

planning and organization
of fertilizer use development
in **AFRICA**



DANIDA

FOREWORD

It is the aim of the present Soils Bulletin to set out for the benefit of a wider audience and those particularly interested in the subject matter the proceedings of the Regional Seminar on Planning and Organization of Fertilizer Use Development, for the English speaking countries of the FAO Africa Region, which was held with the financial support of the Danish International Development Agency (DANIDA) and the Kenya Ministry of Agriculture at Nairobi, Kenya, in December 1972.

Since the Seminar was held, the global situation of food and agriculture has deteriorated considerably. Food reserves in the world are at their lowest level. Chemical fertilizers have become scarce and highly expensive. On the other hand, the use of chemical fertilizers, although complemented as much as possible by organic ones, must continue if levels of agricultural production are to be maintained and increased.

From 1958 to 1972 the world's cultivated area increased from 1 390 million hectares to 1 457 million ha, or by 67 million ha, corresponding to about 4.8 percent. During the same period the population of the world rose by more than 30 percent from 2 800 million to 3 800 million. The increase in cultivated area was mainly in the developing countries where there is a comparatively lower level of production. Assuming an average production of one ton of cereal equivalent per hectare, the additional 67 million ha would have produced about 67 million tons of cereal equivalent or the basic food for about 135 million people.

From fertilizer years 1957/58 to 1971/72 the world's consumption of chemical fertilizers rose from 24 million tons of pure nutrients to 72 million tons, an increase of 48 million tons or about 200 percent. By considering a production potential of about 8 tons of cereal equivalent per ton of pure nutrients, the additional 48 million tons of pure nutrients would have provided 400 million tons of cereal equivalent or the basis of nutrition for 800 million people.

The changed price situation calls for adjustments on crop production. Research will have to be reoriented to some extent toward cropping systems which help to maintain natural soil fertility, produce complementary nutrients, improve physical soil conditions and give protection against erosion. Policies concerning subsidies might have to be reconsidered and far more attention will have to be paid to the economics of the use of fertilizers which would imply, among other measures, the development of more detailed and adjusted recommendations. The findings will have to be brought, in a practical way, to the farmers.

Better distribution of fertilizers and related inputs will increase their efficiency and help to avoid losses. Sound agricultural credit would assist in extending the use of fertilizers and in avoiding unbalanced social conditions.

This Soils Bulletin should be able to provide information and guidance on these special and essential subjects.

Edouard Saouma

Director

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INTRODUCTION

Member Governments of FAO's African Region have for some time been aware of the increasing relative importance of fertilizers and related inputs in improving agricultural productivity. This view was shared by responsible personnel of field projects and by FAO itself, and therefore it was decided to organize a seminar to deal with all aspects of fertilizer use development and to provide a forum for the exchange of experience. Moreover, it was the intention of the convenors to enable representatives of Ministries, Planning Commissions, Cooperative Organizations etc. from the English-speaking member countries of FAO's African Region to become acquainted with modern methods of work on long term fertilizer use development.

The seminar was convened under the FAO/DANIDA (Danish International Development Agency) Cooperative Programme. The Government of Kenya was host, and the seminar was held at the Kenya Institute for Administration, Nairobi, from 1-16 December 1972. It was attended by 38 observers and participants from the following countries: Botswana, Ethiopia, Kenya, Lesotho, Malawi, Mauritius, Nigeria, Sierra Leone, Swaziland, Tanzania, Uganda and Zambia.

Ten lecturers presented a total of 19 papers.

It is hoped that this Soils Bulletin will serve as a useful reference to the participants in the seminar and to others involved in the planning and organization of fertilizer use development.

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FERTILIZER IN AGRICULTURAL DEVELOPMENT

Situation

The use of fertilizers has been a key factor in raising crop yields and income in advanced countries, because not only do fertilizers in combination with other improved practices increase yields, they can also decrease unit costs and increase profits. About 60% of the yield increases achieved during the last 120 years is due to the rational use of fertilizers.

Much has been done in developing countries, with the assistance of multi-lateral and bilateral aid, to introduce fertilizers into agriculture on a large scale. Considering the needs, however, only a modest beginning has been made, which calls for renewed efforts to develop fertilizer use.

Fertilizer use (in million tons N+P₂O₅+K₂O) in developing countries has increased as follows:

1954/55	1.4
1962/63	3.2
1969/70	8.8
1970/71	10.0

The Indicative World Plan estimates the future requirements of fertilizers in developing countries (in million tons N+P₂O₅+K₂O) as:-

1975/76	14.7
1980/81	22.4
1985/86	33.0

The total value of fertilizer use estimated for 1985 will represent approximately 45 percent of the total value of all current inputs in agricultural production.

Fertilizer use has increased considerably in a number of developing countries, especially those which have adopted high yielding cereal varieties (Table 1). Nevertheless, though the annual rates of increase have been larger than those in advanced countries, use per hectare and per capita is still low and very low in developing countries.

The introduction of fertilizers can have a great potential effect on other factors of importance to continued rural and agricultural development. This applies to traditional inputs such as labour, soils, irrigation, local plant varieties and manure, but also to purchased inputs like improved seeds, pesticides and equipment.

The introduction of fertilizer use on an extensive scale requires the development of a distribution network, including transport, storage and credit facilities, which can also be used for distribution of other farm inputs.

As fertilizer use produces quick visible results on the fields and its effects are directly measurable, it provides an excellent basis for extension work which can, once the farmers accept it, also include the other production factors. For these reasons fertilizer use development has already proved to be the spearhead which opens up a short cut to integrated agricultural development.

Although there are considerable differences from country to country, the main obstacles against a rapid development in fertilizer use are still: insufficient knowledge about the use of fertilizers and also in relation to other inputs; inadequate facilities for the

transfer of the knowledge to the individual farmer and inadequate facilities for fertilizer marketing and credit. After more than a decade of development aid in fertilizer use development, the countries can be classified as follows as regards the stage they have reached in fertilizer use and the need for further assistance.

- A. Countries which are still in need of basic technical and economic information on fertilizer use. For these, assistance should concentrate on experimental and demonstration work, followed by pilot schemes for fertilizer distribution. There are 25 countries in this category, most of them in Africa.
- B. Countries which have (1) recognized the importance of fertilizers for the development of agriculture, (2) information on rational fertilizer use available, and (3) developed a sizable demand for fertilizers among farmers, but which, mainly because of inadequate infrastructure and deficiency of foreign exchange, cannot build up fertilizer use on their own as quickly as would be desirable. This category includes 39 countries, about evenly distributed in Asia, Africa and Latin America.
- C. Countries with an already relatively efficient infrastructure but where (1) the lack of or insufficient foreign exchange for the purchase of fertilizers represents a major bottleneck in further development, (2) the infrastructure for distribution of fertilizers and other inputs still needs further improvement either in the country as a whole or in parts of it: 22 countries are included in this category, mainly in Asia and Latin America.
- D. Countries (1) which do not need any more foreign assistance in fertilizer use development, or (2), which need assistance in fertilizer use development only in parts of the country, or (3), which need assistance only for solving specific problems, for instance, building up a soil testing service, establishing a fertilizer unit in the Ministry of Agriculture, introducing fertilizer legislation, preparing an overall plan for long term fertilizer use development and eventually fertilizer production. There are at present only three countries in this category.

Still more than 60 countries are in need of assistance in one way or another in fertilizer use development. The real problems in this respect are the economically weak farmers with small and often remote holdings who produce the bulk of the food crops, and the limited economic possibilities of the countries as a whole.

Future needs

Future planning of assistance should take into consideration the following factors:

1. The number and the scope of soil fertility and fertilizer use development projects should be better related to the size of countries and regions. The possible effects of small scale projects have often been overestimated.
2. The type of projects should be adjusted more carefully to the needs of the countries which, in practice, means mostly a widening of the scope of the project activities, technically and for fertilizer supply.
3. The duration of the projects should be kept more flexible, taking into consideration the possibility of phasing the activities and the time it takes to introduce lasting improvements on small farms.
4. A better coordination of the development aid in soil fertility and fertilizer use could increase the efficiency, taking into account the considerable knowledge and the worldwide organization of FAO and the very considerable possibilities for input supply by some bilateral donors.

5. Standardization of projects and working methods and the exchange of information should be considered for improvement.
6. Training still needs to be improved in order to make sure that the work of fertilizer development projects will continue.
7. The following factors, technical and partly economic, will probably influence the need for fertilizers in a particular direction (based on IWP):
 - (a) High yielding varieties and other developments under the term "Green Revolution". It has been estimated however that by 1985 only about 30% of the area under cereals will be planted with high yielding varieties.
 - (b) Tree and other permanent crops which are replanted by plant material with higher yield potential. The limiting factors in this field might be the relative saturation of the world market by produces like coffee, cacao, copra, palm oil, citrus, etc.
 - (c) Existing and future irrigated areas. There are still vast areas already under irrigation which are uneconomic because they are not yet using fertilizers adequately. On the other hand, the substantive expansion of irrigated areas is a relatively slow process.
 - (d) Rainfed agriculture. This type of production has been relatively neglected so far, particularly the areas of small farmers for which any improvement is basically a matter of economic considerations.
 - (e) Multiple cropping. The increasing use of high yielding varieties, improvements in cultivation and the need for crop diversification are important factors in these developments.
 - (f) More rational use of natural resources, including soil conservation.
 - (g) Improvements in shifting cultivation. FAO has initiated a number of activities in this field, particularly in Africa. It is apparent that any improvement will be closely related to increased use of fertilizers.
 - (h) Forage production under relatively intensive conditions.

It is obvious that these future needs should be reflected in the planning of future development work and development aid.

Level of Fertilizer Use in Developing Countries 1970/71

Region and Country	Consumption (kg) N+P ₂ O ₅ +K ₂ O		Region and Country	Consumption (kg) N+P ₂ O ₅ +K ₂ O	
	per ha. arable land	per capita		per ha. arable land	per capita
<u>NORTH AND CENTRAL AMERICA</u>	68.5	54.6	Tanzania	1.5	1.3
			Lesotho	2.0	0.7
			Somalia	2.4	0.8
<u>EUROPE</u>	169.6	54.0	Cameroon	2.8	3.5
			Ivory Coast	2.8	5.0
			Dahomey	4.4	2.5
<u>ASIA</u>			Malawi	4.5	3.0
Laos	0.2	0.1	Zambia	4.5	5.0
Khmer Rep.	0.8	0.4	Libyan Arab Rep.	5.0	6.3
Burma	1.4	0.9	Madagascar	5.1	2.1
Afghanistan	2.0	0.9	Sudan	9.4	4.3
Jordan	2.1	1.2	Tunisia	10.7	9.2
Iraq	2.3	2.4	Congo P. Rep.	11.3	8.0
Nepal	2.6	0.5	Morocco	12.4	6.3
Iran	5.9	3.4	Algeria	17.5	8.6
Syria	6.0	6.5	Kenya	32.4	5.0
Saudi Arabia	7.0	1.1	Swaziland	36.6	20.9
Thailand	8.2	2.6	Egypt	121.8	10.4
Malaysia, Sabah	9.8	3.5	Mauritius	209.4	26.3
India	13.2	4.0			
Indonesia	14.0	2.1	<u>LATIN AMERICA</u>		
Pakistan	15.1	3.3	Bolivia	0.5	0.3
Turkey	15.8	12.3	Venezuela	3.3	6.3
Philippines	25.2	5.9	Argentina	3.4	3.6
Vietnam, Rep. of	42.3	6.7	Haiti	4.1	0.3
Ceylon	47.3	7.5	Ecuador	8.9	5.6
Cyprus	63.5	43.4	Paraguay	9.5	3.8
Lebanon	120.8	15.5	Guyana	12.3	13.1
Korea, Rep. of	243.6	17.4	Mexico	24.9	11.7
Malaysia, West	335.0	15.5	Uruguay	25.8	17.5
			Panama	26.6	10.2
<u>AFRICA</u>			Guatemala	30.9	8.9
Guinea*	-	-	Honduras	30.9	9.9
Niger*	-	-	Brazil	32.2	10.2
Ethiopia	0.2	0.1	Colombia	33.7	8.4
Burundi	0.3	0.1	Nicaragua	33.8	14.5
Chad	0.3	0.7	Chile	34.4	16.2
Togo	0.3	0.4	Peru	41.9	8.8
Central African Rep.	0.4	8.6	Dominican Rep.	44.0	10.8
Mali	0.5	1.1	Costa Rica	51.9	28.6
Liberia	0.6	2.0	Trinidad	68.4	9.0
Nigeria	0.6	0.2	Cuba	110.6	47.1
Sierra Leone	0.6	1.0	El Salvador	112.3	20.4
Ghana	0.7	0.2	Jamaica	141.0	17.0
Zaire Rep. of	0.9	0.4	Martinique	586.2	49.0
Senegal	1.3	1.9			
Uganda	1.4	0.8			
Gambia	1.5	0.8			

* Negligible

TECHNICAL AND RESEARCH ASPECTS IN SOIL
FERTILITY AND FERTILIZER USE

by
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INTRODUCTION

Irrespective of the continent be it Europe, America, Asia or Africa, all agricultural activity was, and much still is exploitive in nature - in other words the farmer generally removes more from the soil than he returns to it.

It can also be assumed that the various systems of agriculture which have developed in different parts of the world aimed at producing the maximum amount of crop with the minimum of effort but also that traditional cropping systems in those areas with only a brief growing period had built into them systems which would ensure against a complete crop failure.

Divergence from these generalizations will occur when a farmer changes from a shifting type of agriculture to a more permanent type and when he changes from a subsistence agriculture to a monetized economy. However, even before these changes occur, a soil fertility crisis may develop, due not to a fault inherent in the agricultural system developed but to the demographic problem of increasing population pressure.

The current pattern of fertilizer consumption in Africa shows that, large farms and plantation crops apart, only the export or export substitution crops are widely fertilized viz. groundnuts, cotton and, to an increasing extent, rice. Most of the traditional food crops produced in Africa are still grown without fertilizer and because of continuing low prices fertilizer use on export crops has even fallen in some countries.

It is against the background of increasing population pressure, the collapse of traditional farming systems and the generally low prices of agricultural produce that this paper is presented.

To understand fully the role of soil fertility in agricultural development in Africa, it is necessary to understand the nature of the soil resources of Africa, the traditional systems of agriculture, the changes which are now occurring and finally as fertilizers are the central theme of this seminar, to understand those soil and crop factors affecting fertilizer use.

SOIL RESOURCES

The first step in any development planning is to make an inventory of the resources and soil surveys have been high on the list of agricultural research activities in most countries of Africa both at the national and regional levels and even at the world level.

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A soil map of the world was the goal of a group of eminent soil specialists who were called together by FAO and UNESCO in the early 1960's. The problems facing these international experts were enormous but the correlation of all the different data to produce a uniform and universally acceptable nomenclature was probably the greatest obstacle, as terminology varied both between and within language groups.

Whilst the world soil map has obvious uses in global development planning and in initial national planning, detailed surveys of specific areas will always be needed before adequate planning at the national level can be made; but at whatever scale of mapping, it is essential that all surveys should be based on internationally acceptable nomenclature and the role of FAO and the Inter-African Bureau of Soils in encouraging international cooperation in soil work in Africa should be noted.

Soil resources though of vital interest are only one part of the agricultural resources of a country and as Moormann (1971) has pointed out, to regard 'soil suitability classifications' and 'land suitability classifications' as essentially synonymous is misleading as the range of data collected in soil surveys does not necessarily lend itself directly to land resource classification which is the real requirement of the agricultural development planners.

Soil surveys in the past were often carried out by only one scientist with a few semi-skilled or unskilled workers to help him and so it would be ungenerous to criticize past achievements, nevertheless the multi-disciplinary approach so fruitful in other scientific fields is now making a great impact on land-resources classification - the use of meteorological data to produce soil moisture balance sheets is one very important aspect of the newer approach as the vagaries of rainfall at certain sensitive phases of crop growth can jeopardize the crops of whole regions.

A well planned soil survey can be an invaluable guide to agriculturists as the parameters described such as texture and structure have an important bearing on root development and therefore on plant growth. The chemical fertility of the soil is also usually well described and data on soil pH, organic matter content and cation exchange capacity are invaluable guides in assessing the agricultural potential of a soil and its suitability for various crops.

In the context of much of Africa, because of the large size of many of the countries and the large areas with low population density, a soil resources map is invaluable, but once we are concerned with crop production or intensification of land use, then economic, sociological and political aspects become determinant. In other words when the need is there man can tailor the soil to meet these needs by investing in irrigation, drainage and fertilizers but it must also always be borne in mind that man can also destroy the soil by overcropping and overstocking and thus by denuding the soil lead to irreparable erosion losses. The soil resources of a country should be regarded as national assets to be developed nationally and in the interests of all.

Large areas of African soils have developed under rainfall conditions sufficiently intense to lead to profile leaching and consequent loss of plant nutrients in the drainage water. Free draining soils therefore are typically acid and low in plant nutrients whilst the soils formed in valley bottoms enriched with these drainage waters are usually chemically fertile; however because of the type of clay minerals formed under these conditions they are often heavy intractable clays, whilst the free draining soils, in contrast, are relatively easy to work.

The parent materials of the soils also affect their characteristics, as soils derived from low-iron rocks such as sandstones and granites often have weak structures and are high in fine sand making them very susceptible to surface wash; in contrast the basalt derived soils rich in iron and aluminium oxides have a good structure and they can therefore absorb heavy showers of rain and yet they are resistant to erosion when run-off occurs.

It may seem strange to say that African soils are generally of fairly low fertility when one can see large areas supporting abundant growth of vegetation, particularly in the forest areas.

In actual fact these forests have 'mined' nutrients from great depths and the living plant species and the shallow organic surface layer of the soil contain almost all the plant nutrients available in the soil profile. When such a forest is cleared and burned, excellent crops can be grown as ample supplies of nutrients are available. However, the foregoing facts also imply that the total plant nutrients available over a unit area are in delicate balance with the forest growth; this applies both quantitatively i.e. the absolute amounts of nutrients available and also qualitatively i.e. the ratio of the different essential plant nutrients is closely balanced.

The Belgian research workers paid particular attention to the correct ratios of nutrients, particularly the bases K, Ca and Mg in tropical soils, and there is no doubt that careless acidification of the soil through heavy dressings of ammoniacal fertilizers can precipitate serious base deficiency problems (Russell 1968).

With population pressure, leading to the rapid expansion of the area under cultivation, traditional cropping patterns are often transferred to completely unsuitable ecological conditions. Part of the reason for this is the traditional staple food habits of the people - one can see attempts to grow both banana and maize in areas with a rainfall pattern more suitable for sorghum, or maize being grown where potatoes would be more productive.

As modern agriculture demands intensive production, the division of each country into soil and agro-climatic zones should be made and the intensive development of those crops most suited to particular zones should be encouraged (Kanwar, 1970).

SHIFTING CULTIVATION AND CROPPING PATTERNS

a) Shifting Cultivation

The universal practice of shifting cultivation developed solely from the fact that more crop yield could be obtained with the same or less physical effort by moving the site of the planted area into a virgin area at regular intervals.

Shifting cultivation has developed to a high degree of sophistication in many African countries both in the forest and savanna areas, and all those systems were in balance with the population of the area for many generations; however populations grow and the demand for more food leads to a shortening of the regenerative cycle which in turn leads to lower yields and a further shortening of the regenerative fallow period.

Most African countries have examples of areas where the increase in population pressure has led to a collapse of the traditional shifting cultivation practices and to the consequent misery of eroded soils, flash flooding and reduced productivity.

In addition to the adverse effects of increased farm population, urbanization, which is growing rapidly in Africa, has created huge markets for food. This has led to a shift around the cities from subsistence agriculture to the production of food as cash crops - a change which has subjected traditional shifting cultivation in many areas to pressures it was never intended to bear.

Nevertheless it is around the cities of Africa that increases in demand for farm produce backed by adequate purchasing power can lead to sound agricultural development in food crop production.

The reasons for the breakdown of the shifting cultivation system when fallow periods are shortened beyond a certain critical period is complex but the exhaustion of the chemical fertility of the soil is a major factor.

Results from Ghana (Hauck, 1971) have shown that even small dressings of nitrogen and phosphorus (22.5 kg/ha of N and P_2O_5) could prevent the rapid decline in yields of maize in the second and third years following bush clearing. These results indicate that, in terms of mineral fertility, fertilizer use can replace the fallow periods.

Unfortunately, and this is particularly true of the forest soils, not only the chemical fertility of the soils falls but the physical structure which is so important in preventing or lessening erosion, also degenerates.

The central role of organic matter as a key component of soil fertility in its widest sense i.e. in structure, moisture penetration and holding capacity, and as a source of N, P and S as well as its contribution to the C E C is continuously stressed by most soil fertility workers in Africa and much attention has been given to developing suitable cropping rotations which would maintain the level of organic matter at acceptable levels.

One way of maintaining adequate organic matter in the soils is by maximizing yields with fertilizer use - the roots and crop residues would then contribute to soil fertility maintenance or improvement.

The development of fallow crops, particularly the leguminous ones, offers an obvious way to maintain fertility without heavy expenditure on nitrogenous fertilizer, but the establishment of such fallows is not easy and often they appear to have little advantage compared with natural fallows (Greenland 1970). Additionally, in many areas heavy dressings of fertilizer phosphorus will be needed. Legume fallow systems will therefore only develop in mixed farming areas where the fallow crop has an economic value as cattle-feed.

b) Cropping Patterns

The problems of changing from shifting cultivation are thus seen to be complex and this complexity is increased by the fact that one of the most striking aspects of cultivation in Africa is that there is a definite mixture and sequence of crops in any one area.

The practice of intercropping, i.e. the practice of growing two or more crops intermingled together at the same time, which is particularly popular in Africa, has been brought to a fine art in places like China and it has always been part of the art of the successful vegetable grower.

It might be assumed - by the conventional wisdom of western-trained scientists - that sole cropping is inherently superior, as a form of agricultural exploitation, to intercropping; in fact, sole cropping is linked with the use of the plough rather than with yield maximization.

Scientists have naturally tended to avoid becoming involved with work on **intercropping** because of its complicating effects on the problem they wish to study, be it soil fertility and fertilizer response, or some other aspect of crop production; for example a study of the effects of fertilizers on yields in some of the complex cropping situations which exist would be most tedious and expensive, and understandably therefore almost all fertilizer research work in Africa has been carried out on pure stands.

The cropping picture in the heavily populated savanna areas still appears complicated by Western standards, but compared with practices in the forest zones where the fields are in a state of planned abandonment from the moment they are cleared, it is easier to see some cropping pattern. In Northern Nigeria the picture becomes even clearer as crops are by tradition grown on ridges or raised beds and these give a geometrical order to fields which helps in the appreciation of the spatial distribution of the crops.

Even with this simplification of cropping in Northern Nigeria however, almost all scientific work has been carried out on sole crops, and the Package Demonstrations, which are the basis of the Northern M.A.N.R.s extension work are based on sole crops.

This emphasis on sole crop Package Demonstrations had raised two technical points:

- 1) The small farmer does not practise sole cropping and therefore it could be questioned whether the levels of inputs i.e. fertilizer and labour in the Package Demonstrations will be the correct ones for the traditional inter-cropping system.
- 2) Is, in fact, intercropping a more rational practice for the small farmer than sole cropping?

As intercropping has both a space and a time dimension, it is possible by judicious selection of crops to adjust the timing and spatial arrangement of mixed crop stands to give maximum leaf area production over longer periods than is possible with sole crops.

As rooting patterns and distribution would also vary, theoretically water and nutrient exploitation of the soil profile could also be maximized.

In pathological terms, although the pest and pathogen picture will obviously be more complex in a mixed stand, there is evidence that the effects are never as acute as they are with sole crops (Aiyer 1949) and moreover early and continuous ground cover helps to control weeds and erosion (Geertz, 1968).

Perhaps the key factor in inter-cropping so far as African tradition goes is the insurance against total crop failure, as staggered planting with a mixture of crops will always provide some yield even in the worst years - the very time when even the smallest yield would be welcome (Webster & Wilson, 1966).

