cent of the P_2O_5 and 40 per cent of the K_2O requirements at present and, in the future, 69 per cent of the N, 53 per cent of the P_2O_5 and 33 per cent of the K_2O requirements. The second largest consumer of fertilizers is the group of vegetables and fruit, already receiving quite large quantities because of the ready and profitable market for the produce. In the future, it is likely that maize and sugarcane may also need relatively large amounts of fertilizers, in comparison with other crops.

It is difficult to make recommendations on the carriers most needed for these nutrients. A compound NP fertilizer with an $N:P_2O_5$ ratio of 1:1 or 3:2 would be best for rice and could serve as a basic dressing for many other crops. A single source of nitrogen (ammonium sulphate or urea) is essential to allow for split application of N and to increase the ratio of N to the other nutrients which is often needed. A compound NPK fertilizer with an $N:P_2O_5:K_2O$ ratio of 1:1:1 could also serve as a basic dressing for the vegetable and fruit areas (a 13-13-13 compound is commonly used there now). A single source of potassium is also advisable for split application.

Fertilizers for rubber have been excluded from this assessment because rubber trees are normally fertilized with compounds containing magnesium as well as N, P and K. These are imported by special arrangements and any organization for manufacture or import of single N, P or K fertilizers or NP or NPK compounds would probably exclude fertilizers for rubber.

Original singed by
John W. Dewis

JWD/AB

22 July 1971

Present Minimum Requirements of Fertilizer Nutrients for the Main Crops of Thailand

Crop	Area	Metric Tons per Year		
	1,000 Hectares	N	P_2O_5	K_2O
Maize	762	15,240	7,620	3,810
Cotton	130	2,600	1,300	1,300
Kenaf	254	5,080	1,270	1,270
Cassava	170	1,700	850	850
Sugarcane	182	7,280	1,820	1,820
Beans	260	-	1,300	1,300
Peanut	120	-	600	600
Tobacco	71	1,420	710	710
Miscellaneous upland crops	120	1,200	600	600
Coconut	220	2,200	2,200	3,300
Vegetables and Fruit	550	22,000	11,000	11,000
Total	2,839	58,720	29,270	26,560
Rice	7,000	70,000	70,000	17,500
All Crops (excluding Rubber)	9,839	128,720	99,270	44,060

Annex 2 to Final Report
UNIDO THA-041-D (SIS)

Optimum Requirements of Fertilizer Nutrients for the Main Crops of Thailand

Crop	Area 1,000 Hectares	Metric Tons per Year		
		N	P_2O_5	K_2O
Maize	762	45,720	38,100	15,240
Cotton	130	6,500	6,500	2,600
Kenaf	254	6,350	6,350	6,350
Cassava	170	12,750	6,800	6,800
Sugarcane	182	21,840	18,200	21,840
Beans	260	-	10,400	10,400
Peanut	120	-	4,800	4,800
Tobacco	71	2,840	4,260	5,680
Miscellaneous upland crops	120	4,800	4,800	4,800
Coconut	220	8,800	11,000	17,600
Vegetables and Fruit	550	44,000	44,000	44,000
Total	2,839	153,600	155,210	140,110
Rice	7,000	350,000	175,000	70,000
All Crops (excluding Rubber)	9,839	503,600	330,210	210,110

Estimated Nutrient Applications for the Main Crops of Thailand

Crop	Minimum			Optimum		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Maize	20	10	5	60	50	20
Cotton	20	10	10	50	50	20
Kenaf	20	5	5	25	25	25
Cassava	10	5	5	75	40	40
Sugarcane	40	10	10	120	100	120
Beans	-	5	5	-	40	40
Peanut	-	5	5	-	40	[illegible]
Tobacco	20	10	10	40	60	80
Miscellaneous Upland Crops	10	5	5	40	40	40
Coconut	10	10	15	40	50	80
Vegetables and Fruit	40	20	20	80	80	80
Rice	10	10	2.5	50	25	10

All figures are Kg per hectare.

We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards, even though the best possible copy was used for preparing the master fiche

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