Because of the foregoing points the Agricultural Economics Department of the Agricultural Research Institute Samaru has initiated a special study of small farmers inputs and outputs in three villages near Zaria.

The results of the studies carried out to date show the following points:

- a) Profit maximization - the result in general indicates that the profitability of crop mixtures was about 60% higher than that for sole crops.
- b) Under indigenous technological conditions the profitability of crops grown as mixtures are higher than when grown as sole stands.
- c) Under indigenous technological, sociological and economic conditions the growing of crops in mixtures is consistent with the goal of security.

The conclusions of these studies (Norman 1970 a, b) are very pertinent to the whole problem of agricultural extension in Africa for in the text the following statements are made:

"There are valid reasons of a technological, sociological and economic nature for the farmer's reluctance to change to a sole cropping system".

"This reluctance highlights one of the fundamental problems of extension workers. Unfortunately, most farmers still remain unconvinced of the value of recommendations demonstrated by such individuals. Until these workers can suggest changes that have a convincing return, and yet do not involve big changes in farming methods, it is unlikely they will ever be truly effective in their work. It is suggested that once the farmer has adopted an innovation that does not conflict too much with his present traditional outlook, e.g. improvement of his returns from inter-cropping, it will then be easier for the extension worker to suggest more radical changes, e.g. sole cropping".

Norman concluded by saying that it is difficult not to agree fundamentally with the observation by Evans (1960) that unless sound evidence is obtained that production from pure stands is appreciably higher than that from intercropping and that there are advantages such as reduced labour input, pest and disease control, and convenience, it will not be possible to introduce rotational systems of agriculture based on pure stands as long as the hoe remains the most important agricultural implement.

The relevance of these points to the Kitale maize data discussed in the chapter on the inter-relation of soil fertility with other production factors will be clearly seen.

INTER-RELATION OF SOIL FERTILITY WITH OTHER PRODUCTION FACTORS

Plants need only light, water and nutrients for them to grow to their full genetic potential; air with its supply of CO₂ cannot be considered as a factor limiting normal agricultural productivity although addition of CO₂ to the atmosphere does give large yield increases. Unfortunately, all three of these factors are often limiting in absolute amounts and additionally, the individual plant is faced with severe competition for them from other plants of the same crop or with different plant species, more particularly weeds. Aggravating these growth limiting conditions are the pests and diseases to which all crops in varying degrees are susceptible.

Therefore high soil fertility, either natural or developed through fertilizer use, does not guarantee high yields of agricultural crops - but equally without fertilizer use the genetic potential of the crop cannot be reached.

As this meeting is being held in Kenya, it is opportune to use results from the Research Station at Kitale (Allen, 1971) to illustrate the marked degree of interaction between various agronomic practices.

The requirements for a good maize crop in Kenya and indeed in most other places are early planting, a good plant population, clean weeding and hybrid seed.

Yields of maize (g/ha)

	Without fertilizers	With fertilizers (56 kg P ₂ O ₅ and 80 kg N per hectare)	Difference
BH + LF	20.9	26.0	5.1
GH + Hy	74.7	90.8	16.1
Differences	53.8	64.8	

- GH = Early planting + good plant population + clean weeding
 BH = Planted four weeks late + low population + poor weeding
 LF = Local farmers maize
 Hy = Hybrid 613B

This work is interesting in that it shows the very high yield levels which can be achieved under the best conditions and it does provoke the thought as to why the small farmer has not accepted the recommended practices as readily as would be hoped, although undoubtedly good progress is being made.

The maize results just quoted are based on yields per unit area but yield per man hour and yield per unit of input comparisons would also be useful, as it is often the case that labour and cash for inputs and not the surface area available for planting are the limiting factors. There is always competition for the farmer's time in peak periods of the year and it may be physically impossible for him to plant early and weed as regularly as is necessary for high yields.

Studies in Uganda (Hall, 1971) have shown that the group often most interested in technical inputs were not, as would be expected, the younger and better educated group, but the older people whose physical capacity for hard manual work was falling off, and who therefore were looking for alternative means, such as fertilizer, to maintain the production levels of their shambas.

The popular 'package of inputs' demonstrations show, often with some degree of technical arrogance, what yields can be achieved, but they often fail to involve or motivate the small farmer.

The introduction of the high yielding varieties (HYV) of wheat, rice and maize has raised the potential for yield increases to levels which were unthought of ten years ago. However, the actual increases in yields at the farm levels have not been spectacular over large areas. Thus in the Philippines, the home of HYV rice, almost 50% of the area under rice is in the new varieties, but average national yields in the Philippines have not improved very much.

It has been claimed that the new dwarf rice varieties give higher yields than the local varieties when grown under the same conditions and particularly when grown with little or no fertilizer - this could explain in part the rapid adoption of the new varieties in the Philippines but the fact remains that the use of other inputs, particularly fertilizer, has lagged behind the adoption of the newer rice varieties (FAO 1971) and therefore the yield potential of these varieties has not been exploited.

ORIENTATION OF RESEARCH TOWARDS THE NEEDS OF THE COUNTRY

a) General

The problem of how best to use the scientists and technicians now becoming increasingly available has been the subject of much discussion and some of the opinions put forward, particularly as regards agricultural research, and the development of soil fertility and fertilizer use research, will be given.

The history of agricultural science is one of promises to improve agriculture and probably the greatest success story of chemical research applied to agriculture, was the discovery that the trace elements copper, zinc, molybdenum and cobalt were deficient over some 400 million acres of land in Australia and New Zealand; this land, although it had adequate rainfall, was completely unproductive.

To know that 2 oz. of molybdenum per acre turned barren land into fertile grazing land, led to a public admiration for agricultural science, from which the Australian and New Zealand scientist still benefits.

The development of the strong soil science research programme of the U.S.A. has an interesting history, very different from that which occurred in Australia.

Kellogg (1961) has pointed out that the history of American expansion across the subcontinent meant that the study of the soil and problems associated with its management were neglected. In the period up to 1914, homesteading had developed to such an extent that American agriculture was spread over a greater surface than was needed even with indifferent management. The first world war aggravated the position by making even the worst farmers solvent.

In other words there was plenty of fertile land available and money could be made simply by exploiting this resource.

It was not until the development of the dust bowl and the great dust storms from Oklahoma which appeared over New York in 1933 that American public interest in the soil wealth of the nation was sufficient to attract funds for soil and water conservation, and fertility studies on a large scale.

In north west Europe, and Britain in particular, the great developments in the intensity of agricultural research came after the second world war, when there was a national consciousness of the near starvation years of 1940-45.

In Africa and in East Africa in particular, the scientists employed were, with the possible exception of those working in institutions similar to E.A.A.F.R.O., expected to improve the yields of local crops primarily by demonstrating good husbandry and soil conservation techniques.

They were therefore primarily agriculturists, working at the level of local conditions, and at this level they may have improved yields, yet the knowledge obtained was not generally applicable to a larger scale.

A major aim of the large research centres must be to establish general principles, but unlike most industries where projection of results is easily carried out, in agriculture the site and the crop differ considerably, so that field trials for specific crops and locations will always be needed.

Bawden (1962) has said "there are two equally important aspects of research, one the discovery of better agricultural methods, and two the willingness of the peasant or farmer to adopt these methods. No industry can advance without research, but research alone however good will not automatically benefit an industry - this will only happen when the practitioners are willing and able to act on its results. The ultimate aim of agricultural research must be to increase the efficiency of agriculture, that is to lower costs of production by increasing yields per acre, per man or per unit of money spent and to improve the quality of the end product."

"This however need not, and should not, be the immediate aim of all research. Work that may seem remote from practice, but that establishes general principles, will often produce more beneficial results than seemingly immediately practical experiments that simply measure responses to treatments. Thus Penman's work on the physics of evaporation has done more for agriculture than thousands of individual practical experiments would ever have done."

Governments invest in agricultural research not because of the feeling that research for its own ends is worthwhile, but because they feel it is an investment in an applied project which will yield dividends in the short as well as in the long term (Parish 1969).

The international foundations have given considerable thought to agricultural research organization and as they have had undeniable success, their words should be carefully weighed.

The Rockefeller Foundation's philosophy is simply stated (Wortman, 1967):

- 1) Agricultural productivity is a problem of individual nations and individual crops - in other words the 'site' conditions mentioned previously must be studied.
- 2) The only measure of adequacy of technology with any crop in any region is the yield. If high yields can be obtained then the major technological problems have been solved and economic and political factors are limiting development.
- 3) All agricultural scientists including those of the educational institutions must work together on projects which reach the farmer.

This philosophy may not fit in exactly with the position in some countries but the point made that all agricultural scientists should be involved in production orientated research and should be intimately concerned with the problems of the small farmer is sound.

The assessment of the value of research work solely on the volume of publications is not adequate to ensure a good return for money invested in research. To take a subject close to the theme of this seminar - the fixation of soil phosphorus - approximately one hundred learned papers on this subject are published each year but as Jacks (1966) has said "our knowledge of soil phosphorus has not advanced commensurately with these outpourings of sweat and ink."

As there are many other subjects which have not proved amenable to solution by scientific method and so have remained unproductive, all soil fertility research should be regularly screened to divert money away from non-productive projects.

To the intensive farmer of northwest Europe and North America maximum yields are essential to cover the high costs of land, labour and machinery. Fertilizers to these people are cheap and the whole aim of their farming is to build up soil fertility to the level where it is not a brake on the genetic potential of the crop.

Also much of the more sophisticated agricultural research carried out in the so-called advanced countries has, as its aim, those marginal increases in yield which in large scale agricultural enterprises often mean the difference between profit and loss, such research need not be regarded as a high priority in many countries.

The farmers of Africa are not working at those high levels of investment (although the estate crops like tea, sugar, oil palm etc. often are), and what is desperately needed are simple examples of changes in crop management with the individual changes assessed and quantitatively demonstrated to the farmer to convince him that the change suggested is justified.

b) National Research Work of Fertilizers

The need for continuing and developing work on soil fertility and fertilizer work would appear to be self-evident and yet there is often the feeling that either all this work is for the benefit of the more prosperous farmer or, even worse, in some countries the attitude has developed that the small farmer knows all about fertilizer and would use it if it paid.

The situation in China contradicts both of these attitudes; land reform eliminated the larger farmers and yet active research at all levels still continues, and if the Chinese rice farmer can still be shown correct fertilizer techniques by simple trials and demonstrations in 1972 then there is no room for complacency in other developing countries.

i) Organization

Fertilizers are often the first production input purchased by an African farmer and the expense incurred represents a major portion of his liquid capital or available credit. It is therefore the duty of all nations to provide sound information to the farmer about the types, timing and quantities of fertilizers he should use in order to obtain a sound return on his investment.

Such guidance would seem to be a fairly simple matter to obtain but in actual fact the need to develop sound fertilizer recommendations at the farmer's level has often been unappreciated.

The country which probably gave more thought to this problem than any other was India where the national situation was similar to local situations in some parts of Africa, that is communities of small farmers all attempting to grow all of their food needs, with little or no specialization and with a low level of inputs had received no technical guidance from the extension services.

On the basis of a national soils map and a climatic map using the Effective Moisture Index:

$$\left(\frac{\text{Precipitation} - \text{Potential Evapotranspiration}}{\text{Potential Evapotranspiration}} \times 100 \right)$$

a series of Soil-Climatic zones was delineated. Forty Model Agronomic Centres were then established in the more important zones and at each of which a series of complex and replicated experiments were laid out. Additionally, a Simple Fertilizer Trial Project, whose aim was to study fertilizer responses under cultivators conditions, was also set up around the Model Centres.

In many areas useful responses to fertilizers were obtained with current agricultural practices, in others varietal or other problems were dominant. However the principal aim of obtaining a wealth of yield and fertilizer response data from the farmer's own fields proved invaluable for planning purposes.

The philosophy of the programme as well as the techniques have been modified over the years, but the effort is undiminished with more than 400 trials being carried out annually at the Model Agronomic Centres and over 7 000 simple fertilizer trials annually on farmer's fields.

This approach of the Indian authorities went straight to the source of one of the major drawbacks of experimental station work, namely that with the high level of technical ability and with the high input resources available trial results from these experimental or research stations are not generally applicable directly to the small farmers' conditions.

The FAO Fertilizer Programme accepted the soundness of the Indian approach and has since used it in many countries.

There is need for active and continuous research at all levels, but usually the need for large research centres and educational institutions is clearly seen, whilst the equally vital support of well sited sub-stations actively involved in supporting a series of trials and demonstrations at the small farm level often goes unappreciated.

Implicit in the 'down to the poorer farmer approach' is the philosophy that it is better for the extension worker to improve a little the lot of many, rather than to improve the lot of a few a hundred fold, which modern production techniques are certainly capable of doing.

ii) Research Needs

When one considers that less than 50%, and often very much less, of the fertilizer nitrogen applied to a crop is recovered in the crop then research on improving this efficacy is sorely needed - it is nonsense to ship fertilizer half way round the world and then tolerate such low efficiencies of recovery.

Phosphate is widely deficient in Africa, and for short term crops some soluble form is usually recommended, although in francophone Africa rock phosphates are widely used. Recovery here too is very low, but as no phosphate is lost from the soil profile, unless there is erosion of the soil, residual effects, which are quite pronounced and long lasting, may compensate eventually for low efficiencies of recovery in the early applications.

In some areas (Le Maire 1968) negative yield responses as yet unexplained, are found when small doses of phosphate are used whereas heavier doses give rise to normal yield response curves.

Potassium has not been found to be widely needed on food crops in Africa and then only in the forest zone (Stephens 1960) but once intensive cropping starts the natural soil reserves may not be adequate and continual care will have to be exercised to make sure that potash reserves are not depleted to the stage where yield loss might occur.

Fertilizer work is usually involved with just N, P and K response information, but over much of Africa low soil sulphur is either already limiting plant growth or it becomes limiting once yields are stepped up.

Sulphur is not generally limiting in industrial countries due to the high levels in rainfall as a result of industrial pollution; the cleaner air of Africa, however, gives rise to very low levels of sulphur in the rainfall and so for the majority of countries sulphur-containing fertilizers will continue to be needed and delineation of the area of potentially sulphur deficient soils is therefore a priority.

Trace elements receive periodic interest and there are many examples of responses under specific conditions. The detection of boron deficiency in cotton in Zambia is of interest, as at that time Tanzania was making rapid strides with intensive cotton production using an N:P mixture developed at Ukiriguru. Many complaints were received from farmers that fertilizers did not pay, fortunately boron deficiency was quickly diagnosed as a limiting factor and the corrective treatments given. This example does show once more that responses in the farmers' fields are the only true test of fertilizer recommendations and that only by continual contact with the farmer can mutual confidence be established.

Ammoniacal fertilizers acidify the soil and as there are large tracts of light textured poorly buffered soils with only low base reserves in Africa the use of non-acidifying nitrogenous fertilizers will need to be developed. Liming programmes so common in the U.S.A. and Europe will be unlikely to play much part in African agriculture in general due partly to the isolation of the known deposits and the high costs of distribution - it should however also be noted that very good crops of all types can be grown in Africa on soils with a pH down to 5.0, a degree of acidity which would seriously affect crop growth in temperate zone countries.

The long distances over which fertilizers have to be transported in many African countries adds considerably to their costs and concentrated fertilizers will have a role to play. Unfortunately, such concentrated fertilizers present distribution problems to the farmer and developmental work on simple farm machinery to meter and place fertilizers on the small farmer's crops is needed.

Research items which should receive priority, in view of the lack of capital or credit availability of the small farmers, are those which will maximize the profitability of fertilizer use. For the fertilizer specialist this means:

- 1) The achievement of maximum efficiency by finding the correct level, form, timing and placement of fertilizer.
- 2) Studies of all the newer fertilizer materials particularly the highly concentrated ones.
- 3) Studies on the control of nitrification rates and nitrate losses and of the effect of these on base depletion - these studies to include both soil and fertilizer nitrogen.
- 4) The establishment of a large series of continuous simple fertilizer trials in farmers' fields designed to obtain the correct economic fertilizer treatment for the area. These trials should be grouped to cover the most important soil and climatological zones.
- 5) Continued surveillance of all trial sites to make sure that factors other than the nutrients being tested are not limiting yields.

The foregoing are given just as examples of the multitudinous problems and active applied research on soil fertility and fertilizer use is the only way of making progress.

SOIL ANALYSIS

It has been continually stressed throughout this paper that the effect of site variables is to change the level and type of fertilizer needed for maximum profit.

If the philosophy of numerous simple fertilizer trials and demonstrations in farmers' fields is the backbone of the fertilizer research effort then an attempt has already been made to acquire sufficient information to give generalized fertilizer recommendations to cover similar sites.

The ideal would be of course for each small unit to have its own trials and demonstrations but unfortunately the cost factor mitigates against this and the soil scientist or crop nutritionist has consequently spent much time in developing simple chemical tests which could be applied to each individual site and could give the farmer specific fertilizer recommendations for specific crops.

Such an ideal remains a pipe dream for many reasons, the principal one being that both the soil and the crop growing on it are dynamic systems. The complexities of their inter-actions with different soil physical conditions, including soil moisture potentials, and for the crop of varying intensities of incident radiation, disease infestation, storm damage and competition from other plants are such that it is unlikely that the ideal will ever be achieved.

The fact remains however that for maximum crop yields certain levels of soil fertility are needed and many soils fall below these levels, if therefore the search for a suitable soil test is restricted to separating those soils which are almost certainly deficient in a nutrient from those which are definitely not, the results will have real practical value.

Further refinement then is to predict relative yields i.e. the percentage increases in yield the fertilizer will produce. When only one nutrient is limiting yields, soil analysis can give correlation co-efficients of 0.85, which means that soil analysis can explain about 75% or more of the variation in yields (Cate, Hunter & Fitts, 1969).

The methodology of soil analysis is simple, the soil is extracted with a chemical solution which theoretically dissolves that portion of the nutrient element which the plant root can utilize. The fact that there is such a wide range of extractants used and that neighbouring laboratories often use different extractants implies that the aim of duplicating the extractive power of plant roots has not been entirely successful.

Results obtained with one extractant cannot be converted to give an indication of the results which would have been obtained had a different extractant been used, thus illustrating clearly the empirical nature of this approach.

The soil nutrients most studied in the attempt to forecast crop availability are naturally the major nutrients N, P and K. The measurement of soil acidity and organic matter content are also standard measurements which give very valuable information to the scientist. Methods for determining the lime requirement of soils are well developed and are used extensively in Europe and America but as mentioned previously will only be used in very special circumstances in Africa.

Nitrogen supply is generally the key to high yields and nitrogenous fertilizers make up one half the world's total fertilizer production. Because soil nitrogen is mainly in the form of organic compounds and is converted to ammonium ions and nitrate ions, the forms in which the plant takes up nitrogen, by bacterial activity, the dynamics of soil nitrogen are very complex and despite a considerable research effort soil nitrogen analyses have only a limited applicability to commercial agriculture; however the work of Robinson (1968) at E.A.A.F.R.O. on incubation techniques for the mineralization of plant available nitrogen shows that considerable improvements can be expected.

The flush of mineralized nitrogen liberated when the soil is rewetted after a dry period has been closely studied in Kenya and at one time was considered the explanation for the higher yields of maize obtained with early planting; however, the problem is far more complex.

Phosphorus is the second most important fertilizer nutrient and in the forecasting of phosphorus requirements soil analysis has had considerable success and most soil laboratories have now mapped out the phosphate deficient soils of the country and some have worked out basic data for the correct amount of phosphatic fertilizer to apply for various crops.

In East African soil, pH and organic matter content have been found to be extremely useful in accounting for the degree of phosphorus and nitrogen response; the work carried out in Uganda using numerous simple trials in farmers' fields and the backing up of the work with well planned soil sampling and analysis has given invaluable results in this direction.

Since so many uncontrollable factors affect yields, the use of multiple regression analysis to explain yield variations caused by sites, climate, management, etc. are now being widely developed and many of these analyses can account for more than 80% of the variations in yields. However, even using only percentage yield data, i.e.

$$\text{Percentage yield} = \frac{\text{Yield with all nutrients but one}}{\text{Yield with all nutrients}} \times 100$$

and simple scatter diagrams the International Soil Fertility Evaluation Programme of North Carolina State University has shown that, for example, the critical levels of soil phosphorus determined by the Olsen sodium bicarbonate procedure is between 6-8 p.p.m. on a wide range of soils in South America and India (Fitts & Hanway, 1971).

As potash is not markedly deficient in most African soils, soil tests for potash response have aroused little or no interest, as it is only when very deficient or deficient soils are tested that soil analysis can be developed into a reliable guide for fertilizer use.

It should always be borne in mind that soil test data must be continually developed from a continuing series of field experiments carried out on as many sites as possible, and that not only trials giving high yield responses to fertilizers but also those giving low responses should be carefully studied, as lack of response to fertilizer may indicate that other factors are limiting growth rather than that the fertility of the soil is high.

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TYPES OF FERTILIZER

by
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INTRODUCTION

In the field of fertilizer use development, agricultural planners are often confronted with the problem of determining the types of fertilizer which are suitable for the conditions prevailing in the country.

In this selection, a great number of factors have to be considered, and the planner has to rely on information and recommendations of many specialists in the field of research, economy, marketing, infrastructure and extension.

It would exceed the limits of this lecture to deal comprehensively with all the factors influencing the choice of the right fertilizers for the various conditions. The principal aim of the paper is, therefore, to encourage mutual understanding of the problems among all those contributing their share to successful planning.

CRITERIA FOR CHOICE

Agronomy

One of the most important criteria in the determination of the optimum types of fertilizers is their suitability for the existing soil conditions and crop requirements.

Fertilizers having an acidifying effect should not be used on soils with existing low pH values. Due to the chemical composition of soils, the active material in some types of fertilizer might be converted by chemical reaction into insoluble forms and thus not be available to the plants. Soil structure and precipitation patterns may facilitate run-off or leaching of readily available forms of nutrients. The latter property would in turn be advantageous under arid climatical conditions.

The special fertilizer requirements of the various crops are agronomic criteria, especially if fertilizers containing more than one nutrient are to be considered. In this case, the ratios of content of these elements are important. In addition to the major elements, certain crops may need secondary elements such as magnesium, sulphur, or trace elements such as manganese or molybdenum. Others may be affected by certain constituents of fertilizers, as for instance tobacco plants by fertilizers containing chlorine.

Collaboration of agricultural research and extension will also result in valuable information for a forecast of the quantities required, based on the recommended rates of fertilizer application and on the areas designated for the various crops. Fertilizer recommendations originate from the results of field trials; their economic analysis indicates the prospects for acceptance of fertilizers by the farmers, and further indicates the potential assets for the national economy.

Economy

For the farmer who has to buy the fertilizers, their price is of primary interest whether they are imported or produced locally. This applies also to Governments who import, produce, or pay subsidies on fertilizers.

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The economist has further to investigate the price relation of fertilizer and produce, through information from agricultural research and extension, as well as from markets.

Inland transport is another important element of cost. Especially where fertilizers have to be hauled over long distances, they should be as highly concentrated as possible, otherwise up to 80 percent of inert material may be transported at high cost. Possible future local production of certain types of fertilizers should be investigated.

If bulk imports and local mixing is considered, the chemical properties of the fertilizers must allow blending without deterioration of qualities such as solubility and availability to plants.

Marketing

The field of marketing, prices, transport and handling all play an important role in the farmer's decision, and the marketing specialist will have to consider transport and storage capacities.

Storage properties of fertilizers may also influence choice. With hygroscopic fertilizers, which compensate for their disadvantage of easily absorbing humidity by being readily soluble and available to the plants, the right type of packing must be foreseen.

Extension

Experience has shown that in many cases planners failed to obtain the extensionist's advice. This advice is extremely important, especially where a new type of fertilizer is to replace another which had already been used by the farmers for some time.

As farmers are rightly conservative, they are not easily prepared to accept innovations. Consequently, the market has to be prepared, probably by new demonstrations and information campaigns, to further prompt acceptance by the farmers.

The physical form of fertilizers, whether granulated, crystallized, prilled or powdered, has an influence, as well as the colour.

A typical example is the case which occurred in a country where farmers had been used to calcium ammonium nitrate of greyish colour. The colour of this fertilizer is conditioned by the colour of the limestone used in the processing. With new products from another area, having a slightly different colour, many farmers refused categorically to buy the new fertilizer, thinking that it was a substitute unequal in quality to the known one. Consequently, a demonstration campaign had to be started again. Meanwhile the distributor, in that case the government, suffered financial losses by a reduced turnover of capital.

In the change to new types of fertilizer, possible future local production should be considered. If this is foreseen in the not too distant future, it might be advisable not to switch to an intermediate type which will later not be produced locally.

With frequent changes within relatively short periods, farmers may become confused and agricultural extension services might not be able to cope with the recurrent task of introduction work, at least not within the danger of having to neglect other projects.

An additional task for the agricultural extension service is to train the farmers how to use a new fertilizer. The change from a fertilizer low in nitrogen to urea is a typical example, the concentration of N in urea being more than twice as high. The farmer might need at least some information, if not training, by demonstration that he now has to apply, say, one bag on the area on which previously he broadcast two bags. The harm of uneven distribution is obvious. Part of the field will not receive any fertilizer, part receives a quantity uneconomically high. Thus the loss is double.

The importance of feed-back of information from the agricultural extension field staff to assist research to obtain realistic information on crop responses and economics should also be emphasized. Education of field workers in this respect is necessary, as good planning cannot be achieved if it has to be based on bad information.

TYPES OF FERTILIZERS

Although not considering the latest developments in fertilizer technology which are still more or less in the experimental stage, the annex to this paper should give a fair picture of the existing types of fertilizer. To indicate commonly used types of fertilizer and to avoid possible discrimination, the types of fertilizer used in operations in 34 countries in three continents connected with the FAO Fertilizer Programme are marked by an asterisk. Generally, these are types of fertilizer which were already used, though in more limited quantities, before the inception of fertilizer use development programmes. The asterisk on Ammo-Phos B refers to a special case where that type of fertilizer is produced in the country. The degree of acidity or basicity of some fertilizer materials as shown in the annex appears in nearly all tables listing chemical fertilizers and is determined by a chemical method used in the United States.

It is well established that the continued use of certain fertilizers causes a residual acidity in the soil which, if not corrected, is eventually injurious to plant growth. Soils that are already fairly acid, or sandy soils which are readily made acid, are the first to show decreased crop yields. The soil-acidifying effect of fertilizers is due mostly to ammonium compounds. The use of fertilizers that have a basic or alkaline residue generally present no serious problem except on rather impermeable heavy or alkaline soils liable to injury by the introduction of too much sodium.

Compound fertilizers may include two or three major nutrient elements, as well as secondary and trace elements. Compounds are usually relatively highly concentrated, thus reducing transport cost as well as the required transport and storage capacities. The ratio between the various nutrients is usually adapted to the special requirements of certain crops.

Generally, compound fertilizers are granulated and all granules are of the same chemical composition. That might be an advantage over mechanically prepared mixtures, which the danger of a certain mechanical decomposition, mainly on transport, may exist. On the other hand, mechanically prepared mixtures may be advantageous where exact proportions are desired for special plant requirements and relatively smaller quantities of the mixture are needed.

Economy of labour is a common advantage of both compound and mechanical mixtures, as compared with straight fertilizers. An extensive range of compound fertilizers is available; new types appear continuously, others are phased out. It would be impossible to list all, and therefore only those are indicated which are used in fertilizer promotion activities connected with the FAO Fertilizer Programme. These types are: 20-20-0 and 25-10-0 for the compounds containing two major elements and 15-15-15 for those containing all three.

It should be noted that operations connected with the FAO Fertilizer Programme deal mainly with commonly grown food and cash crops and not with crops requiring large quantities of specially formulated compounds.

PACKING

To safeguard against losses and to facilitate handling from factory or port to the farmer, the choice of the right packing material and of the weight of individual bags is also very important. As for the packing material, multiwall paper bags were still in use a few years ago where transport distances were short. By now the paper

bag has almost entirely been replaced by bags made from plastic materials. These bags have usually a valve to avoid condensation induced by change of temperature.

Jute bags are also widely used. For hygroscopic fertilizers, an inner liner made from plastic materials gives better protection from absorption of humidity. In this connection, the bad habit of transport workers, especially in ports, of using hooks needs to be mentioned; losses are caused which can become quite serious, especially with hygroscopic types of fertilizer, apart from the general danger of breakage of bags and spilling of the contents. To facilitate handling many fertilizer manufacturers have sewn string or ears to the four corners of the jute bags. It goes without saying that this caused additional costs which were worthwhile because of reduced losses. Locally produced material might be substituted for jute.

A relatively new type of packing is the woven polypropylene bag with a plastic inner liner. For hygroscopic material, this type has the advantage that even when bags have been pierced by a hook, the two holes are displaced by further handling, so that the bag is closed again.

The size of bag should depend on local conditions. The bag containing 50 kg (110 lb) has more or less become standard. Bags containing 100 kg (220 lb) are relatively heavy and bulky, thus difficult to lift and carry by hand. A bag of 25 kg would be more convenient when the consumer cannot be reached by lorries. Sometimes farmers' financial capacity does not allow them to pay cash for 50 kg at the time, an obstacle which could probably be removed by the provision of credit. Extremely small sized holdings are also indicative of the need for such smaller packing. However, although this size of bag facilitates handling considerably, it should be kept in mind that the cost of packing is doubled in comparison to the 50 kg bag.

CONCLUSIONS

In planning and organizing fertilizer use development, a change to new types of fertilizer might have to be considered. Should that be the case, planning and selection has to be based on information on soil conditions, crop requirements and economies to be expected from use of the new type. These indications should come from agricultural research and extension. Further information has to come from the marketing economist and from the agricultural extensionist, who besides testing the new fertilizer under average farmers' conditions, in collaboration with the agricultural research, has also to prepare the market.

The selection of the most suitable type of packing material and size or weight of bags are of further importance.

ANNEX

TYPES OF FERTILIZER

Material	Total nitrogen (N) %	Total phosphorus pentoxide (P ₂ O ₅) %	Available phosphorus pentoxide (P ₂ O ₅) %	Water-soluble potash (K ₂ O) %	Total lime (CaO) %	Total magnesia (MgO) %	Total sulphate (SO ₃) %	Equivalent acidity 1/	Equivalent basicity 2/
Urea *	45.0	-	-	-	-	-	-	80	-
Urea-ammonia solution ^{10/}	33.5-45.5	-	-	-	-	-	-	60-82	-
Urea-formaldehyde compound ^{11/}	38.0	-	-	-	-	-	-	68	-
PHOSPHORUS MATERIALS ^{12/}									
Basic slag, Bessemer ^{13/} *	-	15.0-18.0	13.5-16.5	-	45.0-50.0	2.0-5.0	0.5	-	(^{14/})
Basic slag, open-hearth	-	8.0-16.0	5.0-15.0	-	45.0	5.0	0.5	-	(^{14/})
Basic slag, open-hearth fluorspar	-	6.0-12.0	2.0-4.0	-	45.0	5.0	0.5	-	(^{14/})
Calcium metaphosphate	-	64.0	63.0	-	25.0	-	-	0	0
Defluorinated phosphate rock ^{15/}	-	20.0-40.0	18.0-37.0	-	28.0-49.0	-	-	-	(^{14/})
Dicalcium phosphate ^{16/}	-	37.0	35.0	-	32.0	-	2.0	-	²⁵
Phosphate rock-magnesium silicate glass ^{17/}	-	20.0	18.0	-	32.0	18.0	-	-	(^{14/})
Phosphoric acid, liquid	-	54.0	54.0	-	-	-	3.5-18/	(^{19/})	-
Rhenania phosphate ^{20/}	-	25.5	24.0	-	41.0	1.0	1.0	-	(^{14/})
Rochling phosphate ^{21/}	-	18.0	17.0	-	31.0	1.0	7.0	-	(^{14/})
Superphosphate, ordinary ^{22/} *	-	14.0-22.0	13.5-21.0	-	24.0-31.0	0.5	25.0-32.0	0	0
Superphosphate, double ^{23/} *	-	42.0-50.0	40.0-49.0	-	17.0-23.0	0.5	3.5-24/	0	0
POTASSIUM MATERIALS									
Alunite, calcined ^{25/}	-	-	-	5.5	4.0	0.5	5.0	(^{26/})	(^{26/})
Bittern potash ^{25/}	-	-	-	7.0	-	14.0	24.0	0	0
Cement-kiln dust ^{25/}	-	-	-	5.5	45.0	2.0	18.0	-	(^{14/})
Kainite, including carnallite and sylvite	-	-	-	10.0-20.0	0.5-5.0	0-15.0	1.0-25.0	0	0
Manure salts ^{27/}	-	-	-	25.0-42.0	0-1.0	0-6.0	0-13.0	0	0

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TYPES OF FERTILIZER

Material	Total nitrogen (N)	Total phosphorus pentoxide (P ₂ O ₅) %	Available phosphorus pentoxide (P ₂ O ₅) %	Water-soluble potash (K ₂ O) %	Total lime (CaO) %	Total magnesia (MgO) %	Total sulphate (SO ₃) %	Equivalent acidity 1/	Equivalent basicity 2/
Potash from cement-kiln dust <u>25/</u>	-	-	-	25.0	28.0	1.0	31.0	-	(<u>14/</u>)
Potash from distillery waste <u>28/</u>	0.5	2.0	1.5	34.0	16.0	5.0	12.5	-	(<u>14/</u>)
Potash from Steffens waste <u>25/</u>	1.0	-	-	36.0	0.5	-	2.5	-	(<u>14/</u>)
Potash from sunflower ash <u>25/</u>	-	-	-	63.5	(<u>26/</u>)	(<u>26/</u>)	0.5	-	(<u>14/</u>)
Potash from wood ash	-	-	-	51.0	(<u>26/</u>)	(<u>26/</u>)	6.5	-	(<u>14/</u>)
Potassium carbonate (carbonate of potash)	-	-	-	65.0	-	-	0.5	-	(<u>14/</u>)
Potassium chloride (muriate of potash) *	-	-	-	48.0-62.0	0-3.0	0-3.0	0-7.0	0	0
Potassium magnesium carbonate (carbonate of potash-magnesia)	-	-	-	20.0	1.0	20.0	0.5	-	(<u>14/</u>)
Potassium magnesium sulphate (sulphate of potash-magnesia) <u>29/</u>	-	-	-	21.0-30.0	0-6.5	6.0-19.5	32.0-56.0	0	0
Potassium sulphate (sulphate of potash) *	-	-	-	48.0-52.0	0-2.5	0-2.0	39.0-48.0	0	0
Quartz trachyte, calcined	-	-	-	4.5	(<u>26/</u>)	(<u>26/</u>)	(<u>26/</u>)	-	(<u>14/</u>)
NITROGEN-PHOSPHORUS MATERIALS									
Ammoniated super-phosphate, ordinary <u>30/</u>	2.0-5.0	14.0-20.0	13.0-19.0	-	23.0-29.0	0.5	24.0-30.0	4-7	-
Ammoniated super-phosphate, double <u>30/</u>	4.0-6.0	40.0-49.0	38.0-48.0	-	16.5-22.5	0.5	3.5- <u>24/</u>	11-14	-

ANNEX

TYPES OF FERTILIZER

Material	Total nitrogen (N)	Total phosphorus pentoxide (P ₂ O ₅) %	Available phosphorus pentoxide (P ₂ O ₅) %	Water-soluble potash (K ₂ O) %	Total lime (CaO) %	Total magnesia (MgO) %	Total sulphate (SO ₃) %	Equivalent acidity 1/	Equivalent basicity 2/
Ammonium nitrate - dicalcium phosphate 31/	20.0	20.0	19.5	-	14.0	-	-	25	-
Diammonium phosphate (Diammonphos) 32/*	21.0	53.0	53.0	-	-	-	-	74	-
Diammonium phosphate - ammonium sulphate (Leunaphos)	20.0	20.0	20.0	-	-	-	36.0	93	-
Monoammonium phosphate (Ammo-Phos A) 33/	11.0	49.0	48.0	-	1.5	0.5	6.0	55	-
Monoammonium phosphate -ammonium nitrate 33/	28.0	14.0	14.0	-	0.5	-	2.0	61	-
Monoammonium phosphate -ammonium sulphate (Ammo-Phos B) 33/*	16.0	20.5	20.0	-	0.5	-	38.5	86	-
Urea-superphosphate (Phosphazote)	7.0	(26/)	15.0	-	(26/)	(26/)	(26/)	13	-
NITROGEN-POTASSIUM MATERIALS									
Potassium ammonium chloride (Potazote)	13.0	-	-	22.0	-	-	-	70	-
Potassium chloride - ammonium nitrate 34/	16.0	-	-	28.0	-	-	-	29	-
Potassium nitrate (nitrate of potash)	13.0	-	-	44.0	0.5	0.5	-	-	23
Sodium potassium nitrate 35/	15.0	-	-	15.0	-	-	-	-	26
PHOSPHORUS-POTASSIUM MATERIALS									
Monopotassium phosphate, pure	-	52.2	52.2	34.6	-	-	-	0	0

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TYPES OF FERTILIZER

Material	Total nitrogen (N)	Total phosphorus pentoxide (P ₂ O ₅) %	Available phosphorus pentoxide (P ₂ O ₅) %	Water-soluble potash (K ₂ O) %	Total lime (CaO) %	Total magnesia (MgO) %	Total sulphate (SO ₃) %	Equivalent acidity 1/	Equivalent basicity 2/
Potassium metaphosphate	-	55.0	55.0	38.0	0.5	-	-	0	0
NITROGEN-PHOSPHORUS-POTASSIUM MATERIALS									
Ammonium potassium phosphate	5.5	54.0	54.0	18.5	-	-	-	(19/)	-
Nitrophoska <u>36/</u>	13.0	13.5	13.0	21.0	9.0	1.5	3.0	(19/)	-

FOOTNOTES

- None, or present in quantity less than 0.5 percent.
- 1/ "Equivalent acidity" is the number of parts by weight of calcium carbonate (CaCO_3) required to neutralize the acidity resulting from the use of 100 parts of the fertilizer material. For example, ammonium sulphate has an equivalent acidity of 110. It takes, therefore, 110 kilograms of calcium carbonate to neutralize the acidity developed in the soil by the use of 100 kilograms of ammonium sulphate as fertilizer.
- 2/ "Equivalent basicity" is the number of parts by weight of calcium carbonate (CaCO_3) that corresponds in acid-neutralizing power to 100 parts of the fertilizer material. For example, calcium cyanamide has an equivalent basicity of 63. This means that in its capacity for neutralizing soil acidity 100 kilograms of calcium cyanamide are equivalent to 63 kilograms of calcium carbonate.
- 3/ Ammonium hydroxide, aqua ammonia, ammonia liquor, "B" liquor.
- 4/ Muriate of ammonia, sal ammoniac.
- 5/ Aqueous solutions of ammonium nitrate and ammonia. Several solutions containing different proportions of ammonium nitrate and ammonia are marketed in the United States under various trade names.
- 6/ Cal-Nitro, A-N-L, Amnical, Calmonite, Nitrolime, kalkamonsalpeter, calcium ammonium nitrate, and other names. Mixtures of ammonium nitrate with either precipitated calcium carbonate, ground high-calcium limestone, or ground dolomitic limestone. Another grade of Cal-Nitro contains 16 percent nitrogen and about 27 percent CaO . Also similar products are marketed under the names of Nitro-Chalk (15.5 percent nitrogen and 27 percent CaO) and Peti So (17 percent nitrogen).
- 7/ Leunasalpeter, Montansalpeter. Another product of similar character, called sulfonitrate d'ammoniaque contains 25.5 percent nitrogen.
- 8/ Cyanamid, lime-nitrogen, kalkstickstoff, Nitrolim, and other names.
- 9/ The natural product from Chile is commonly called Chilean nitrate or Chile saltpetre.
- 10/ Aqueous solutions of urea and ammonia. Several solutions containing different proportions of urea and ammonia are marketed in the United States under various trade names.
- 11/ This material is also called urea-form, Uramite, Nitroform, Borden's 38, and other names.
- 12/ No figures for composition of rock phosphates are given because responses of crops to dressings of ground rock phosphate are extremely variable, depending on soil, climate, kind of crop, and type of rock. Analysis figures would be misleading.
- 13/ Thomas slag, Thomas phosphate, Thomas meal.
- 14/ Basic.
- 15/ Defluorinated phosphate, fused rock phosphate, fused tricalcium phosphate, alpha phosphate.
- 16/ Precipitated phosphate, Fertiphos. Product made in Europe by dissolving rock phosphate in hydrochloric acid and treating with milk of lime.
- 17/ Serpentine-fused phosphate, calcium magnesium phosphate, Thermo-Phos.
- 18/ Sulphate content of material made by the sulphuric acid process. Electric furnace acid contains little sulphate.
- 19/ Acidic.
- 20/ Made by heating rock phosphate with silica and soda ash. Other products made with silica and soda ash or sodium sulphate include silicophosphate, Basi-phosphate, Supra-phosphate, Supertomasyna, and Palatia phosphate.
- 21/ Made by heating rock phosphate with soda slag from desulphurization of pig iron.
- 22/ Superphosphate, normal superphosphate, standard superphosphate, single superphosphate, acid phosphate.

- 23/ Triple superphosphate, treble superphosphate, multiple superphosphate, concentrated superphosphate.
- 24/ Sulphate content of material made with phosphoric acid manufactured by the sulphuric acid process. Material made with electric furnace phosphoric acid contains very little sulphate.
- 25/ The composition of this material varies widely.
- 26/ No data.
- 27/ Other products similar in composition to manure salts include Emgekali (33-37 percent K_2O , 5 percent (minimum) MgO , and 10 percent (minimum) SO_3) and Reform-Kali (minimum analysis: 26 percent K_2O , 3.5 percent CaO , 8.5 percent MgO , and 33 percent SO_3).
- 28/ Fermentation of sugarcane molasses.
- 29/ Patentkali, Kalimag, kalimagnesia, double manure salts.
- 30/ Ammoniated superphosphate is the product obtained when superphosphate is treated with ammonia or with a solution containing free ammonia and other forms of nitrogen dissolved therein.
- 31/ Material manufactured in relatively small quantities.
- 32/ Material made with phosphoric acid manufactured by the electric furnace process. Material made with phosphoric acid manufactured by the sulphuric acid process has lower purity.
- 33/ Material made with phosphoric acid manufactured by the sulphuric acid process. Material made with electric furnace phosphoric acid has higher purity.
- 34/ Potassium ammonium nitrate, kaliammonsalpeter. Another product of similar character, called nitropotasse, contains 16.5 percent nitrogen and 25 percent K_2O .
- 35/ Nitrate of soda-potash, Nitrapo.
- 36/ This is an example of the so-called "compound" fertilizers made by processes involving treatment of rock phosphate with nitric acid. Other such products, varying widely in composition, are marketed under various names and designations.

FERTILIZER USE DEVELOPMENT IN DENMARK 1870-1970

by

V. Johansen ^{1/}

The Initial Situation

In the Middle Ages most Danish farmers were subject to a strict feudal system which did not provide much initiative for the individual to improve his farm or his land as it was usually somebody else who would reap the benefit.

Only after the abolition of the feudal system in 1788 was it possible for Danish farmers to enjoy fully the fruits of their own labour, but they were poorly educated and their financial means were at an absolute minimum; therefore many years passed before Danish agriculture developed in a significant way.

Until the middle of the 19th century Danish farm land was managed in a primitive way, and very little was done to maintain fertility. Even the value of farm manure as a soil improving agent was not realized until comparatively recently.

With the medieval practice of using all cultivable land for grain growing and leaving farm animals on permanent pastures, practically nothing was returned to the soil to replace the nutrients continuously removed by each crop. The soils became so depleted that only by summer-fallowing every second year was it possible to get a crop worth harvesting during the cropping years.

Introduction of Fertilizer Use

When fertilizers were first introduced in Denmark the positive effect on crops was immediately evident, and whatever agricultural research facilities were available in those days began to concentrate on determining the profitability of using fertilizers relative to prices then current.

The first fertilizer work was based on the use of primitive crude phosphates, and up to the year 1900 practically all fertilizer used was phosphate. The application of nitrogen and potash did not become common until after the turn of the century. With the nearly complete depletion of nutrients in the soils there is in any case no reason to believe that any nitrogenous fertilizer would have had much effect.

During the period 1871-1900 the annual consumption of crude phosphate rose from about 15 000 to 38 000 tons. In the year 1900 the consumption of nitrogenous and potassic fertilizers reached 3 000 and 6 000 tons, respectively.

It is clear that during the initial stages of fertilizer use the consumption rose very slowly. This can be explained by a number of factors such as conservatism towards new ideas, suspicion regarding negative side effects, forgery of products by traders, unreliable supplies, lack of knowledge concerning application, shortage of financing, etc.

^{1/} Agronomist, Delegate of the Danish International Development Agency (DANIDA)

Moreover, interpretation of experimental results deriving from field trials was difficult, and even good yield increases did not automatically produce increased demands for fertilizers.

During the late 19th century it became impossible for Danish farmers to export grain, and immediate steps were taken to increase the livestock population towards developing an export of secondary food products to the growing populations in the industrial centres of Western Europe.

In order to supply the increasing livestock population with sufficient amounts of roughage feeds, the growing of fodder beet became popular. This crop, however, has a high nutrient requirement, and the use of commercial fertilizers was found to be the quickest way to secure a sufficient soil fertility.

Types of Fertilizer Used

Generally speaking, it is safe to state that when soils are very depleted of nutrients, the application of phosphatic fertilizers will provide the quickest returns. Heavy application of nitrogenous fertilizers will not be profitable until the basic fertility of the soil has reached a certain minimum. Neither phosphatic nor potassic fertilizers are washed out very easily, so it is possible to build up the fertility of the soil over a period of years through continuous application of these nutrients.

A stage of reasonable soil fertility was reached in Denmark in the beginning of the 20th century. Before the year 1900, practically all fertilizers used were crude phosphates or superphosphates. The fertilizer statistics of 1924 show that 98 percent of all farms using fertilizers were applying phosphate, 64 percent were applying potash and 94 percent were applying nitrogen. This indicates that nearly all fertilizer users were applying both nitrogen and phosphorus, whereas the use of potassium was still not fully developed.

At the initial stages of fertilizer use only simple types containing one nutrient each were available. This meant that the different types of fertilizer would have to be applied separately or mixed on the farm prior to application. Most farmers adopted the practice of mixing prior to application, mainly because this type of work could be done under the roof at home, and because the application of larger amounts per hectare would result in a more uniform application rate. Unfortunately, the fertilizers to be mixed were not all of the same physical structure which could result in a certain degree of separation before they could reach the field resulting in a correspondingly uneven application of the nutrients concerned.

After the second world war increasing amounts of fertilizers have been supplied to the farmer in the form of homogenous compound fertilizers containing two or more nutrients. Large amounts of PK-fertilizers for application well before planting in the spring are now produced and are delivered to farmers on a nearly year-round basis. This involves a number of advantages for the farmers such as price discounts for purchase made in the off-season, distribution of the work load on the farm, and a uniformity in application rates which is only limited by the quality of the equipment used.

The disadvantage of using compound fertilizers is the fixed ratio between the nutrients concerned which is not necessarily optimal for the soil type or crop in question. There are now, however, so many different types of compound fertilizers available that this matter normally does not cause serious problems.

In the early days of fertilizers only low content N-fertilizers such as calcium nitrate (15.5 percent N) and Chilean nitrate (16 percent N) were available. With the tremendous increase in nitrogen use during recent years it became necessary to find alternative types of nitrogenous fertilizer.

While still using the traditional application methods it was possible to reduce fertilizer volumes by using ammonium sulphate (21 percent N), calcium ammonium nitrate (26 percent N), ammonium sulphate nitrate (26 percent N) or urea (46 percent N).

However, the real break-through did not come until the necessary technology for transport and application in the field of anhydrous ammonia (82.2 percent N) was put to commercial use in the early 1960's. Since then the consumption of anhydrous ammonia has increased at a very steep rate with a decrease in the consumption of solid nitrogenous fertilizers being the immediate result.

Due to the high costs of the necessary equipment for handling of anhydrous ammonia most farmers are now getting this delivered directly in the field on a contract basis.

With the increasing amounts of major plant nutrients being applied to our soils, crop yields are continuously becoming higher. There are now, however, signs that these big crops have made such heavy demands on the soils' natural resources of trace minerals that a replacement of these is also necessary.

During the past few years signs of deficiencies of such trace minerals as magnesium, copper, boron and manganese have been found in various Danish crops. These nutrients are simple to apply through compound fertilizers, and such fertilizer types are now widely available at slight extra cost.

Trace minerals are only found in combination with PK- and NPK-compounds, except for boron which is also available in combination with calcium nitrate.

Mechanization of Fertilizer Handling

In the early days all fertilizer handling was manual and considerable unpleasant work was added to the farmers' already numerous tedious tasks.

Fertilizers were then only applied in small quantities and an exact application was necessary. They were, therefore, as a general rule applied in the same way as the sowing of grain, which was done from a bag carried across the field on the farmers' shoulders.

Later, as fertilizer applications became slightly more liberal, fertilizers were applied from the back of a horse-drawn wagon. The main advantage of this system was that the capacity of the wagon itself allowed longer intervals between refilling, no walking across fields for the person applying the fertilizers, and less time spent per ton of fertilizer or per hectare of land. The main disadvantages were an uneven application and the necessity of having two people available, one for driving the horses and one for applying the fertilizer.

After the second world war it was almost universally realized that a uniform application would increase the utilization of the fertilizers to such an extent that considerable efforts to obtain it were justified. At the same time a rapid mechanization of field work took place and tractors were introduced on nearly all large and middle size farms. With farm tractors being available, the power requirements of fertilizer spreaders became less significant as compared to the earlier horse-drawn fertilizer spreaders.

Numerous types of fertilizer spreader were developed, the centrifugal type soon became the most common. This type is mounted in a tractor's three-point hitch and powered from the power-take-off shaft, and it will apply fertilizer over 4-6 times the width of the tractor depending on fertilizer type and field conditions. However, the application rates often vary significantly between the various sections of the spreader pattern.

An older type of fertilizer spreader reminds one in many ways of a precision seed drill, and its application accuracy is about equal to that of the seed drill. This type is powered

by its own wheels, and it has been developed as a horse-drawn model and for use behind farm tractors. The width of application equals the width of the machine itself.

The latest developments in fertilizer application include pneumatic applicators for solid fertilizers, pressurized equipment for application of anhydrous ammonia and aerial application of solid concentrated fertilizer types.

The last mentioned methods involve expensive and highly efficient equipment which is usually owned and operated by the supplying companies or by private entrepreneurs who deliver the fertilizer in bulk and apply it in the field in appropriate quantities at the time of delivery.

Increasing numbers of farmers now rely on such services, thereby eliminating the need to invest in field equipment and storage space for fertilizers on the farm.

It should be noted that aerial application of fertilizers has not so far been very common under Danish conditions, except in the case of some forest areas and fields under very special conditions.

Price Relationships

Commercial fertilizers are still the least expensive input in Danish agriculture. In spite of heavy monetary inflation during recent years, fertilizer prices have remained nearly the same on a cost per weight unit basis.

Looking at fertilizer prices in terms of costs per unit of pure nutrient, the new concentrated compound fertilizers have reduced this, especially in the case of the price per unit of pure nitrogen in the form of anhydrous ammonia.

Also when comparing the price of fertilizers to that of grain, the relation is very favourable; 100 kg of grain will now buy more plant nutrients than in most previous periods in history.

These favourable price relationships result from the fact that fertilizers of nearly all types lend themselves so easily to mass production, bulk handling and computerized control systems. To a very great extent the cost of plant nutrients will be inversely proportional to the amount consumed.

During the depression years in the early thirties the Danish government imposed import restrictions on numerous products but these did not include fertilizers. This should clearly illustrate that the government had already then realized the importance of maintaining soil fertility, apart from the role which fertilizer could play as a spearhead of future agricultural development.

Results

Around 1964 the total annual consumption of fertilizer material peaked at 1 800 000 tons corresponding to over 600 kg/ha/year. The corresponding amounts of pure plant nutrients were 115 kg/ha and this latter figure has increased by about 50 percent since then.

The increase in consumption of pure nutrients since 1964 has taken place without a corresponding increase in fertilizer tonnage. This is due to the increasing use of concentrated fertilizers such as new compounds and the fast expanding use of anhydrous ammonia in place of solid nitrogenous fertilizer types.

The latest increases in fertilizer use, mainly of nitrogen, can be explained by the continuous adoption of higher yielding varieties of common crops; the growing of new crops with very profitable nitrogen responses such as rape seed and tetraploid rye-grasses should also be mentioned.

In 1969 Danish farmers exported agricultural products valued at D.Kr. 6 892 500 000 and during the same year the total imports of equipment and raw material for agricultural use amounted to D.Kr. 1 415 000 000. This figure does not include farm supplies purchased from the domestic industry, but the fact remains that Danish farmers produce food for three times as many people as the present population in Denmark. The proportion of Danish people living on farms is now less than 10 percent, and the well managed use of chemical fertilizers is one of the most important reasons for this achievement.

Few countries, if any, consume similar amounts of chemical fertilizers. Keeping in mind that considerable amounts of plant nutrients are returned to the soil in the form of well preserved farm manure, it is no wonder that Danish crop yields are among the highest in the world as the following figures will illustrate:

Barley	4 - 6 t/ha (grain only)
Wheat	5 - 7 t/ha (grain only)
Sugar beet	35 -50 t/ha
Potatoes	20 -30 t/ha
Grass (dry matter)	8 -11 t/ha

While studying the above figures, it should also be kept in mind that Danish soils are not inherently of particularly good quality, growing seasons are cool with limited sunshine intensity, and the average annual rainfall is 650 mm of which about 50-60 percent is available during the growing season.

Development
of
Danish Consumption of Plant Nutrients N, P and K
during the period 1880-1970

(in 1,000 ton /year)

Year	N	P	K
1880	0.02	1.17	0.00
1890	0.05	1.35	0.04
1900	0.47	2.96	2.43
1910	1.47	5.96	4.94
1920	6.37	11.23	15.04
1930	34.88	40.67	32.08
1940	38.81	29.44	43.06
1950	59.58	34.26	83.66
1960	122.90	50.80	142.80
1970	270.50	55.40	151.70

Figures stated up to and including 1920 are subject to the less accurate statistical methods of that period.

Nutrients are expressed as elemental N, P and K.

EXPERIENCES OF THE
FAO FERTILIZER PROGRAMME

by
H. Braun ^{1/}

INTRODUCTION

The FAO Fertilizer Programme was initiated more than 10 years ago in order to provide additional assistance to Member Countries in their endeavours to increase crop production by the appropriate use of fertilizers. In the course of time action was extended to field trial work and to the propagation of related inputs and the promotion of sound fertilizer distribution and credit practices. This development is the consequence of the experience gained in the early years of the Programme. The extended approach provided new experience in the various countries of operation, which is now being communicated to the field staff, thus complementing earlier work by FAO.

The FAO Fertilizer Programme is an action programme aiming at the promotion of the best use of fertilizers and related inputs. Because it was created in order to furnish assistance to Member Countries in addition to the action financed under the United Nations Development Programme and the Regular Programme of FAO, the FAO Fertilizer Programme budget is derived from funds in trust contributed by donors. At present the main contributors in cash and kind, in order of importance, are: (i) the FAO/Government Cooperative Programmes of the Northern European countries (mainly Denmark, Sweden, Norway); (ii) the World Fertilizer Industry under the Action for Development Programme; and (iii) Member Governments and non-governmental organizations also under the Action for Development Programme. In 1972 the Programme was operational in twenty countries of which one half are in Africa. By the end of the year 1971 the Programme's activities were already completed in 14 countries in Africa, the Near East and Latin America. Several countries have submitted requests which, however, have to remain on the waiting list for prospective donors.

SCOPE OF PROGRAMME

Phases

On average, a country Fertilizer Programme has a five year duration. Action during that period consists of three main phases which are usually executed simultaneously or at least overlapping, namely simple trials, demonstrations and pilot schemes. Simple dispersed trials on farmers fields represent the first phase, as it were to polish existing fertilizer recommendations. In many cases it commences at the same time as the second phase which constitutes extension work in the form of field demonstrations combined with farmers field days.

Pilot schemes to establish models for the improvement of fertilizer distribution and related credit are a logical consequence of the above phases. They usually start in the third year of operations.

Throughout all phases, great importance is attached to the training of agricultural staff concerned with fertilizer use and other improved soil and crop management practices.

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Demonstrations

Farmers all over the world are best convinced of improvements by practical demonstrations, i.e. seeing is believing. Therefore, mass demonstrations are carried out on farmers' fields with the farmers own participation.

A bad demonstration is worse than none. For this reason care is taken that field workers are well trained for the job in theory and practice and that the number of demonstrations correspond to their working capacity.

Selection of the crops is made according to national priorities and to the economy of fertilizer use on these crops. Indeed, a ratio of 2 between the investment in fertilizers and the value of the yield increase obtained is generally considered as a pre-condition to generate farmers' interest in purchasing fertilizers.

Farmers and demonstration sites have to be carefully selected. The site should be representative of the prevailing environmental conditions and the farmer should be popular in the community.

The layout of the demonstration varies according to requirements. For a demonstration of fertilizers only, a two-plot design (control and one dose of fertilizers) may be sufficient although this simple design has usually been replaced by the inclusion of plots for (a) control, (b) fertilizer A, and (c) fertilizers A + B. Sometimes the treatments may be: (a) control, (b) fertilizer level 1, (c) fertilizer level 2.

Where related inputs and improved management practices are to be demonstrated, more plots may be required but their total number should be limited to five.

As a rule, the Fertilizer Programme insists on the identification of the fertilizer effect in the so-called package demonstrations, as generally fertilizers represent a relatively high investment (average 80% of total annual inputs). Consequently, the farmer feels that the other less costly improvements will suit him well enough. Therefore his crop will not yield its full potential, especially in the case of improved varieties.

The following two designs are recommended: (i) plot 1, control; plot 2, improved practices except fertilizers; plot 3, improved practices including fertilizers, or still better, a 4 plot design, (ii) plot 1, farmers practice (control); plot 2, farmers practice plus fertilizers; plot 3, all improved practices except fertilizers; plot 4, all improved practices including fertilizers. Split plots, with e.g., improved seeds, can also be arranged.

As to the size of individual plots, opinions are controversial. In most of the cases farmers prefer large plots which provide more free fertilizer, and the field worker, of course, is glad to please the farmer. But plots larger than 1000 m² lose their extension effect as the visitor should be able to assess effects with one glance. Further, the establishment of such large plots is time and fertilizer consuming; a proportion of both would be better employed for additional demonstrations on other sites thus increasing the extension effect.

The Programme therefore recommends and practices individual plot sizes of about 200 to 500 m² or approximately 1/20 to 1/10 of an acre.

Recently a few cases arose of rather advanced farmers who refused to have demonstrations on their land because of the presence of a control plot and its lower yield. To overcome this difficulty it was suggested that the loss be compensated by the supply of free fertilizers to the value of the difference in yields.

Field days or visits to the sites supplement efficiently the demonstration effect of field demonstrations. The Fertilizer Programme recommends and practices a minimum of two per cropping season, one during the growing period and one at harvest time.

The main activity of the harvest field day is the harvesting of the plots by the field level worker with the farmers and the weighing and comparing of the yields. The ensuing calculations with the participants, of the economics of the use of fertilizers and related inputs, is essential to reach the full effect of the field day and the demonstration as a whole.

Field Trials

In many individual Fertilizer Programmes, simple field trials are part of the operations. This is usually the case where fertilizer recommendations do not exist for certain crops, or where existing blanket recommendations need refinement according to varying ecological conditions, or where results obtained in research stations are to be proved under average farming conditions.

Based on experience, not only of the Fertilizer Programme but also of national services and other projects, "unreplicated" trials on "dispersed" farmers fields are advocated and executed by the Programme.

The reason for the insistence on work being carried out on farmers' fields is obvious. Soils on research stations and even on farm centres are for many years managed differently from those of the average farmer. It is true that accuracy of the results obtained at these locations can be expected to be higher than of those carried out and supervised by field level workers. But what is needed are recommendations for the average farmer under his own conditions. Therefore, both kinds of approaches are justified and needed, with FAO placing the emphasis on farmers field locations.

Working on farmers' fields with field level workers calls for a certain degree of simplicity. Farmers must have a positive attitude towards the undertaking on their fields. This positive attitude cannot easily be assured if there are too many plots, posters, bunds, etc.

Concerning the results to be obtained, experience has shown that the first and foremost need is for return curves of each nutrient element in order to determine the appropriate optimum recommendations.

Considering the two aforementioned conditions, simplicity of design and the need for response curves, the following 8-plot design is recommended, in terms of pure nutrient level (N-P₂O₅-K₂O):

000	011	101	110
		111	
	211	121	112

In many cases the fertilizer levels are based on already existing recommendations; the control plot 000 is needed in all trials to allow the determination of the economics of fertilizer use.

Experience has shown that interactions between nutrients are much less important than was generally thought. With the aforementioned design, full interaction is included in the centre treatment 111 around which the other treatments of the curves are arranged.

Where the effects of secondary or trace elements are important a ninth plot, 111 + 1, can be added. For the evaluation of results the trials are grouped into sets of similar ecological conditions, each set forming one "dispersed" experiment of which the trials are replicates. The results have an average validity for the farm conditions of the whole area.

The basic 8-plot trial can be extended and broken down into a combination of three four-plot trials, resulting in a 12-plot design:

000	011	000	101	000	110
	111		111		111
	211		121		112

The three sub-trials may be laid out on separate sites situated within the same ecological zone. They form together one replicate trial, all having the treatments 000 and 111 in common. This allows statistical calculation of the "within-site" variance for each site, and each sub trial indicates the effects of the absence of one nutrient and its double rate forming a return curve. For calculation of results, the yield data of the treatments 000 and 111 are used.

If more complex designs are needed, they are planned and carried out in close co-operation between the agricultural/research authorities and FAO, but in the majority of cases the Fertilizer Programme restricts its activities to the aforementioned kind of trials on farmers fields.

What was said in the previous chapter on the number of demonstrations per field worker and their required training level and consciousness is still more important with the execution of trials.

Evaluation of Demonstrations

For their extension effect, the results of demonstrations are first of all used at the harvest field day. Yields from the different plots are compared and gross and net benefits as well as the value:cost ratios ^{1/} are calculated by the participants in the field day.

Later these data are summarized at the national project headquarters. They provide information on the effects of fertilizers, related inputs and improved crop practices.

In addition they afford an opportunity to all concerned to judge whether or not the fertilizers and other inputs supplied for demonstration purposes have been used **appropriately**.

For the country's planning authorities the yields of control and fertilized plots provide useful and realistic information on production levels and possible increases by fertilizer use.

Evaluation of Trials

The principal aim of fertilizer trials under individual Fertilizer Programmes is to arrive at appropriate fertilizer recommendations. In addition to agronomic considerations, these recommendations must take into account the farmers economic situation.

The design of the trials allows to calculate return curves for each nutrient N, P and K. From these curves the rate for each element can easily be determined which results in the highest benefit per area unit. This formula is called the "high benefit" recommendation. With the help of the curves these lower rates can also be estimated by interpolation at which the farmer obtains a higher return for the money invested in

^{1/} Value:cost ratio (VCR): value of yield increase divided by the value of fertilizers applied.

fertilizers, although the benefit is somewhat lower. This recommendation is called the "high return" recommendation.

Annex I shows an example of such an analysis of trial results obtained on maize in Togo. Indicated are the results from the plots forming the N-curve and the calculated highest benefit and highest return recommendations together with some intermediate possibilities for recommendations.

The results of the calculations show that the highest benefit of the nitrogen application is obtained at 76.5 kg N/ha (76.5-20-20) which should produce a benefit of 7549 CFA Francs/ha as compared to the 90-20-20 treatment with a benefit of 7433 CFA Francs/ha.

The intermediate points could provide a choice for the agricultural advisory service or even the advanced farmer to select the recommendation which suits him best. The less wealthy farmer without relatively easy credit facilities at his disposal would probably select an intermediate recommendation which still produces a reasonable benefit combined with a lower investment and a higher return for the money invested.

It is obvious that these calculations become time-consuming if a great number of results are to be dealt with. Data processing by computer has therefore been introduced which necessitates a certain standardization of designs.

Trial results are also statistically analysed to obtain information on their reliability. In addition to the determination of recommendations, the knowledge of the probability of obtaining similar results as in the trials is also of importance to the advisory service as well as to the farmer.

An example from France illustrates this problem. In 1968, the French Fertilizer Industry had similar trials on wheat. The analysis of 277 trial results showed for nitrogen that:

97 percent of the nitrogen applications were economic between	0 and 60 kg/ha
81	- do - 60 and 90 kg/ha
60	- do - 90 and 120 kg/ha
43	- do - 120 and 150 kg/ha

From these figures it will be seen that some farmers must have lost money by applying certain fertilizer rates. Whereas it is relatively easy to ascertain the percentage of probability, it is extremely difficult to predict which farmers would lose money apart from those who are in any case likely to lose because of poor management.

For this purpose the correlation of trial results data on soil, on other ecological conditions as well as on management conditions are required. Such perfected recommendations can be reached step by step only, depending on the agricultural development situation and the means which are at the disposal of individual countries. As the Fertilizer Programme is also developing, based on its own experience and on new findings from outside, correlations are increasingly being included in its work.

Trial results, combined with information on ecological and management conditions received from the field, are increasingly processed by computer and the results returned to the field. In addition, the data obtained are fed into a soil and fertility data storage and retrieval system which is being developed at FAO Headquarters in cooperation with other institutions working in the same field. The availability of both soil and fertilizer response data from many countries will in future allow extrapolation for comparable conditions with the practical effects for the farmer.

Pilot Schemes

An essential corollary to the creation of a demand for fertilizers through field demonstrations and extension work is easy availability of fertilizers to the farmer in the right quality and quantity, at the right time and place, and on acceptable financial terms.

For this reason, pilot schemes for the distribution of fertilizers for cash and/or credit have become a standard phase of individual Fertilizer Programmes.

An important supplementary function of pilot schemes is to demonstrate to national authorities how the fertilizer supply situation could be improved. It is evident that their pattern might be different from country to country according to individually prevailing conditions.

In one country it might be the organization of group orders for cash purchase and in another it might be the supply for credit not only of fertilizers but also of other related inputs.

In both cases the criterion is to group those farmers already convinced of the utility of the innovations in order to provide them with the input(s) required. It is essential that the grouping is not imposed from outside, but emerges from inside the existing community with which the pilot scheme is working.

A basic feature of all pilot schemes is a revolving fund based on the proceeds of sales for credit and/or cash for fertilizers supplied free of charge to the country during the course of a Fertilizer Programme. Pilot schemes and revolving funds are subject to a special agreement between Governments and FAO, in which FAO is engaged to supply a given quantity of fertilizers over a given number of years, usually 500 tons of material over a period of three years. The Government is required to create, if not already existing, a national fertilizer committee, to deposit the revolving fund in a special account and to maintain its value at the level corresponding to the value of the fertilizers supplied.

Members of the committee are usually the Government officer responsible for agricultural extension, one or more persons competent in fertilizer distribution and the person responsible for the management of the revolving fund.

Fertilizer distribution is done through national distributors, either state controlled or nominated by the Government.

Some 80 percent of the fertilizers used in the world are purchased on credit and only 20 percent are purchased for cash by those fortunate enough at planting time to have sufficient liquid capital to be able to meet all necessary investment. For this reason and whenever feasible, pilot schemes for the distribution of fertilizers on credit are organized.

With the experience of the Fertilizer Programme in this field three crucial facts have become clear: (i) the system requires increased services to be rendered to the farmer; (ii) the unsuitability of agricultural extension staff in the role of debt collectors; (iii) the classical problem of repayments.

The following executing agencies should join efforts for the success of pilot schemes:-

- The agricultural extension service to ensure that fertilizers and related inputs are ordered in time and are applied properly in conjunction with other improved practices.

- A fertilizer/input distribution agency to ensure timely and appropriate supply. Sometimes the distributor also takes care of farmers' orders, usually in cooperation with the agricultural extension service.
- A marketing agency to provide an outlet for produce at steady and remunerative prices.
- A banking agency for the scheme which would also take charge of repayment procedure.

It is generally recognized that the development of credit is adversely affected by bad debts.

To obtain a reasonable rate of repayment at the time of maturity, which should be in the order of 90 percent, two conditions should be fulfilled: (i) the net benefit obtained from the use of fertilizers for credit should be considerably higher than the value of the credit (value:cost ratio > 2); (ii) sufficient pressure, moral or economic, should be applied to obtain proper repayments.

Moral pressure can perhaps be exercised within a restricted group such as a family, religious or ethnic groups, etc., but economic pressure is usually more effective.

The ideal solution is always a crop lien where the produce is marketed through the same body offering the credit. The most effective penalty is always to exclude debtors from further credit.

Regarding repayments, the educational task of the agencies involved in the application of credit cannot be overemphasized, and the same applies to the role of local authorities and distinguished personalities.

There are of course other credit systems in use such as the offering of credit to "licensed" dealers.

Experience has shown that successful pilot schemes can generate projects of a larger scale for input supply on credit, involving outside credit and/or several thousand tons of fertilizers. This type of project is appropriate for countries where a steady demand for fertilizers already exists but where distribution and credit are major constraints to further fertilizer use development.

The confidence of the farming community is an unconditional pre-requisite for agricultural development. Generally, the use of fertilizers produces a visible and quantifiable positive effect within a short time and is, therefore, one of the most suitable means of opening minds for other inputs and improvements and in gaining the confidence of the farming community. This confidence, gained with the help of fertilizers, is of further importance in the improvement of the supply conditions and, even more so, for the success of agricultural credit.

Impact

The development of the use of fertilizers and related inputs depends on many factors which vary from country to country as well as within individual countries. The same applies to the FAO Fertilizer Programme whose impact depends greatly on these factors.

In Annexes II and III of this paper an attempt has been made to obtain some indication concerning the impact on fertilizer use development resulting from common efforts of individual governments and the FAO Fertilizer Programme. The term 'common efforts' must **strongly** be underlined because an impact could hardly be achieved without total cooperation between extension services, research, marketing and financial agencies.

To obtain some general idea on the impact of these common efforts on fertilizer use development, the Near East and North African region has been selected because the comparison

of agricultural conditions is relatively easier than, for instance, in Africa south of the Sahara.

In Annex II a number of these countries are placed in groups of those having had a fertilizer use development programme assisted by FAO and those not having had such assistance.

As it would be impossible to compare the fertilizer consumption of a different number of countries of various sizes, this table serves as general information only and as a basis for the indices of the increases of fertilizer consumption.

Government/FAO Fertilizer Programmes commenced in Lebanon, Morocco, Syria and Turkey in 1961; activities in Tunisia started in 1964. In Annex III a graph demonstrates the indices of average fertilizer use development within the two groups of countries. These indices are based on the average annual consumption figures for the period 1961/62 - 1965/66 (equal 100). The index for 1969/70 of the country group having had no fertilizer programme is 145, of the other group, 325. This approach to determine the impact might be controversial but it gives at least some indication on the effect of the common efforts.

CONCLUSIONS

Since 1961, the FAO Fertilizer Programme has assisted 34 countries in their efforts to develop the agricultural sector of their economy. Based on experience gained during that period, related agricultural inputs and improved crop practices have been included in the operations. Fertilizers serve as a spearhead for other improvements and in gaining the confidence of the rural community.

From an approach mainly concentrated on extension through demonstrations, four phases of work have developed:

- (i) Mass demonstrations on farmers fields;
- (ii) Where required, small specific trials on farmers fields for the formulation or adaptation of fertilizer recommendations;
- (iii) Improvement of fertilizer distribution;
- (iv) Development of a credit system.

Progressively, efforts have been made to improve the quality of fertilizer recommendations. In countries where a steady demand for fertilizers and related inputs exists already, but distribution and credit are constraints, action is concentrated on these two factors. At the same time, training and educational aspects are important features. Agricultural field staff is trained in extension methods and field trial practices and staff of distributing bodies in their special subjects. Farmers are shown how to make best use of the inputs at their disposal and are educated towards a group approach and an awareness of their responsibilities.

Annex I

Results of Fertilizer Trials - Example of Interpretation

Maize, Togo (1972)

N Curve

Prices/kg - Crop : 15 frs CFA

(i) Results:

- N : 43 frs CFA

Treatments (N P ₂ O ₅ , K ₂ O)	<u>Yield</u> ^{1/}	<u>Response</u> ^{1/}	<u>Value</u> ^{2/}	<u>Cost</u> ^{2/}	<u>Benefit</u> ^{2/}	<u>VCR</u> ^{3/}
0-0-0	1 270	-	-	-	-	-
0-20-20	1 630	360	5 400	1 747	3 653	3.09
45-20-20	2 035	765	11 475	4 582	6 893	2.51
90-20-20	2 260	990	14 850	7 417	7 433	2.00

Curve of benefit $y = 3\ 653 + 4\ 590 x - 1\ 350 x^2$

Maximum benefit at $x = 1.7 = 76.5$ kg N/ha

(ii) Table of recommendations:

	<u>kg N/ha</u>	<u>Response</u> ^{1/}	<u>Value</u> ^{2/}	<u>Cost</u> ^{2/}	<u>Benefit</u> ^{2/}	<u>VCR</u> ^{3/}
1.7	76.5 (-20-20)	941	14 115	6 566	7 549	2.15
1.4	63.0 (-20-20)	870	13 050	5 716	7 334	2.28
1.1	50.0 (-20-20)	796	11 940	4 897	7 043	2.44
0.9	40.0 (-20-20)	733	10 995	4 267	6 728	2.58
0.6	27.0 (-20-20)	625	9 375	3 448	5 927	2.72
0.0	0 (-20,20)	360	5 400	1 747	3 653	3.09

^{1/} in kg/ha

^{2/} in frs CFA/ha

^{3/} value : cost ratio

Annex II

Increase of Fertilizer Consumption in Countries of the
North African and Near East Region 1/

(in 100 metric tons of N, P₂O₅, K₂O)

A. FAO Fertilizer Programme Countries

	<u>48/49-52/53</u> ^{2/}	<u>61/62-65/66</u> ^{2/}	<u>66/67</u>	<u>67/68</u>	<u>68/69</u>	<u>69/70</u>
Lebanon	34	172	200	225	241	330
Syria	13	177	149	236	294	289
Turkey	107	1 007	1 902	2 789	3 900	4 457
Morocco	180	404	574	744	939	930
Tunisia	102	205	243	230	288	386
Total	436	1 965	3 068	4 224	5 662	6 392
Indices of increase:	-	100	156	215	288	325

B. Non-FAO Fertilizer Programme Countries

Algeria	359	454	514	463	494	944
Egypt, Arab Rep. of	990	2 806	2 886	2 845	3 278	3 150
Iran	-	243	490	753	778	870
Iraq	1	27	68	94	110	146
Israel	143	363	399	465	460	509
Sudan	47	281	397	478	473	446
	1 540	4 174	4 754	5 098	5 593	6 065
Indices of increase:	-	100	114	122	134	145

^{1/} Source: FAO Production Yearbook 1970, FAO Annual Fertilizer Review, 1970.

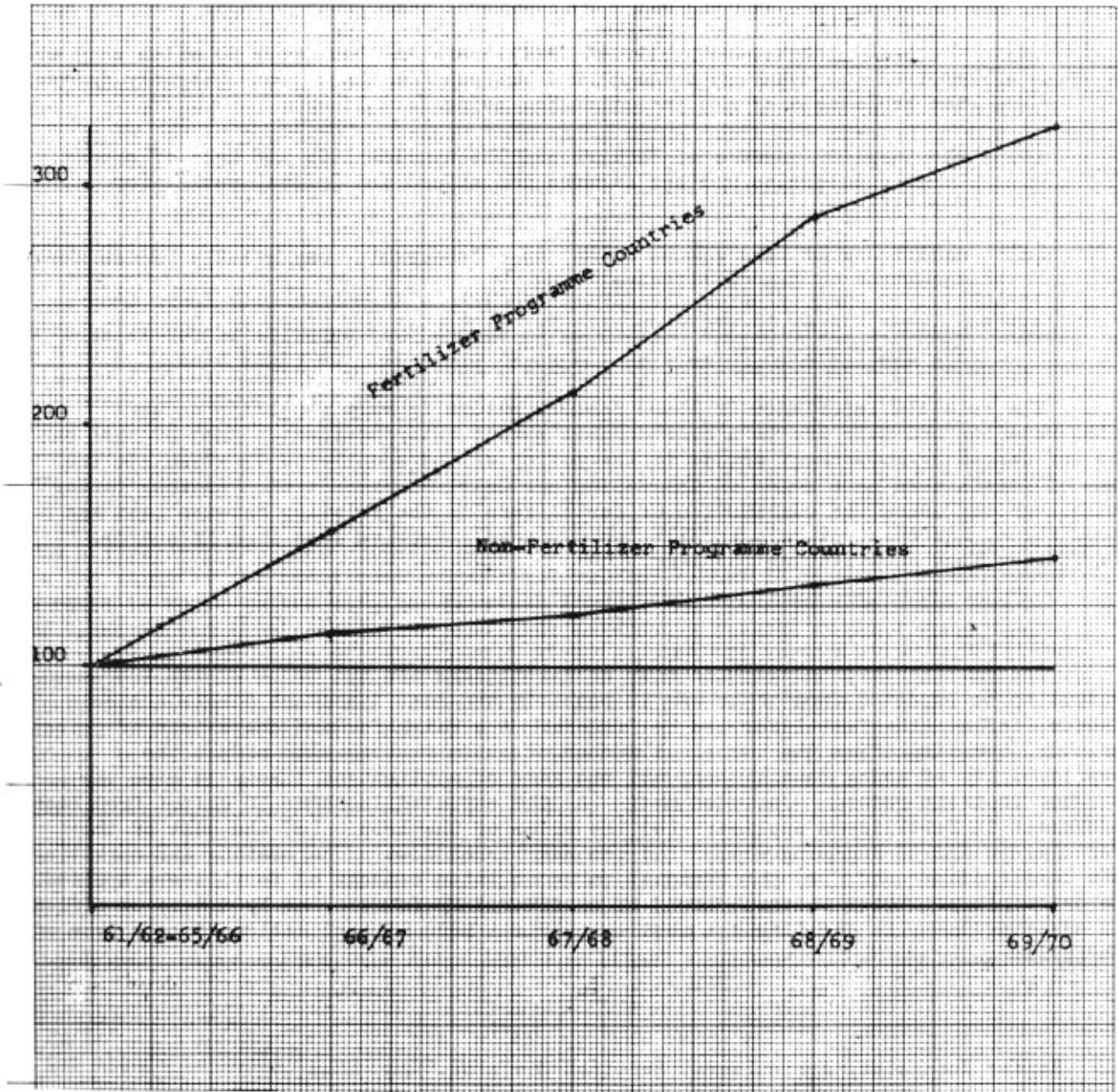
^{2/} Average annual consumption.

ANNEX III

Near East and North African Region

Indices of Average Increase in Fertilizer Consumption of
FAO Fertilizer Programme Countries

(average consumption 1961/62-65/66 = 100)



ECONOMICS OF FERTILIZER USE

by

J.W. Couston^{1/}

INTRODUCTION

Knowledge on the part of farmers about fertilizers and their effect on yield is, of course, a precondition for their efficient use. The question of whether or not to use fertilizer on a crop, however, is generally an economic one. That is, will their use be profitable? In addition to the physical response to be expected, certain economic and institutional factors are also important. These include:

- (a) the price relationship between fertilizers and the crops to which they are applied, together with the market outlook for these crops, largely determines the profitability and incentive for using fertilizers;
- (b) the level of incomes of farmers and the availability and cost of credit, largely determine whether farmers can afford the initial outlay for fertilizers;
- (c) conditions of land tenure which, if unfavourable, may greatly reduce the incentive to use fertilizers; and,
- (d) adequate distribution facilities to ensure that supplies of fertilizers are available to farmers at the right place and the right time.

The relative importance of these factors naturally vary depending on the circumstances and they are to a considerable extent interdependent. Each of them can be influenced by government action if the policy of the country is to stimulate the use of fertilizers as a means of increasing agricultural production. Another factor which may influence the consumption of fertilizers is the relation between land and population, for cultivation naturally becomes more intensive when land is scarce, fertilizer thus substituting for land.

FACTORS AFFECTING ECONOMICS OF USE

Farm Level

The relationship between the cost of fertilizers and the value of the increased output to be expected from their use is probably the most important single economic factor, influencing fertilizer use by farmers. A straightforward comparison of prices, however, oversimplifies the issue. A number of other factors also affect the profitability of using fertilizers, and the rate of application likely to give the largest economic return. Included are: (a) the expected increase in output from each increment in fertilizers applied; (b) the price of the crop; (c) the cost of the fertilizers and of applying them; (d) the additional cost of harvesting and marketing the larger crop; and, (e) the residual value in later seasons of fertilizers applied. In principle all these factors should be considered by farmers, or by extension officers in advising them, in deciding the most appropriate rate of application of each type of fertilizer.

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Yield response to fertilizers depends upon many things including soils, soil moisture, quality of seed, time of planting, plant population, disease and insect control, cultivation practices as well as kinds and amounts of fertilizer nutrients needed and applied. Obviously, anything that can be done to improve yield response is tremendously important in making fertilizer use profitable. A small response of a high value crop, however, may be economic. On the other hand, a fairly large response of a low value crop may not be economic. It is food crops that generally have the lowest prices, particularly at harvest time. The very large fertilizer response of hybrids and the new high-yielding cereal varieties has, however, substantially altered the profitability of some food crops.

Not only do fertilizers and other improved practices increase yields, they also decrease unit costs and thereby increase profits. This is shown in an economic study of maize production by a group of farmers taking part in a pilot scheme in Honduras, in which improved seed, insecticides in addition to fertilizers were provided on credit (Table 1.).

Generally in experimental, field trial or demonstration work the application cost of fertilizers, and the extra harvesting and marketing costs of a larger crop are not known. It is common practice to assume that these extra costs are covered by the value of the residual yield and usable crop residues, to simplify the calculation of the economic return to fertilizer use.

Economic Optimum

If each equal application of additional fertilizer gave the same crop response (constant returns), it would pay to use an infinite quantity of fertilizers, and the world's food supply could be raised in flower pots. That the crop response to fertilizers follows a curve, which after a certain point increases at a diminishing rate (decreasing returns) and eventually declines, is of the greatest economic importance. The most profitable level of fertilizer may be well below the amount required to produce the highest possible yield. This is shown in Table 2, when the largest yield of 2,900 kg/ha is obtained with six units of fertilizer but the maximum net returns of \$60.50 is attained at four units. If a fifth unit is applied, this additional unit costs more than the value of the additional yield obtained: \$17 vs. \$12. Maximum net returns are thus obtained when the cost of the additional unit of fertilizer equals the value of the additional output: \$17 vs. \$17. That is when the input/output price ratio is equal to the marginal physical product(*). This is also shown in Figure 1, where the total fertilizer cost line intersects the net returns curve at its highest point at four units of fertilizer. At this point the vertical distance between the cost line and the total value of production or gross return curve is also the greatest, indicating maximum net returns. It will be noted that the marginal product (yield) and marginal return are zero when total product (yield) is at the maximum. Therefore, to determine maximum net returns, i.e. the economic optimum, information in the form of marginal yield and price relationships must be available. As price ratios change, the level of fertilizer must also change, to maintain maximum economic returns.

In practice, however, such refined information of the production function is not usually available or, if so, is not representative applying only at a discrete set of conditions. However, from experimental, field trial and demonstration data there is a predictable range of fertilizer rates which are economic under given cost and price relationships. It is within this range that fertilizer recommendations are made and within

(*) $P_x/Y_x = \Delta y/\Delta x$ or $P_x \Delta x = P_y \Delta y$, the value of the change in input is equal to the change in output.

which farmers apply fertilizers, either to maximize the return per hectare in terms of yield or to the money spent on fertilizer. Generally farmers with sufficient resources use fertilizer rates which are near the optimum economic return per unit of land. This is near the top or on the flatter part of the response curve. The rates of fertilizer application of interest to small-scale farmers with limited resources who are concerned with the return they get on the money they spend on fertilizers, are those on the steeper part of the response curve where the value/cost ratios (VCR) are larger.

Net Return and Value/Cost Ratio

Much field trial and demonstration work does not permit the calculation of the response curve to the different nutrients owing to the design used. Nevertheless, if the range of treatments is great enough it will bracket the economic sector, and by a simple calculation of the net return ^{1/} and value/cost ratio (VCR) ^{2/}, the most economic treatment amongst them can be determined. The following example illustrates this:

Treatment	Yield Increase kg/ha	%	Gross Return	Cost of Treatment	Net Return \$/ha	VCR
Control	3000	-	-	-	414	-
40 0 0	890	29	122.82	16.80	106	7.3
40 40 0	1090	36	150.42	30.30	120	5.0
40 40 40	1455	49	200.79	47.10	154	4.3
80 80 80	910	30	125.58	94.20	31	1.3

Of the four treatments used in this example, the lightest NPK treatment gave the largest response and net return with a good VCR. The heaviest NPK treatment on the other hand gave a smaller response and only marginal economic returns. The largest VCR was to the N-alone treatment which gave a good economic return, only slightly smaller than that to the NP treatment. Assuming these results to be representative, on economic grounds the lightest NPK treatment could be recommended for use by the better-off farmers, and the N-alone treatment by those with limited financial resources.

It is, however, difficult to say at what VCR value a farmer becomes interested in using fertilizer. The general rule of thumb is a VCR of at least 2, i.e. a return above the cost of the fertilizer treatment of 100 percent. The net return should also be considered, because at low rates of fertilizer application the VCR may be 2 or more, owing to the small cost of the treatment, but the net return small and unattractive to the farmer. In addition other factors should also be taken into account including the ready availability of fertilizer to the farmer, the likelihood of the expected yield being obtained (e.g. whether or no the crop is irrigated) and an assured market for the crop.

In practice farmers use less than the recommended rates. This is because the amount of fertilizer which a farmer will use depends on the anticipated yield response, crop prices expected, fertilizer availability and cost, level of financial resources and credit availability, tenure considerations, the degree of risk and uncertainty and the

^{1/} The net return is the value of the extra crop produced after deducting the cost of the fertilizer treatment used to obtain the yield increase.

^{2/} See footnote Table 1.

farmers ability to bear them. At the time the farmer buys his fertilizer only one of these, the cost of the fertilizer, is accurately known. An average figure, based on experimental or farm trials or the farmers own experience, is used to estimate the probable increase in yield, but the actual response varies with the weather, and in turn affects the cost of harvesting and marketing. The price of the crop when it is harvested some months later can also be an estimate, unless a fixed support price is effectively implemented. The price may be substantially reduced on a free market if favourable weather or the widespread use of fertilizers leads to a sharp rise in yields and total output. A farmer thus has to be rather cautious and allow what he considers a fair safety margin when deciding how much fertilizer to use on his crops.

National Level

A good deal, however, can be done by government action to reduce the risk and increase farmers' incentives for using fertilizers. The factors to be considered include institutional as well as purely economic ones. They are concerned with ensuring that the right kinds of fertilizer are supplied to farmers at the proper time and place at favourable prices, that farmers are provided both the knowledge and the means to make full use of them and that they are able to sell their crops at remunerative prices. This requires an efficient marketing, grading and distribution system, storage facilities, adequate amounts of credit on reasonable terms and good research and extension services. In many countries such facilities are either poorly developed or do not function efficiently, and feeder roads tend to be inadequate and usable only during the dry season. As a result the cost of fertilizers tend to be high and crop prices low; transport costs alone may double the ex-factory or c.i.f. price of fertilizers at the farm. These aspects are discussed in other papers in this seminar, and are mentioned here because of their economic implications for fertilizer use. Also of importance are lease arrangements and tenure conditions. There is little or no incentive for the farmer to use fertilizers to increase crop output when he must give a share of the crop to a landlord who does not share the fertilizer costs. Tenants paying a fixed rent would not be inhibited from using fertilizers on this account, since like owner-operators, they would receive the whole of the resulting increase in output. Even so, insecure tenure, or the practice of shifting cultivation when the field is abandoned after a period of time when weeds become uncontrollable or yields begin to fall, may also affect the farmers' interest in using fertilizers, especially those (e.g. phosphates, potash) where an appreciable residual value may be carried over to the next season.

Price Controls

It is clear that these factors have a very important bearing on the cost of fertilizer to the farmer and the prices he receives for his crops, as well as the success of any price policies implemented by government to increase agricultural production. Price support and price stabilization schemes improve prices farmers receive either by eliminating or reducing the impact of seasonal fluctuations, or by raising the general level of prices. Even a fairly low support price, provided the farmer can count on receiving it, removes a large element of risk, but the higher the price the greater the incentive to increased output.

Price stabilization is important to the increased use of fertilizers because if the resulting additional crop production substantially depresses prices, this may discourage their further use. In Japan, Taiwan and many developed countries price policies were successful in raising fertilizer use to high levels because of the very favourable relationship maintained between the price of the crop and the price of fertilizers. In Japan in the early sixties, when fertilizer use was increasing rapidly, it took only 1.2 kg of rice to pay for 1 kg of fertilizer and 1.5 in the U.S.A. In Egypt,

however, because of the very unfavourable relationship, it took 7.1 kg of rice to pay for 1 kg of fertilizer. Yet the problems involved in implementing effective price support and stabilization schemes, particularly in countries with limited financial and institutional resources, can be considerable. This is particularly true when food crops are produced by thousands of small, mainly subsistence farmers. Moreover, such schemes may require transfer payments to agriculture from other sectors of the economy through higher prices to consumers or some form of government subsidy. Such transfer payments are possible in countries where agriculture accounts for a small portion of the population and national income. In countries where the agricultural sector is large and the other sectors weak, in the first stages of economic development the movement is usually in the opposite direction; agriculture as the largest sector of the economy has to provide funds for investment in industry and other new activities. Nevertheless, as already mentioned, a fairly low support price, provided the farmer can count on receiving it, may be sufficient to encourage the farmer to produce more, yet at the same time require a minimum of funds for the purchase of only a small share of the crop by the government to maintain reasonable price stability.

In some countries, particularly those where shortages increased staple food prices, and where high-yielding cereal varieties are now being grown, guaranteed minimum or procurement prices have been introduced. The effectiveness of such a price policy depends on how well it is implemented at the farm level, particularly immediately following harvest. The record so far appears to be a mixed one in the different countries either because of inadequate arrangements to buy the grain from farmers, with the result that they receive less than the support price, or lack of funds to pay the procurement price or buy all of the quantity offered. The predictable effect of such short-comings is the reduced use of fertilizer and other yield increasing practices by farmers.

Subsidy

In that it is the relationship of prices rather than their absolute level which is important, these difficulties with price supports suggest that if an adjustment in prices is considered necessary, a decrease in the cost of fertilizer to the farmer should be easier to achieve than to insure the farmer receives the support price. Furthermore, if an incentive price to the farmer would mean raising the general level of prices for food, with the attendant inflationary implications and hardship for the large low-income sector of the population, a subsidy would be preferable. Subsidies are relatively simple to operate and unlike price supports benefit only those farmers who use fertilizers. The quantities involved are also much less, so the cost of the fertilizer subsidy scheme would be considerably less than a price support programme. Another advantage is that a differential subsidy may be used to encourage the use of the recommended ratio of nutrients, since the tendency amongst farmers is to use nitrogen only, even if phosphate and potassium are also recommended. Transportation charges may also be equalized making fertilizer prices uniform throughout the country and benefitting farmers furthest away from the major centres. It may be argued that having the closest farmers, with the comparative advantage, subsidize those further away, distorts the use of resources. Such a policy, however, has a social aspect of assisting farmers economically disadvantaged because of their greater distance from the market place.

A subsidy may also be used to encourage the production of specific crops, e.g. food crops, or to assist a particular category of farmers such as small-scale farmers. In these cases, however, without strict control the fertilizer is usually diverted to crops providing a better return and to farmers with more adequate resources.

The rate of subsidy at present being used in most countries ranges from 20 to 60 percent. This suggests that the rate varies considerably depending on the policy objectives and conditions within a country, and perhaps in determining the subsidy

there is a considerable degree of "guesstimate" involved. Because of this uncertainty of what rate of subsidy to apply, a simple formula has been developed on the basis of the VCR which it is considered would provide an adequate incentive for farmers to use fertilizers (*). The formula with the subsidy expressed as a percentage of the unsubsidized farm price of the fertilizer is as follows:

$$VCR_I = \frac{VCR_F \times 100}{100 - \text{subsidy}} \quad \text{where,}$$

$$VCR_F = \frac{\text{Value of Yield Increase}}{\text{Cost of Fertilizer Unsubsidized}}$$

$$VCR_I = \frac{\text{Value of Yield Increase}}{\text{Cost of Fertilizer to Farmer}}$$

The VCR_F is obtained from field data, and the VCR_I is the value which it is considered is required to provide the incentive for farmers to use fertilizers. For example, if the VCR_F obtained from field data is 2 and the incentive VCR_I should be 3, then the fertilizer subsidy should be 33 percent of the farm price.

$$(3 = \frac{2 \times 100}{100 - 33} ; \frac{200}{67} = 3).$$

Using this formula gives a good basis for determining incentive rates of subsidy, assuming sufficient field data are available to determine a representative VCR_F for different crops.

Whatever form of subsidy is chosen, it should be realized that its primary contribution lies in providing the initial impetus to the adoption of fertilizer by farmers by making its use more economic. Once farmers become acquainted with the benefits from its use, the need for the subsidy may become less. As the use of fertilizers becomes more widespread a subsidy tends to become too costly for most developing countries to maintain, even though on a national basis it should more than pay for itself in increased farm output. Rather than discontinuing the subsidy abruptly, it should be reduced gradually so that the prices paid for fertilizers by farmers increase only slowly and the possibility of a decline in consumption is minimized. Even a gradual phasing out may be politically difficult once a subsidy has been introduced. A reduction in the subsidy should, however, be facilitated by a decline in transportation and other marketing costs which will be likely as fertilizer consumption increases.

Risk

In addition to economic measures directed toward stabilizing or increasing the value of the yield and reducing the cost of the fertilizer treatment, others measures may also be required to decrease the risk of weather. Although the risk due to weather is

(*) The formula was developed with the assistance of Mr. K. Kuiper.

difficult to reduce, variations in yield may be lessened by the provision of irrigation facilities where this is possible and feasible, and the risk of crop failure partially offset by crop insurance. Like price supports, however, crop insurance may be beyond the means of most developing countries. In addition, the reliable long period data of crop losses required to work out a sound actuarial basis may not be available. Another practical problem in most developing countries is that the majority of farms are small. This implies greater hazards, both from a physical and moral point of view, as well as limited resources of the farmers to pay premiums, i.e. their pro rata share of losses, even if they understood the meaning and the significance of the insurance.

Taxes and Duties

Some countries tax both crops and fertilizers to obtain public revenue. The source of supply may also have an important bearing on the cost of fertilizers, whether locally produced or imported, owing to inefficient plants and procurement methods. The elimination of import duties or taxes on fertilizers would reduce their prices and have an effect similar to that of a subsidy. Reduced production costs and more efficient procedures with regard to fertilizer imports to obtain quantity discounts and off-season rebates would also lead to lower prices.

Imports vs. Local Production

In the early stages of fertilizer use by a developing country, the agronomically suitable fertilizers will almost certainly have to be imported. As fertilizer demand increases, however, the question of a domestic fertilizer industry will no doubt arise. The initial step may be to prepare mixed fertilizers from imported materials. An alternative would be to construct a plant for processing imported intermediate materials, e.g. ammonia and nitrogenous fertilizers and continue to import other fertilizers. Eventually the stage may be reached when the primary manufacture of fertilizers would be appropriate.

Many factors must be considered in arriving at a decision as to whether to import or produce the increasingly larger amounts of the various fertilizers required. Much will depend on the availability of local and external sources of raw-materials, the cost of production vs. importation, the country's capital and foreign exchange position, and political considerations. A key question is the cost to the farmer who is going to use the fertilizer.

The prerequisites for the manufacture of fertilizers are cheap raw materials and power, preferably a ready home market large enough to provide for low-cost; large-scale production capacity, because primary fertilizer plants designed to produce small volumes are almost always high cost units. Within broad limits, as plant size increases, the unit cost of production declines. As a general rule, doubling the size of the plant, increases the total capital investment by about 40 to 50 percent. This results in lower capital or fixed costs per ton of fertilizer produced, declining about a third as the plant size is doubled. Operating or variable costs per ton of fertilizer also decline as the plant size increases, by as much as 40 percent depending on the size of the plant and the process used, as shown below:

<u>Plant Capacity</u> ton/day	<u>Capital Cost</u> per ton	<u>Production Cost</u> per ton
- Indices -		
200	100	100
500	67	78
1000	45	61

Additional considerations are that modern fertilizer plants are capital intensive providing only limited employment and primarily to skilled personnel. The siting of the plant and its construction, as well as its operation, entail special problems, equipment and skills, the equipment and skills in most cases having to be imported at a considerable cost of foreign exchange, ranging from 40 to 70 percent depending on circumstances. Furthermore, the foreign exchange saved by domestic manufacture may not be as large as the apparent savings from reduced import would suggest because a major share of the raw material may have to be imported on a continuing basis.

Although economics of scale will normally contribute to lower unit costs of production, there will sometimes be other considerations favouring the construction of well-placed smaller-scale plants, particularly those using intermediates. Larger sized plants have the disadvantage that any breakdown in the plant itself or its essential services such as electric power, a common problem in many countries, has a much more damaging impact than where only one of a number of small plants is affected. It is also much simpler, and usually cheaper, to organize a distribution system based on several strategically located plants of smaller size than one or two very large ones, particularly where distances are great and communications are difficult.

These various factors which must be considered in determining the need for and the type of fertilizer production facility, require careful study by a team of experts consisting of an economist, agronomist and engineer. Anticipated developments in other fields should also be considered in planning for the development of a fertilizer industry. Expansion of electric power and water-supply systems may provide the required energy for plant operation; the existence or construction of a steel plant may make basic-slag or coke-oven gas available. The discovery of economically exploitable deposits of phosphate rock, potash ores, petroleum or natural gas may provide a domestic source of other raw materials. Such factors as these may also be decisive in indicating the type of plant to be built, where it should be located and the fertilizers to be produced.

Each case must be decided on its merits, but if domestic demand is so limited that the locally manufactured fertilizer cannot be absorbed locally or by a group of countries, e.g. East African Community, and would have to be sold on a highly competitive world market, or the plant operated at a very much reduced capacity, it would be advisable to continue to import fertilizers until demand was built up to a high enough level to justify a large plant. An alternative, as already mentioned, would be to establish plants which relied on semi-manufactured raw materials, or to concentrate on mixing or blending and packaging of materials imported in bulk.

If, however, the alternative is simply one of importing food or fertilizers, it is clear on economic and social grounds that importing fertilizers makes the most sense. Without even considering the effect of fertilizer use on increased production and farm incomes, the crop output of 8 or more kilogramme per kilogramme of fertilizer nutrient, commonly obtained with most crops, indicates that it is more economic in terms of saving foreign exchange to use fertilizers, whether imported or locally produced, to provide needed food crop supplies, rather than to import the crop. Even if food grains can be imported on concessional terms, the social and economic benefit of domestic production rather than importation should not be overlooked. On the other hand, of course, export of cash and other crops earns foreign exchange. Assuming a market, fertilizer use may provide larger quantities of such crops for export.

A programme to encourage the use of fertilizers as a means of increasing crop production must give careful consideration to the timely provision of adequate supplies. Limited or untimely supplies of fertilizers may adversely affect such a programme. Even though other factors are favourable to their use and a demand is built up, actual use will depend on the amount of fertilizers available, whether produced domestically or imported.

CONCLUSIONS

While the most rapid expansion and effective utilization of fertilizers and other inputs is likely to occur when all the constraints to their use are adequately dealt with, it is clearly unrealistic to expect to implement all the required policies and measures in a short period of time. The identification of the crucial factors, which either hold back or have the greatest potential to stimulate their use, is an essential first step in formulating and implementing appropriate policies and measures at a particular time. They should provide the necessary incentive for farmers to use fertilizers and other inputs to raise crop yields and hence agricultural productivity, which is a major element in economic development in countries where the bulk of the population is in agriculture.

For example, the growth of per capita incomes in East Africa is very much dependent on the growth of agriculture. Agriculture accounts for a substantial portion of total output in all three countries: about one-half the Gross Domestic Product in Tanzania and Uganda and about a third in Kenya. Much of the output of other sectors of the economy of each country is also dependent on agriculture. A large part of their manufacturing involves the processing of agricultural products such as coffee, tea, cotton, sisal, animal products, fruits and vegetables. Much of the trade, financial, transport, communications and construction sectors directly or indirectly service agriculture. A substantial proportion of government services is directed to agriculture. Growth of agriculture in East Africa, thus, has substantial direct and indirect effects on the economic welfare of both the farm and non-farm people of the region. This is, of course, also the case for other African countries.

Table 1 Average Effect of Fertilizers, Improved Seed and Insecticides on Maize Yields,
Production Costs and Economic Returns of 46 Farms

	Fertilizer, improved seed, insecticide		Change	
	Without	With	Amount	Percent
Yield (kg/ha)	1,740	4,550	+ 2,810	+ 161
Production cost (\$/ha)	54.30	86.80	+ 32.50	+ 60
Production cost (\$/100 kg)	3.12	1.90	- 1.22	- 39
Economic return (\$/ha)	41.40	163.21	+ 121.81	+ 294
Value/Cost ratio (*)	1.76	2.88	+ 1.08	+ 61

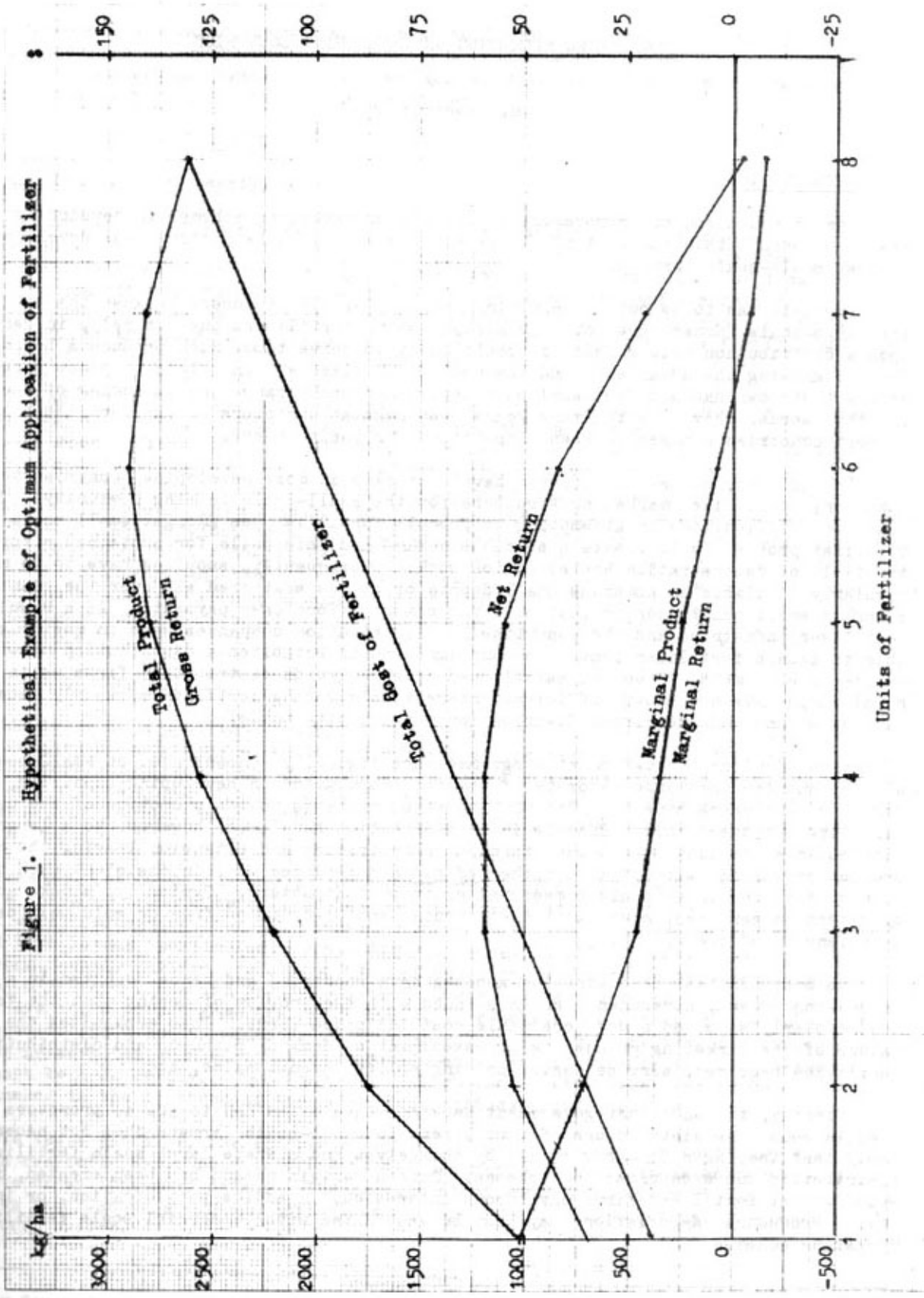
(*) The value of the yield increase divided by the cost of the fertilizer dressing used to obtain the yield increase.

Table 2 Hypothetical Example of Optimum Application of Fertilizer

Units of fertilizer applied per ha (x)	Total crop output (kg/ha) (y)	Marginal product for each unit of fertilizer (kg/ha) ($\Delta y/\Delta x$)	Value of additional fertilizer \$17/unit	Marginal return of additional crop at \$0.05/kg	Gross return \$	Net return \$
1	1030	1030	17.00	51.50	51.50	34.50
2	1740	710	17.00	35.50	87.00	53.00
3	2230	490	17.00	24.50	111.50	60.50
<u>4</u>	2570	340	<u>17.00</u>	<u>17.00</u>	128.50	60.50
5	2810	240	17.00	12.00	140.50	55.50
6	2900	90	17.00	4.50	145.00	43.00
7	2820	-80	17.00	-4.00	141.00	22.00
8	2670	-150	17.00	-7.50	133.50	-2.50

$$Px \Delta x = Py \Delta y; (\$17) (1 \text{ unit}) = (0.05) (340); \$17 = \$17.$$

Figure 1. Hypothetical Example of Optimum Application of Fertilizer



FERTILIZER MARKETING IN DEVELOPING COUNTRIES

by

H. Creupelandt ^{1/}

INTRODUCTION

The introduction or improvement of fertilizer marketing schemes in developing countries has to be seen within the context of the efforts to stimulate agricultural development amongst small-scale farmers.

Emphasis has to be put on servicing the small-scale producers because the estates and the large-scale farmers are not only already using fertilizers but can rely, in general, upon a distribution network set up specifically to serve them. Such producers, beyond the fact of knowing the advantages and the use of fertilizers, can afford to place large orders, secure their own haulage from wholesale depots and can arrange the financing of their purchases. In other words, they have for many years been regular customers of the fertilizer trade which in most countries engages in keen competition for their orders.

In contrast, not enough efforts have been made in most developing countries to secure a rational fertilizer marketing structure for the small-scale farming community. There are numerous difficulties in attempting to promote fertilizer use amongst small-scale farmers. The first problem is to create a sizeable demand and this calls for sustained efforts in the field of demonstration and extension work. Subsequently, supplies have to be made regularly available in numerous small depots or stores scattered all over the country for sales in small quantities to customers who cannot afford cash payments. As a result the fertilizer industries and the importing and distribution companies were in most cases not able to launch fertilizer promotion campaigns and to establish a distribution network for small-scale farmers. Even the established consumer goods distribution firms which supply rural shops have not shown sufficient interest in covering fertilizers, mainly because of the lack of demand and the narrow distribution margins obtainable.

As agricultural development programmes are logically concentrated on small-scale farmers, who account for the large majority of the farm population in developing countries, governments during recent years have begun to put increased emphasis on the promotion of the use of fertilizers amongst them. Efforts in this direction have been, however, to a large extent, limited to a creation of a demand through demonstration and extension leaving the marketing problem or dealing with it in a rather ad hoc and isolated way, inconsistent with the development of a large scale commercial distribution pattern. Typically, stocks are ordered by extension services, moved with their trucks and distributed free or sold well below cost by extension officers, etc.

As most of these demonstration schemes have succeeded and hence resulted in a rapidly increasing demand, governments are now faced with the problem of seeing that the farmers are regularly supplied under acceptable cost and price terms. This emphasizes the complex nature of the marketing process, e.g. assessment of demand, planning and distribution, facilities required, service costs, pricing policy, credit sales, etc.

Clearly, the fact that government services have often had to act as promoters and also simultaneously as distributors of fertilizers to small-scale farmers does not necessarily imply that they have to carry on all by themselves and operate large scale fertilizer distribution and even promotion schemes. Once a certain demand has been created, it is evident that fertilizer firms may become interested, in active participation, or in taking over. Producers' associations may also be associated with commercial scale fertilizer marketing schemes.

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The purpose of this paper, beyond an attempt to define the elements of the overall marketing process, is to illustrate the different approaches made in certain countries in deciding the channels and agents to be used, and to discuss the problem of transport, storage, financing, credit, training of salesmen, etc.

SERVING THE FERTILIZER MARKET

Role and functions of fertilizer marketing

The role of fertilizer marketing can be defined as making fertilizers available, where and when needed, of the type, quality and in the quantity required and, at the lowest price commensurate with the services required by the customers. These conditions of location, time, quality, quantity and terms of sale have to be complied with and the related functions and services (transport, storage, sales points, quality control, credit, etc.) performed at a cost enabling farmers to purchase at an acceptable price and thus to use fertilizers in a profitable way.

The cost and price concept deserves particular attention as it commands the operation. Indeed, the cost of marketing fertilizer is often greater than the cost of its production or its c.i.f. import price; but unless the final sales price remains within an acceptable limit ^{1/} no economic use can be made of fertilizers. At the same time, making fertilizers available at the places and in the quantities required by small-scale farmers and on credit terms, invariably increases the marketing costs. Thus the economic performance of the marketing functions and services is an essential issue, calling for a rational organization and efficient operation of the distribution network, transport, storage, etc. This implies both appropriate planning, and the adequate utilization of transport and storage facilities as well as existing distribution channels and sales outlets. A special consideration is the degree of complementarity between the marketing of fertilizers and of other inputs and of agricultural crops.

Assessment of demand (quantitative aspect)

In order to be in a position to supply the farmers at their request, dealers must be able to determine the approximate requirements ahead of the next campaign. The fertilizer industry, the fertilizer import and distribution firms or agencies must not only plan their production and imports ahead of a forthcoming season but must also lay long-term plans for their investment in facilities and distribution infrastructure for instance plants, warehouses, sales depots.

On a seasonal basis, conditions of under-supply will of course frustrate farmers, cut across the efforts to promote fertilizer use and delay agricultural development. Over-supply will entail excessive costs in storage, unnecessary immobilization of capital in stocks, and high losses, particularly when adequate storage facilities are lacking. Errors in the seasonal supply pattern are also often reflected in incorrect quantities being available at different areas and selling points. Corrective measures, at the time of demand from users, are found to increase transport costs. Any substantial error in the long-term demand assessment and hence in planning and investment in plants, marketing facilities and distribution network has even more serious consequences, as adjustments from one season to another cannot be made easily. This may entail high financial losses, for example if the effective demand in the forthcoming years has been seriously overestimated.

To avoid these pitfalls, the assessment of the effective demand for fertilizers should be done on a realistic basis starting from actual consumption in all areas concerned and the prospects of an increased demand. The assessment of such prospects must take account of continuous and planned promotion activities and the likely value-cost ratio between fertilizer crop prices.

^{1/} Allowing for a favourable value:cost ratio.

Experience shows that there is a real risk of heavy wastage of supplies and funds, if forecasts are primarily based on development plan targets, total acreage under crops and technical input rates.

As a method of estimating the effective demand ^{1/} over a given number of years (and covering as well crops or areas which may yet not benefit from their application) the following approach may be recommended:

- a) selection to be made of crops showing a profitable response to fertilizers and having an export or domestic market potential;
- b) evaluation in the field of the official application rates and types of fertilizers (as applied in general by farmers) for each of the crops selected;
- c) assessment of the areas under cultivation or to be brought under cultivation within the period considered, taking into account the size of farms, and the existing transport as well as marketing infrastructure;
- d) calculation of the effective demand to be expected for these crops and areas on the basis of a, b, and c, taking into account:
 - i) past trend of fertilizer demand increase for the type of farmers concerned
 - ii) the fertilizer promotion efforts to be concentrated on these areas and crops (also to be compared with previous programmes)
 - iii) the likely forthcoming value:cost ratio between fertilizers and crops.

This assessment of demand has to be made, of course, in collaboration with the extension and agricultural staff working in the areas concerned as well as with fertilizer dealers, cooperatives and representatives of the farmers.

The storage problem

Fertilizers have to be produced or imported well ahead of the period of their utilization. Indeed fertilizer production has to be a continuous process to be economic whereas the farmers' purchases are concentrated in a few weeks annually. Even in the case of imports, stocks have to be built up in the rural areas ahead of the planting season either because access roads may be impassable once the rainy season begins or because it is necessary to arrange transport at an earlier time in order to take advantage of return loads and to avoid a peak in transport requirements at the beginning of the planting season.

Beyond these considerations, it is obvious that stockholding at different stages of the marketing channel is also a commercial requirement. Local dealers cannot sell to small-scale farmers by simply passing their orders to a wholesale merchant but have to have at least a minimum working stock on hand. Wholesale merchants must also have storage facilities either for transit storage or to keep a certain reserve stock so that they can make supplementary deliveries to dealers during the selling season. The same applies to importers whereas manufacturers necessarily face a certain stock build up at processing plants.

^{1/} Corresponding to that portion of the total demand potential which one can expect to materialize under the given conditions of a fertilizer use promotion programme and foreseeable value:cost ratio.

The question as to where and at what stage of the distribution channel stocks have to be mainly concentrated and hence extra storage facilities have to be provided can only be answered after a careful study of:

- i) the distribution pattern to be followed;
- ii) the agents who will be involved and the storage capacity they own or can rent; the storage capacity available for other crops which could be used for fertilizers;
- iii) the transport conditions throughout the year.

At first the extent to which available storage facilities can be used for fertilizers has to be checked. In many countries large parts of the storage facilities used for grain or oilseed, are empty, when fertilizers have to be stocked. The second point refers to the location of storage facilities at different levels of the marketing channel, namely import or manufacturing, wholesale or retail level. In order to keep handling costs low an effort should be made to move fertilizers from the factory or the import harbour straight to the retailer or farmer without much interstorage. This, however, requires storage space at this level, a credit programme for farmers and stockists as well as trained personnel. It is recognized that these conditions do not yet exist in many African countries and, therefore, more intermediate storage at wholesale and district level is required. The final objective should be to build up an effective storage and credit system at the retail level.

In order to meet short-term fluctuations in the demand for fertilizers, storage facilities are required at wholesale and import/processor level. The size depends upon local conditions. Full use should also be made of existing storage space, if this can be obtained at lower costs than building specialized fertilizer stores.

Transport of fertilizers

Transport is a crucial element in the marketing process, because of the relatively high weight of fertilizers in relation to value and the remote and scattered selling points which have to be served. Therefore, the cost of transport generally constitutes a substantial part of the final price to be paid by the farmers. In Ethiopia for instance transport charges represent more than 20% of the final price. In the case of Northern Nigeria these costs exceed 50% of the farmer's price whereas in Chad transport costs prohibit a wider fertilizer use.

As mentioned above, a complementary use of marketing facilities and services for inputs and crops can be applied to transport. To avoid idle trucking, scope exists for using fertilizers as return loads after harvest time when farm produce has to be moved to urban centres and export points.

In practice this combined haulage calls for a fair amount of transport planning and a close collaboration between the wholesale merchants or fertilizer distributors and those responsible for the operation of the produce marketing schemes. Experience shows that such combined transport schemes are easier to implement where fertilizer distribution at wholesale and retail level and produce marketing are the responsibility of the same agency. Even in such a case, however, problems may arise if private agents are involved, as they may prefer their own trucking arrangements. Still, whenever such a haulage combination proves to be feasible, a correspondingly lower transport cost allowance should be accounted for, for example in transport cost-pooling schemes.

Transport from retail store to farm is often difficult to arrange. It should, however, not be neglected in areas where farmers have no transport. As producers have to deliver their crops at harvest to collecting or buying centres, fertilizers as well as other inputs could be carried back to farms at this stage. However, this is likely to be well ahead of the

season, in which the fertilizers are to be used and most farmers prefer to purchase at planting time. In some cases this may correspond, at least for staple food crops, to a second crop sales period for those farmers who have retained crops in store in anticipation of higher prices late in the season. Whether or not such a combined haulage is feasible matters little at this level as farmers do not generally put a cost on their market visits. However, the distance to market centres is important. In general these centres service a 10 to 20 km. radius in main producing areas and farm produce, consumer goods and inputs are carried over bush tracks on donkey or horse back, on cart or even as headloads.

The transport of fertilizers in bulk which, up to now, has hardly been introduced, in developing countries, is not covered in this paper, as it is being dealt with in another paper. The question of the pooling of transport costs and the fixing of a uniform sales price for a given area or a country as a whole is treated under pricing policies.

Quality aspects and packing

Appropriate types of fertilizer have to be made available to farmers in the quality and concentration required. This implies not only controls at the production or import level but also steps to prevent adulteration as well as deterioration of the product by the time it reaches the farmer. Farmers are unable to verify the quality and concentration of fertilizers at time of purchase. Furthermore, the risk of incorrect use by farmers increases substantially when different types and brands are offered. All these aspects are related to what can be considered as a quality responsibility of those involved in the overall marketing process, i.e. fertilizer firms, dealers, extension workers and government control services.

In this context packing and labelling plays an important part. Quality alteration and deterioration for instance can largely be avoided by using strong plastic heat-sealed bags of an appropriate retail unit size. These cannot be opened and resealed easily, are resistant to rough handling conditions (as long as no hooks are used) and protect the product against adverse weather and storage conditions. This type of 50 kg bag is now widely used in many countries and provides a rather suitable unit size for purchase and transport for small-scale producers having to use bush tracks to reach their farms. Other types of bags are jute with a single polyethylene inner liner and woven polypropylene with polyethylene inner liner. Disadvantages of the first are that hook handling is tempting and bags may be damaged by rodents, whereas the polypropylene bag appears to be subject to cracking when exposed too long in the sun. Labelling should of course refer also to the kind and concentration of the fertilizer contained in the bag. Although most farmers may be illiterate it would be useful to indicate also, whenever appropriate, the crops on which the fertilizer should be used, and the application rates. This is done by certain fertilizer industries in Europe, at least for some of their products, and would be a help to rural dealers who have to advise their customers at the time of purchase.

Conditions of purchase

It is obviously the crucial function of marketing to ensure that fertilizers are offered to farmers under sales conditions acceptable to them. Failing to achieve this implies that all fertilizer use promotion efforts will have been in vain. Consequently, attention must be concentrated on the question of sales on credit terms as well as, of course, the cost of fertilizers to farmers. These aspects are dealt with in some detail later in this paper.

FERTILIZER MARKETING STRUCTURE

The expression "fertilizer marketing structure" refers to all those channels, enterprises, organizations, services, etc. involved in the fertilizer marketing process irrespective of whether this is their exclusive, principal or incidental activity. The activities involved should be considered in an integrated manner starting from processing and import enterprises down to final distribution units.

As suggested earlier there is a high degree of complementarity between the marketing functions of input and consumer goods distribution and the marketing of agricultural products. This is particularly true near the farm level. This is recognized in practice by the grafting of the fertilizer distribution process largely upon the existing crop marketing and distribution structure in most developing countries once fertilizer use by small-scale farmers and its commercial scale distribution has reached a substantial volume as for example in Zambia and Kenya. Such combined activities allow considerable savings on investments, operational cost and the qualified personnel. Moreover, the need to keep fertilizer cost to farmers at an acceptable level means that relatively high sales margins cannot be taken. Hence, most dealers must be able to rely upon other sales activities as a major source of income.

Consequently the fertilizer marketing pattern is also influenced by the type of crops grown and their marketing structure. In most African countries, export crops are in the hands of monopoly boards relying upon a rather dense network of buying centres. Considering also that hitherto fertilizer use has been mainly promoted for these same crops for reasons of foreign currency returns, it is understandable that these marketing structures are sometimes used as the fertilizer distribution channel down to the producers concerned. For staple foodcrops, however, the local market is sometimes an inadequate marketing arrangement, or organization. The whole burden of making at least temporary fertilizer supply arrangements is then left to the agricultural departments and extension services as in Nigeria. Production or marketing cooperatives and their unions, if they exist, may also play an important role in the fertilizer distribution.

The general government policy and attitude towards marketing and trade in a given country also affects the fertilizer industry and marketing arrangements. In countries with a liberal policy, private enterprise generally prevails whereas in others, state-owned enterprises or government agencies may dominate or even exert monopoly control.

Another fact which largely affects the fertilizer marketing pattern in developing countries is the farm size structure. In countries with a substantial number of large-scale farmers and estates, fertilizer firms are generally well-established to service this part of the farming community. In these circumstances it may be possible for government services also to rely upon these services, e.g. for wholesale deliveries. On the other hand in countries where production is in the hands of small-scale farmers, in landlocked African countries such as Chad, Mali, Upper Volta, etc., government services, when launching fertilizer promotion programmes may have to take the lead in placing import orders themselves. This does not of course exclude the possibility that fertilizer firms may become associated or take over responsibility once demand has reached a level which justifies their entering the business.

Except for a few countries with centrally planned economies, fertilizer marketing structures largely reflect the participation of existing private firms and traders, cooperatives and public authorities in the marketing of crops, consumer goods and farm inputs. Specialized fertilizer firms may come into the picture, e.g. when processing plants have to be built or for substantial imports and distribution at national level. Government participation at this stage, under the form of joint ventures with private firms, have been favoured in certain countries such as Senegal, Tunisia, Algeria.

At the retail distribution level it is often necessary for agricultural departments and extension services to take responsibility for the distribution at farm level where neither cooperatives nor marketing board agents are operating. Indeed, it is a well-known fact that most governments look rather suspiciously upon the participation of private retailers often qualifying them as exploiters of the small farmers. In Ethiopia for instance, input distribution centres have been established in the integrated development project areas by the agricultural extension department, pending their take-over by cooperatives which are to be gradually established.

This attitude is not shared by private distribution firms who in supplying small-scale farmers, readily call upon the services of small dealers. In Kenya, for instance, a substantial number of so-called stockists as well as cooperatives were appointed by the two leading fertilizer import and distribution organizations.

Given a certain amount of supporting services, some training and the access to necessary credit by those traders, private firms believe that this is the answer to the problem of rapidly building up an efficient distribution network, particularly where no cooperatives yet exist. The most delicate point in this sort of arrangement appears to be the sales on credit terms to small-scale farmers, which is discussed later.

It is debatable whether private, cooperative or government agencies are most suitable in the fertilizer marketing process. Beyond what was said on the incidence of overall government policy on marketing and trade and on the use of the existing marketing and distribution structure, it is clear that what counts ultimately is efficiency in performance: low costs and good service.

Specialized firms, operating under normal conditions of competition are known for their efficiency, expertise and dynamic approach. This, of course, does not necessarily apply to small bush traders. Neither can one claim that cooperatives particularly when lacking qualified staff, financing and facilities, offer any sort of guarantee of efficient operation. Government services have rarely demonstrated the necessary flexibility and business approach required in marketing operations, but in the absence of any other alternative, they may perform, at least initially, some essential marketing functions in fertilizer promotion programmes.

THE MARKETING OR SALES MIX

In business enterprise terms, the marketing mix comprises all activities, means and techniques used by a firm to secure increasing turnover and returns. Applied to fertilizer marketing schemes, which may be operated also by non-private enterprises, on a non-profit making basis, it appears more appropriate to talk about effectively expanding demand in general by means of convenient sales conditions and terms as well as services to farmers. As such, the marketing mix comprises:

- the effective performance of the marketing functions, i.e. at the lowest cost possible. This concerns appropriate planning and execution depending largely on qualified management and personnel;
- the elaboration of a suitable pricing policy with or without such means as cost pooling and subsidies;
- the offering of convenient sales conditions so as to enable all farmers to purchase fertilizers. A major element here is favourable credit terms;
- sales promotion activities, technical services and information to farmers.

Planning and Management

A complete course could be devoted to each of these subject matters without exhausting them. In the context of this paper only a brief reference can be made to some essential issues.

Planning: This concerns the structure, enterprises and facilities required. This sort of planning of a general structure, does not fall, strictly speaking, under what was defined as activities and techniques to favour sales. However, it would be virtually impossible to comply with the requisite of effective lowest possible cost performance as a means to enhance sales to farmers if the basic structure, agents and facilities were not chosen according to a rational criterion. A logical planning sequence is as follows:

- i) assessment of present and future demand;
- ii) inventory of existing marketing and distribution enterprises and organizations, likely to suit the purpose and interested in participating (see marketing structure);
- iii) selection of the marketing partners with special attention to their buying and distribution network at farm level;
- iv) decisions on new units to be brought in or to be created, e.g. processing industry, distributed link between wholesale and small-scale farm level, etc.
- v) on the basis of the previous points: - assessment of facilities required for processing, storage, transport; - evaluation of existing ones (see storage and transport aspects); - provisions for additional facilities needed.

Management and Incentives

This is directly related to the planning and execution of marketing campaigns, e.g. stock management, arrangements for transport, storage, sales, promotional activities, etc. The important factors are the qualifications of those in responsible positions throughout the marketing structure and the incentives provided. It is often felt that a major reason for a lower efficiency in marketing operations conducted by government departments and co-operatives is the fact that they are often not in a position to offer appropriate salaries to attract good managers nor to stimulate their personnel by bonus payments.

Incentive payments are also extended under private marketing schemes to agents and small dealers, in the form of special discounts for large orders for out-of-season purchase and for cash payments at delivery. Bonus payments may be given for reaching target sales over a given season. Such incentives which commercial companies consider as essential for rational low-cost operations and for stimulating an active sales approach are often non-existent in most cooperative and government marketing schemes in developing countries.

Pricing Policy

Pricing is the most effective tool for regulating flows of goods according to plan. In practical terms, a price policy must obviously take into account:

- the cost of fertilizer production or imports
- the cost of marketing

Under supervised credit schemes where credit for inputs, for example, is given in kind and the utilization of the inputs is followed closely by the credit agency, repayment performance is high compared to 'traditional' agricultural cash credit systems, i.e. $\pm 95\%$ versus 50 to 60%. However, administration and supervision costs under closely supervised schemes are also high. A concrete solution at a lower cost may be found in integrated credit and crop marketing schemes which offer favourable credit terms and more attractive prices for the farmers' produce than the private moneylenders and village traders. In this respect, cooperative credit marketing schemes, if well administered, have to be regarded as an appropriate basis for the distribution of fertilizers to the small-scale farming community.

The following three prerequisites are applicable to any kind of institutional agricultural credit and they should be fulfilled if a greater impact and a proper recovery of loans are to be expected: (i) the farmer is not seriously indebted in the non-institutional way i.e. to the moneylender and trader; (ii) all legitimate credit needs are properly fulfilled by the credit agency administering the scheme; (iii) the proceeds of the farmer's crops leave him enough margin to repay his institutional loans including the interest.

The problem of eliminating the usury interests charged in many cases for non-institutional credit to farmers is an economic, social, political and psychological one. In the planning and implementation of agricultural credit schemes specific attention should be paid to the existence of the following additional preconditions: (i) adequate and effective arrangements for marketing of produce as well as distribution of fertilizer and other inputs; (ii) a satisfactory functioning of an agricultural extension service; (iii) an adequate rural infrastructure; (iv) efficient government managed price stabilization for agricultural produce; (v) minimum requirements for land tenure.

The problem is that the cooperative movement is far from being fully developed in most countries, and in others, does not even reach an acceptable level of operational efficiency. Therefore cooperatives cannot always cope with the dual function of input distribution on credit terms and the marketing of cash crops. For this reason, government services or the private sector have to step in as in Ethiopia, Kenya, Zambia, etc. The credit problem remains, however, and private dealers may not be willing, or offer adequate guarantee, to sell at institutional credit rates to small farmers.

In principle, fertilizer firms and even commercial banks may be willing to grant credit to local traders, as is done for instance in Kenya, on the understanding that some of it will be passed on to farmers. This, however, is rarely done within the context of an institutional credit sales scheme, which provides that traders are found to offer credit at an officially imposed rate. The advantage of this system, at least for the banks, is that traders usually have some security and take responsibility for dealing with a substantial number of purchasers and for recovering from them the amounts outstanding.

Depending on the credit rates to be charged and the margin left to the traders to defray their credit administration cost and - of more importance - to cover their risks of bad debts, such a solution to the problem of credit sales by private traders may well work. A careful selection of private fertilizer sales agents at the farmers' level, as well as some control of their activities should be part of the scheme. The introduction of an officially announced dual pricing system, i.e. one price for cash and a second for credit purchases for a given fertilizer could also support such a credit sales scheme. This would prevent farmers from being cheated and would encourage them to purchase for cash whenever feasible.

The problem of providing credit to marketing enterprises, as such, is not dealt with separately in this paper. Clearly if the trade is short of finance this will affect not only the capacity to extend credit to farmers but will altogether hamper their business. Commercial banks normally provide the necessary finance, assuming that the enterprise in question is considered credit-worthy. In the case of a fertilizer distribution business

the government's attitude towards the participation of private firms and dealers plays a dominant part in this respect. In some extreme cases, commercial banks may even have been nationalized and governments may be opposed to the granting of credit to private traders or at least non-nationals for the development of commercial enterprises. In others, even government banks may provide finance to assist the active participation of the private sector in this field.

Sales Promotion and Technical Services

Private fertilizer distribution firms are, as a rule, actively involved in sales promotion activities, even in developing countries, when dealing with important customers, such as large-scale farmers and estates. This promotional activity is associated with technical advice to these buyers and technical services such as soil sampling and analysis, visits to farm demonstrations, etc.

It would be unrealistic to expect them to expand such services to the numerous small-scale growers. Services for the latter have normally to be provided by agricultural departments and extension services irrespective of whether the distribution is in the hands of cooperatives or private dealers.

What should be offered, however, at the retail or dealers' level is some technical knowledge so that farmers can obtain basic information at the time of purchase as to what fertilizers should be used on what crops, at what rates, and possibly some details as to how to apply them. Some short practical training courses for these dealers, and the provision of technical information sheets to them, might help to overcome shortcomings in this respect.

GOVERNMENT POLICIES AND SERVICES

Integration of fertilizer marketing into the wider programme of agricultural development

A fertilizer marketing system should be evolved as part of the overall agricultural development policy and coordinated with efforts to secure the efficient distribution of inputs in general and to improve the marketing of crops. Moreover, it is obviously an advantage if farm inputs distribution can be organized in connection with farm output marketing and credit supply facilities, in order to achieve better use of available personnel and facilities.

This integrated approach calls for a clear-cut government policy defining the role of the different sectors concerned and the definition of the responsibilities to be taken in fertilizer marketing by each one of them.

Government responsibilities

a) Promotion and marketing control

Central government services often have to take the initiative and to promote supply arrangements under their own authority when fertilizers are first introduced among small farmers. Still, this has generally to be regarded as a temporary arrangement, as government departments can rarely cope efficiently with such an undertaking once it reaches a commercial scale. Thus new channels have to be created, through cooperatives, private enterprises or joint government/private ventures.

The primary role of the government then becomes one of planning, of encouraging the participation of agencies and enterprises and of improving their services to farmers through regulations and control.

b) Price and market information service

Any planning and effective government policy has to depend upon an accurate and up-to-date market and price information service. This includes regular data on stocks of fertilizers and sales at different levels of marketing, and price information including credit terms to traders and farmers.

c) Regulations

Government services have to control the quality of fertilizers as well as the sales practices, particularly for the benefit of small-scale farmers.

Qualities should be defined by government regulations, but the legislation has to be enforced by inspection and effective sanctions against malpractices. Extension staff, officers of statutory marketing schemes or local authorities may act as inspectors, given the necessary knowledge of the product. Quality control may have to be done on the basis of sample taking and analysis in a central laboratory.

The contents of each bag should be shown by labelling according to the regulations. It is also necessary that farmers be clearly informed by extension agents about the type of fertilizer to be used and the corresponding labelling, type of bag, colour, etc.

d) Price control

Fertilizer prices to farmers are often fixed by government, and therefore rather strict control on their application may be required. There should of course be a public announcement of price levels and an official price list in all dealers' shops.

The need for price control depends largely upon the distribution pattern, the degree of competition and the extent to which transport pooling and subsidization are part of the price setting. Under monopoly distribution schemes relying exclusively upon statutory and cooperative sales agents, price control is virtually built into the system. However, in the case of a liberal trade pattern, dealers, particularly when operating at the farmers' level in a rather monopolistic position, should be subject at least to a price ceiling control. Given imperfect market conditions and the absence of keen competition, some sort of price control is likely to be warranted in order to support the efforts by governments to make fertilizers available to small-scale farmers at equitable and acceptable prices through pooling of costs and subsidies. Inspectors responsible for quality regulations and local authorities are normally in charge of this price check.

e) Training programmes

A realistic planning and pricing policy, and the effective distribution of fertilizers to farmers, calls for qualified personnel in public as well as private agencies.

It is a government responsibility to organize the appropriate training for at least its own officers as well as those of statutory marketing agencies. The private sector operators should be included in such training programmes. In fact joint organization of training programmes by governments and the fertilizer industry and distribution firms should benefit all concerned.

Training should be mainly in the form of seminars and short courses covering management, stock control and trading operations, as well as product technology. In some developed countries, leading fertilizer distribution firms organize courses for their agent-dealers. These courses, including some training in basic retail and sales practices, some book-keeping and a minimum of product knowledge can be important in making private as well as cooperative dealers into good salesmen, able at the same time to provide some technical advice to their customers.

CONCLUSIONS

The introduction or improvement of fertilizer marketing schemes in developing countries should be an integral part of the efforts to stimulate development amongst small-scale farmers, promoting the economic use of fertilizers.

The quality and the costs of the services rendered to the farmers depend on the marketing functions with regard to the quantitative and qualitative aspects, storage, transportation and the conditions of purchase.

An economic fertilizer marketing structure, i.e. enterprises, services and investments involved in the fertilizer marketing process, cannot be envisaged as a separate system. Because of the complementarity between the marketing of inputs, consumer goods and agricultural products, particularly at farmers' level, rational fertilizer and input marketing schemes, in general, have to be grafted largely upon the existing marketing structure for crops and other products. Only in this way can the costs of marketing be kept down to acceptable levels.

Efficient fertilizer marketing schemes need appropriate planning and management for their implementation and are largely dependent upon the efforts of qualified staff and suitable incentives to dealers. Sales on credit terms to farmers at acceptable price levels are also a major issue.

Government participation may be quite substantial in certain cases. In general, however, such intervention, particularly as far as the distribution at the small-scale farmers' level is concerned, should be confined to initial activity pending the establishment and take-over by private trading enterprises or by cooperatives or other producers' associations; the participation of the private sector in this marketing process is, of course, largely a matter of the overall government attitude towards private trade.

The role of government as promoter of an efficient fertilizer marketing pattern, beyond a possible direct participation in the process, is related specifically to policy and planning, a certain control over operations through regulations and supervision and the training of personnel of government services and statutory agencies.

AGRICULTURAL ADVERTISING AND PROMOTION

R.G. Mueller^{1/} and F.J. Myers

MARKETING DEFINED

Marketing is the people side of selling, It can be defined in terms of its organization or in terms of its functions. It is important to separate the two even though they are closely related.

Briefly, marketing functions mean the work to be done. Organization refers to the people who do the work. Marketing is a distinct kind of work and begins with the broad function of 'marketing management', this is leadership through planning, organizing, integrating, and measuring of all marketing functions.

The six basic functions of marketing are:

1. Marketing Research
2. Product Planning
3. Advertising and Sales Promotion
4. Sales
5. Marketing Administrative Services
6. Marketing Personnel Development

Marketing Research

This includes marketing studies and research concerning:

- Size and location of markets, attitudes, preferences, needs for company products, service and policies
- Sales and distribution methods, channels, and territories
- Price indexes, price trends, and product pricing
- Effectiveness of sales and advertising programmes
- Industry sales forecasts

Product Planning

This includes:

- Product planning and timing, additions, eliminations and modifications
- Formulation of pricing, discounts, conditions, terms and services

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- Product functions and quality level, appearance and packaging
- Competitive offerings, markets, buying motives and plans

Advertising and Sales Promotion

This function plans, creates, and schedules all advertising and sales promotion. It conducts copy and media research and coordinates advertising with other marketing functions.

Sales

This function includes sales management, planning and selling. Sales management and planning include:

- Sales objectives and policies
- Sales analysis and control
- Operation and control of distribution channels
- Enforcing pricing, discount and condition policies
- Sales training

Selling can best be described in terms of the requirements of every sale:

- Gain favourable attention
- Arouse interest
- Produce conviction
- Arouse desire
- Effect sale

Marketing Administrative Services

This function includes:

- Establishment of service objectives, policies, standards, plans and programmes
- Sales forecasting, sales records and budgets
- Production scheduling to meet sales requirements
- Warehousing and control of finished goods inventory
- Order processing and billing

This function serves marketing management by helping to free the marketing manager from day to day routine. It also makes certain that moral and legal responsibilities with respect to product performance are met.

Personnel Development

This function is often the most easily overlooked or postponed. It includes:

- Recruiting and selection
- Training and allocation
- Compensation and fringe benefit policies

Marketing is oriented toward people; the greatest involvement with people is reached in the sales function when the consumer is faced with the decision of whether or not to buy the product.

REASONS FOR PURCHASE

Barter transactions took place when one primitive man exchanged a spear tip with another man for a stone hammer or a bunch of fruit. Today, our buying and selling techniques are more sophisticated. Surveys, computerized warehousing, marketing strategy are a few of the tools we use to generate greater efficiency for both the buyer and seller, but the foundation for all this activity is the consumer. Without his support, there could be no economy institutions, none of the financial and industrial institutions, none of the financial and industrial institutions that we take for granted. Therefore, it is important to be familiar with the following factors that motivate people to buy.

(i) Needs and Wants

Once basic needs for survival are met, such as food, clothing, and shelter, man will consider those things that will make him more comfortable or are associated with making a living. Generally, marketing terminology labels the latter wants.

(ii) Convenience

As a nation improves its standard of living, the demand for convenience produces increases. For example, in the United States several companies prepare complete frozen meals which can be quickly heated in an oven and eaten in the same container. More is paid for such foods, but they save time and effort. There is a progression factor in the marketing of convenience products; when a product is introduced it may be a convenience product, but as its adoption spreads, it may be classified by the consumer as a 'wanted' item or even a 'needed' item.

(iii) Impulse

Even careful and selective consumers sometimes buy on impulse which can be caused by a sense of urgency related to the availability of the product, or it may even be contagious.

(iv) Status

Man often buys products in the hope of raising his social status. This can be referred to as status buying. Status buying is a potent force in the market even though an individual seldom admits the cause of his action.

(v) Boredom

If people are surrounded by material wealth, purchases are sometimes, childishly, made in order to relieve boredom.

Among farmers, the need factor is probably the strongest because a farmer hopes that fertilizer will make his crops grow better and yield more, resulting in a better standard of living for himself and his family. The status factor is also important because many farmers try to compete with other farmers in growing higher yielding crops.

It is important to understand how people react in the market place when planning any kind of marketing strategy or promotional campaign.

ADVERTISING AND SALES PROMOTION

The role of advertising in a marketing programme is to create public awareness and acceptance for a product or service. If a company is oriented toward its products but neglects to consider marketing concepts, it thinks in terms of what it wants to sell, of how it wants to distribute, of how to provide after-sale service, rather than considering what the customer wants. A capable advertising staff can change the attitude of such a company and direct it towards meeting the customer's needs. This is perhaps one of the most important functions of advertising, but inadequate planning leads to poor advertising, ineffective campaigns and wasted money.

Advertising should be an integral part of total sales promotional objectives, and is now regarded as a key sales promotional tool. In setting up a new company or reorganizing an established company, management should consider coordinating sales and advertising under the direction of one executive staff who will determine the advertising budget, select advertising media, and approve or disapprove advertising plans and copy prepared by the advertising agency, or the company advertising department.

In smaller companies, where it may not be possible for an executive to devote full time to sales planning, one of the company officers should assume this responsibility and determine the markets to be covered in a sales programme.

It will be seen that advertising is any form of public announcement intended to aid directly or indirectly the sale of a product or a service.

Sales promotion is much broader in definition. According to the U.S. Committee on Economic Development, sales promotion includes 'those sales activities that supplement both personal selling and advertising, coordinate them, and help to make them effective, such as displays, shows and expositions, demonstrations, and other nonrecurrent selling efforts not in the ordinary routine.'

Sales promotion differs from advertising only in terminology; advertising is a form of sales promotion. The advertising department of a large manufacturing company has defined the terms as follows: 'Sales promotion moves the product toward the buyer, while advertising moves the buyer toward the product.' A retail grocery executive has called sales promotion 'merchandising the advertising.'

Both advertising and sales promotion play an important role in company efforts to sell products. Advertising alone cannot be as effective as it is when supported by catalogues, brochures, shows and exhibits, films, and other audio-visual aids. A wide variety of such promotional ideas can help to stimulate buying and product identification.

THE ROLE OF GOVERNMENT AND INDUSTRY IN FERTILIZER PROMOTION

It is generally agreed that there is a need for education and promotion in a fertilizer marketing programme. However, there is some disagreement as to who should initiate this promotion and whom the government should serve. The answers become extremely important as the market matures. In the U.S.A. as the market matured and the pace of competition quickened, it became increasingly difficult and costly to keep in close contact with customer demands. The basic question raised was: What does the farmer want and who should supply him with information? Now, the basic question being asked is whether the government or industry should handle the initial education and promotion phases of the programme, and, further, who pays the cost of servicing an increasingly complex and dynamic market?

The answers are not easy. It might be helpful to look at the roles that have been played by government and industry as the market has grown in the U.S.A. from a young under-developed non-competitive market to one of much competition and complexity.

Government-Industry Role - Early Stages of Development

During the early stages of its development the fertilizer industry in the U.S.A. depended very heavily on the government for fertilizer education and promotion. Farmers were not aware of the benefits of fertilizers. The government, through the Federal Extension Service, land-grant colleges, and vocational agriculture system educated the farmer in the classroom and promoted fertilizer use through demonstrations, farmers' meetings, and field days. In general, the role of the government was to develop the market to a sufficient size within a given area to make it attractive for one or more members of the private sector to wish to serve that market.

The role of the industry in the early stages of fertilizer promotion was to supply product and/or financial grants to the government institutions for research and education. In many cases, industry financed students' programmes for higher education. It also made fertilizer available in areas where the government was promoting its use.

During this early stage of development the fertilizer industry depended heavily on the government to educate the farmers in the use of fertilizers. This seemed logical because of (a) the existence of a well financed and adequately staffed land-grant system and extension service, which was already deeply involved with farmer education and (b) the lack of a well developed fertilizer industry capable of financing and/or conducting such projects alone. Under these conditions, the industry was willing to allow the federal and state governments to assume the primary role of market development.

Government-Industry Role - Intermediate Stage of Development

The government promotion programmes, particularly those led by the extension service were very successful. The early demonstration programmes helped to develop sizable markets, which industry was quick to capture.

This led to competition between companies and to the first big attempt by industry to promote its products through brand identification. As the market developed, a need arose for more service to farmers in the areas of quality and techniques in use. This eventually led to fertilizer control laws and soil testing procedures. In both cases, the government took the lead. These services were apparently designed to protect the farmer from what some considered to be an unscrupulous industry. Little or no charge was made for this service to the farmer nor did the government determine the true cost of these services.

During this period the government took the dominant role through market development and by providing controls on the industry. The industry developed distribution systems, and generated goodwill with programmes such as grants for research and demonstration. Little market development work was done because there was, under the land grant system, no need for it, and moreover government was anxious about the ability and integrity of industry in the role of, what amounted to, extension work. In many cases, this concern was justified.

During the later stages of this phase of development, the market grew, competition increased and because government controlled the service phase, more emphasis was placed on advertising and promotion of specific brands. This did little to improve the image of the industry with the government or the farmer.

Meanwhile, the types of farmer using fertilizer became more stratified. The true managers began to appear and were characterized by (a) large farms, (b) heavy fertilizer use, (c) good education and financing, and (d) little response to brand promotion programmes.

These farmers sought technical information wherever they could find it. Although some companies tried to offer this service, it was always possible to obtain the same service free from the government.

Government-Industry Role - Mature Stage of Development

The fertilizer market in most sections in the U.S.A. is now considered mature; farmers are aware of the benefits of fertilizer, which is readily available and the basic want of the farmers of 50 years ago has been met. The farmer today is sophisticated, he no longer buys fertilizer by brand alone, he seldom believes advertisements regarding brand superiority, he is a well educated manager, and realizes that fertilizer is just one component of a crop production system. He wants and is willing to pay for good service. This may be in the form of better information on time of planting, variety, row spacing, and pesticides. Fertilizer alone is not what the farmer of today is interested in, and if a company offers nothing but fertilizer, then the farmer will buy at the lowest price possible. Fertilizer recommendations must be integrated into a total crop production system which considers all other conditions.

Government programmes are not designed to do this. Fertilizer recommendations and research in most cases refer to average conditions. Also, applied research at experiment stations has not received the support given it during the late forties and fifties. Many universities and Government programmes are not keeping pace with the real problem facing today's efficient farmer. Soil test and plant analysis programmes, which once received major emphasis by government, are being discontinued or relegated to industry. Federal and State Extension programmes are no longer promoting fertilizer use as they once did.

Industry has not been able to fill this void for several reasons. Farmers were never conditioned by either industry or government to appreciate the true cost of fertilizer research and development apart from the day to day costs of soil and plant analysis programmes. Therefore, many are not willing to pay the full cost of this service from industry. A credibility gap still exists between the farmer and the industry. It dates from the days when industry emphasized brand promotion and when government implied that industry had ulterior motives for selling fertilizer. Government stressed the need to buy fertilizer at the cheapest price possible and gave industry no credit for their services.

CONCLUSIONS

There are several lessons to be learned from the experiences in the U.S.A. if a successful and continuous government/industry relationship is to develop. Some of these are:

1. From the beginning the government must clearly recognize its role primarily as a catalyst to get an industry started, developing personnel capable of functioning in the system, serving as a centre for long-range imaginative planning. It must also ensure that the system has enough checks and balances to allow it to function efficiently with the best interests of the farmer in mind, but to be served primarily through industry.
2. The government must in its policies to industry recognize and consider the true costs of fertilizer education and promotion if it expects industry to perform this function.
3. Government must recognize the needs and capabilities of industry and be willing to satisfy these needs. It must let industry perform these duties as quickly as possible after industry has demonstrated that it is capable of performing at a level equal to that of government.

4. Industry must be sensitive to the needs of the market and be willing to accept responsibilities according to its capabilities and as needs develop. It must avoid exploitation of the farmer.

MARKETING OF FERTILIZERS
THROUGH LOCAL STOCKISTS IN KENYA

by
K. Zschernitz ^{1/}

SUMMARY

During the last few years fertilizer consumption has increased considerably in Kenya. Most of the increase in fertilizer sales has gone to small scale farming areas. There are several marketing channels for fertilizers in Kenya; the marketing of fertilizers and other farm inputs to large numbers of small farmers through local traders is the most successful but there is still room for improvement, the lack of credit facilities and shortage of storage space at the village level being the main obstacles. Project proposals have been submitted to several potential donors for the provision of finance for a credit system for stockists.

INTRODUCTION

In recent years fertilizer consumption has increased considerably in Kenya. From 1960 to 1970 the fertilizer consumption has gone up about four times, from 9 846 tons to 39 800 tons of plant nutrients. This trend has even accelerated during the last two years. At the beginning of the sixties almost all the fertilizer was used by large-scale farms or plantations. Very little went to the small scale farming areas. This has changed completely during the late sixties and the beginning of the seventies.

It is generally agreed that almost all of the increase in fertilizer consumption since 1968-1969 went to the small-scale farming areas, while the consumption of the large-scale agricultural sector was almost static.

At the same time as the increase of fertilizer consumption in small-scale farming areas took place, two firms, partly in cooperation with the Kenya Seed Company, established a network of local stockists all over the country. These firms are the Kenya Farmers Association (KFA) and Mackenzie Dalgety Ltd.

Some fertilizer was also channelled to small farmers through cooperative unions and their affiliated societies. However, there were setbacks in that the management of some unions was inadequate. Often fertilizers were ordered late and in insufficient quantities. Because of lack of cooperation between the Ministry of Agriculture extension staff and cooperative officers, the wrong types of fertilizer were sometimes ordered by the unions.

Branches of KFA and Mackenzie Dalgety also sold direct to farmers, but many of these branches are located in large-scale farming areas or they are so far from most of the farms that the farmers have to travel 10 miles or more to buy one or two bags of fertilizer.

Because of these problems the stockist systems emerged as the most efficient channel of fertilizer sales to small farmers during the last few years. In the following an attempt is made to describe the development and functioning of the stockist system in Kenya.

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FERTILIZER CONSUMPTION TRENDS IN KENYA

Fertilizer consumption increased steadily during the last decade, accelerating at the end of the sixties and the beginning of the seventies. Table I gives figures for the last eight years.

Table I. Imports of Manufactured Fertilizer into Kenya
(in metric tons)

1963	38 621
1964	55 364
1965	70 498
1966	71 279
1967	81 476*
1968	84 701*
1969	105 413*
1970	141 215*

*including imports of single superphosphate from Uganda.

Source: Annual Trade Report, E.A. Community.

Consumption in small scale farming areas accelerated even faster than the total imports as can be seen from Table II. Figures given were obtained from KFA stores located in small scale farming areas. Most of this fertilizer was sold through stockists in small market-places. During the last three planting seasons sales have more than doubled.

There have been several forecasts concerning future consumption of fertilizers in specific areas in the world. Among the more realistic seems to be the predictions made by the Tennessee Valley Authority in a feasibility study for the establishment of a fertilizer factory. As can be seen from Figure I, there will be a tremendous increase of consumption up to 1980. Actual consumption figures for 1970 and 1971 are higher than given in the diagram. Most of this anticipated increase of consumption will go to small scale farmer farmers.

PROBLEMS OF FERTILIZER SUPPLY TO LARGE NUMBERS OF SMALL SCALE FARMERS

The author of this paper, working since 1963 with the FAO Fertilizer Programme, has had the opportunity to study fertilizer supply systems to small farmers in a number of African countries. The problems encountered are tremendous. Even if the demand was created by carrying out field demonstrations for several years, most difficulties arose when fertilizers had to be brought to the farms. Kenya was, so far, an exception as in this country an established commercial network existed, which used, in its beginnings, to supply the large-scale farming sector. This system had only to be extended and modified to serve the large number of small farmers.

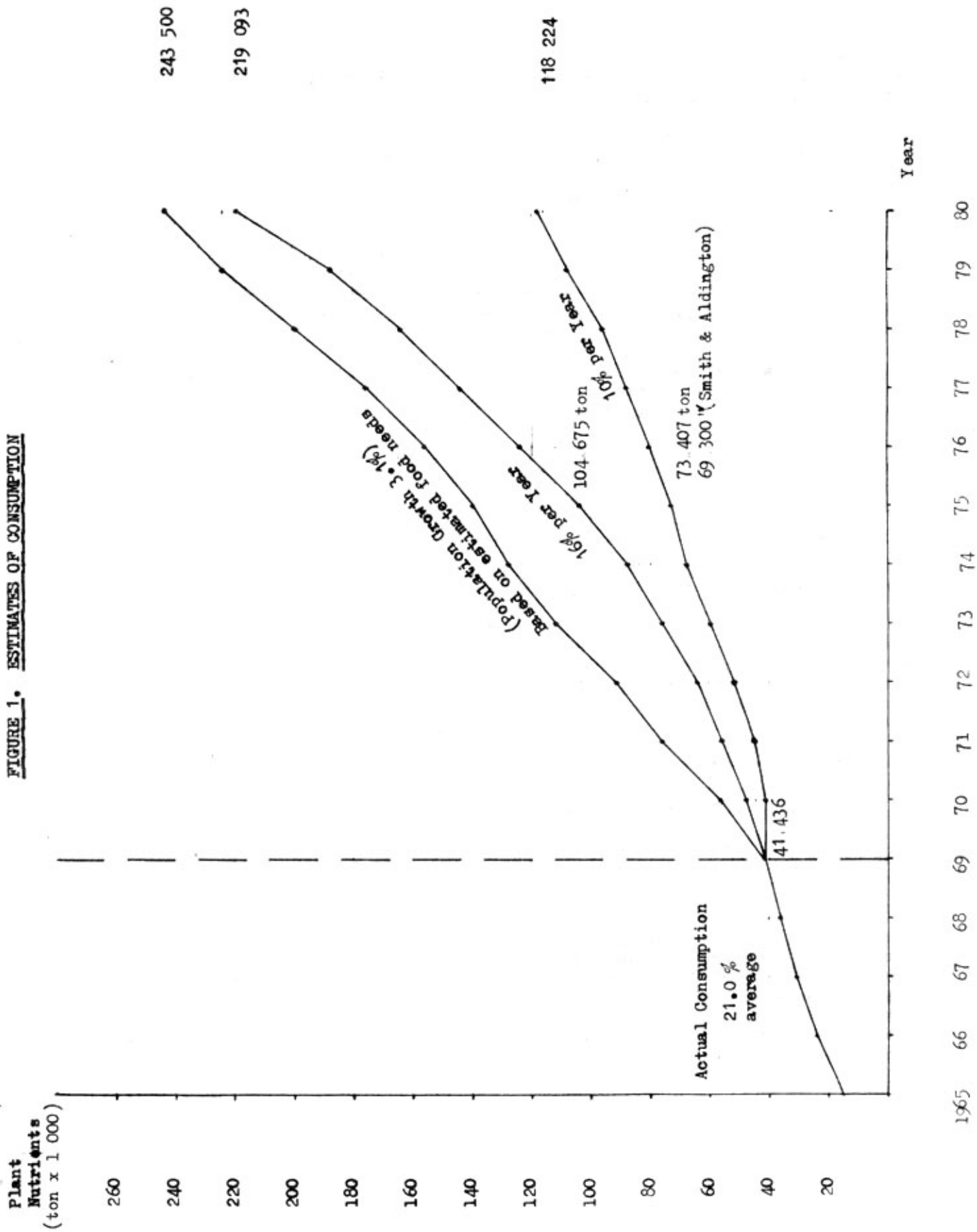
The problems encountered were as follows:

The large-scale farming areas were relatively well served by the railway, but it did not usually extend to the former, so called, African Reserves. A great deal of road transport was required to bring the fertilizers from the railway to the main depots in the small-scale farming areas. This, of course, made the fertilizer more expensive for the consumer. Very often no big stores existed in these areas. As fertilizer sales are usually effected within a short period from February/March to the beginning of April this posed a serious problem. During the last few years in Kenya Farmers Association steadily increased their storage space in the small-scale farming areas. Also the Maize and Produce Board made their stores available for the storage of fertilizers.

Table II. Fertilizer Sales in Small-Scale Farming Areas by KFA

	Number of bags sold						TOTAL
	KARATINA	KISII	KAKAMEGA	BUROMA	BODDERICK FALLS		
<u>1968/1969</u>							
Twiga Single Supers. 21/22%	499	1 759	4 073	6 764	8 374	21 469	
Double Supers. 40/42%	210	226	671	127	370	1 604	
Sulphate of Ammonia 21% - 10Kg	5	22	210	405	207	849	
A.S.N. 26%N - 5Kg	8	82	-	84	-	174	
C.A.N. 26%N - 5Kg	60	30	-	-	-	90	
Compound 11x53/54x0 - 5Kg	-	3	-	-	-	3	
Miscellaneous	-	1	-	-	-	1	
	782	2 123	4 954	7 380	8 951	24 190	
<u>1969/1970</u>							
Twiga Single Supers. 21/22%	4 743	6 274	3 449	8 449	19 686	42 601	
Double Supers. 40/42%	476	200	790	198	176	1 840	
Sulphate of Ammonia 21% - 5Kg	34	85	358	961	302	1 740	
A.S.N. 26%N - 10Kg	84	45	-	68	-	197	
C.A.N. 26%N - 10Kg	263	56	2	-	-	321	
Di-Ammonium Phosphate	87	7	-	-	-	94	
Compound 15x45x0	65	-	46	-	-	111	
Compound 11x53/54x0 - 5Kg	-	-	12	-	-	12	
Miscellaneous	-	1	-	-	-	1	
	5 752	6 668	4 657	9 676	20 164	46 917	
<u>1970/1971</u>							
Twiga Single Supers. 21/22%	6 006	5 129	1 706	12 208	10 725	35 774	
Double Supers. 43%	472	1 104	508	141	513	2 738	
Sulphate of Ammonia 21% - 5Kg	216	471	1 005	2 181	1 127	5 000	
A.S.N. 26%N - 5Kg	39	6	69	116	114	344	
C.A.N. 26%N - 5Kg	30	15	8	1 410	2	1 465	
Compound 15x45x0 - 5Kg	20	-	44	-	63	127	
Compound 11x53/54x0 - 5Kg	2	1	149	-	29	181	
Compound 11x53/54x0 - 33-1/3Kg	212	326	1 521	7 614	1 779	11 452	
Di-Ammonium Phosphate	179	3	8	-	-	190	
	7 176	7 055	5 018	23 670	14 352	57 271	

FIGURE 1. ESTIMATES OF CONSUMPTION



It was soon obvious that main depots alone would not be enough. Many farmers had to travel over long distances to obtain their supplies of fertilizers. That made the use of fertilizers very difficult for them. Although many farmers knew about the good effects of fertilizers, it was too difficult for them to obtain it. The Cooperative Unions and their affiliated societies functioned well only in some parts of the country, mainly where coffee was grown. Even there, the supply function of the Unions was not well organized.

For these reasons a large number of sales outlets had to be created to bring the fertilizer and other inputs such as seed, closer to the farmers. In earlier years some of the Asian traders, who had shops in the local market places, stocked some fertilizers; however, their numbers were rather small and they were scattered far apart.

It became obvious that the large number of African traders had to be involved in the sales of agricultural inputs. It was also the policy of the Kenya Government to channel more business to the new African traders.

By appointing large numbers of relatively untrained local traders as stockists for inputs, a big need for training of these people and cooperation with the Extension Staff of the Ministry of Agriculture arose.

The FAO Fertilizer Programme made it a special task to solve this problem. The KFA and Mackenzie Dalgety also employed a number of field representatives specially for supervision of the stockists.

DIFFERENT MARKET CHANNELS FOR FERTILIZERS IN KENYA

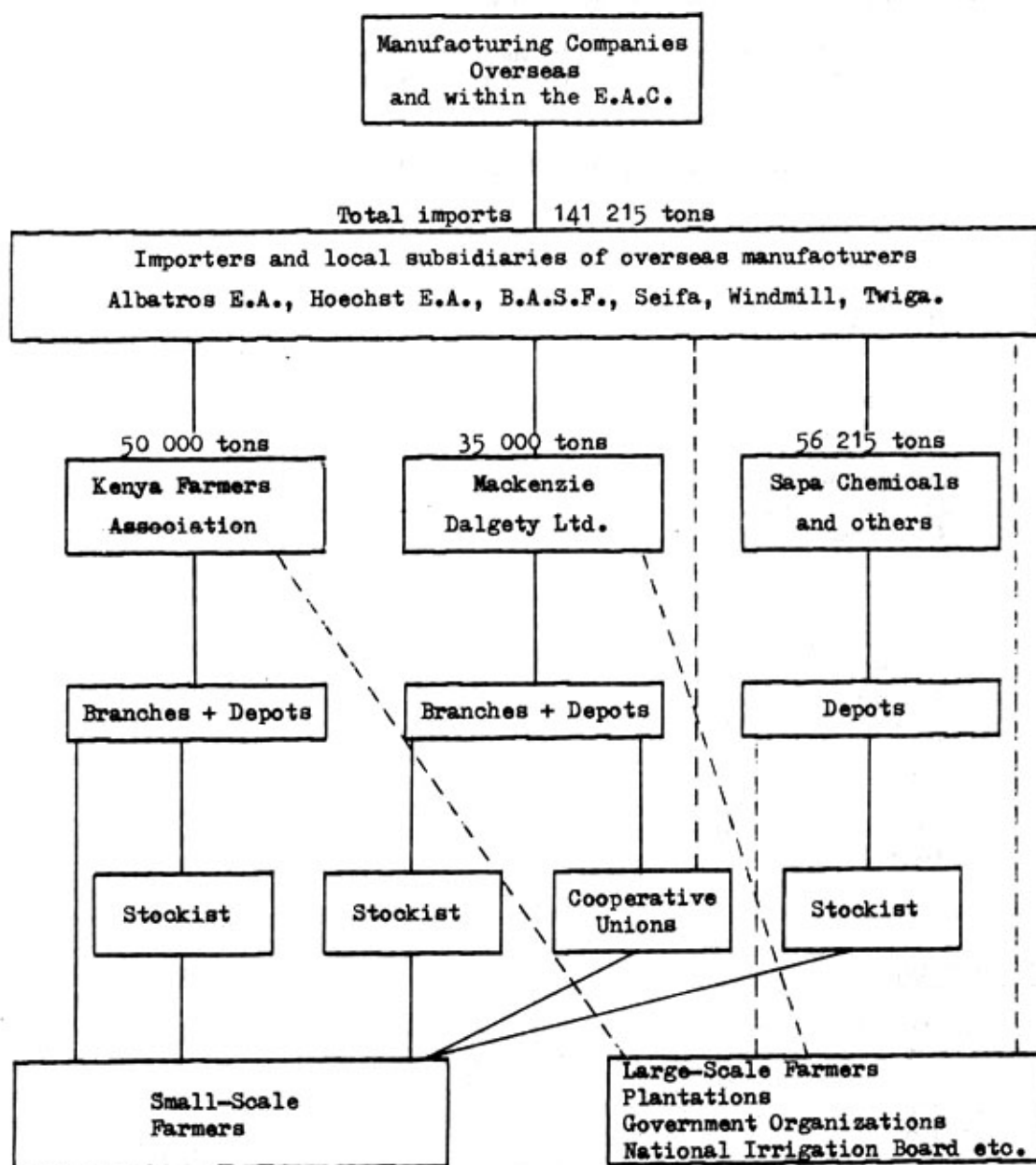
To make the points mentioned above clearer, Figure 2 shows a flow chart giving the different marketing channels for fertilizers in Kenya. Fertilizer imported from overseas goes first through the importers or the local subsidiaries of overseas manufacturers. They supply some fertilizer directly to large farmers' plantations and Government Organizations such as the National Irrigation Board, Kenya Tea Development Authority and the Cooperative Unions etc. Most of the fertilizer, however, goes to the fertilizer trading firms, of which the biggest are KFA and Mackenzie Dalgety. They usually rail the fertilizer directly to their branches and depots up country from where some is sold to farmers, but the larger share is supplied to local stockists and unions who retail it to farmers. As the dotted lines indicate, some large orders are also supplied by the fertilizer trading firms to the large-scale farming sector.

DEVELOPMENT OF THE STOCKIST SYSTEMS IN KENYA

The stockist system developed gradually over the years in Kenya. As mentioned before in the beginning only a few Asian traders sold fertilizer from their dukas in the country market-places.

In 1967 the Kenya Government persuaded KFA and Mackenzie Dalgety to appoint more stockists and to supply fertilizers on credit or on consignment to them. A considerable number of stockists were appointed in this year and credit was given to them. As both firms had no real security from the newly appointed stockists for the credits given to them, there were many bad debts and both firms lost several thousand pounds. The result was that in 1968 no credit was given to stockists. Fertilizers could be obtained from the depots only on a strictly cash basis. Because of this many stockists went out of the fertilizer business completely.

Figure 2. Organization Chart of Fertilizer Trade in Kenya 1970



_____ small amounts

----- large orders and tenders

In 1969 and 70 the strict cash policy continued but the number of stockists increased steadily. Some credits were given again to a selected few stockists that had a good repayment record. Many traders saw that profit could be made by selling fertilizers and seed. In addition many of the new African businessmen gained more experience over the years. All this helped to develop the stockist system further.

In 1971 and 1972 KFA in cooperation with the Kenya Seed Company appointed a very large number of stockists. The total number of stockists appointed in various districts are as follows:

Table III. Total Number of Stockists

<u>Province or District</u>	<u>Number of Stockists</u>
Coast Province	13
Kericho District	126
Kitui District	56
Machakos District	90
Kiambu District	30
Muranga District	34
Embu District	23
Meru District	41
Kiruiya District	8
Nyeri District	54
Nyandarua District	53
Nakuru District	7
Baringo District	39
Elgeyo-Marakwet District	4
Nandi District	48
Trans-Nzoia District	55
Bungoma District	132
Kakamega District	203
Siaya District	33
Kisumu District	27
Kisii District	154
South Nyanza District	53
Busia District	22
Total	<u>1305</u>

THE STOCKIST AND HIS BUSINESS

Considering the large numbers of stockists appointed over the last few years it must be kept in mind that there is considerable variation between them concerning size of the business, personal abilities, location of the store etc. The average stockist is a local African trader, possibly with a helper, whose store is located in one of the marketplaces that are scattered over the Kenya countryside. He is usually not too well educated. Most of them speak Kiswahili besides their local language, but only a few of them speak English. Usually the whole family helps to run the business. Many traders have a piece of land or even a full sized farm besides the store. Usually a considerable amount of merchandise, besides agricultural inputs, is sold in the store, e.g. sugar, tea, cigarettes, kerosene, nails, tools and sometimes cloth. This is sound business because no trader could live from the sale of fertilizer and seed alone.

Some of the better traders have their own transport such as a small pick-up or a lorry. However, most traders hire transport to fetch their supplies from the depots.

Over the last few years a kind of natural selection of stockists has taken place and it is still continuing. Some of the originally appointed stockists have dropped out of the business, while others have secured more of it. In some of the better districts there are now stockists that sell several hundred 50kg bags of fertilizers and up to 1 000 bags of maize seed. A large number of stockists only sell 10-15 bags of fertilizer and less than 100 bags of maize seed. In some cases the fertilizer bags are opened and the fertilizer is sold by the kilogramme.

The profit margin allowed to the stockist by the wholesaler is usually 8%. For transport he can charge 75 cents per ton mile. This profit margin is rather low and the Havelock Report recommended that this margin be increased to 10%. The Author is also of the opinion that the profit margin should be increased so that more traders become interested in selling fertilizers.

Until a short time ago these local traders mainly sold consumer goods. By becoming involved in the selling of agricultural inputs they can contribute considerably to the development of Kenya's agriculture.

FUTURE IMPROVEMENT AND EXPANSION OF THE STOCKIST SYSTEM

To improve the stockist system further it is most necessary to find a source of credit for them. In the FAO Fertilizer Programme Pilot Schemes ways and means are tested to implement this idea. The Kenya Commercial Bank is willing to cooperate in such a scheme. In this sense also a FAO/NORAD fertilizer distribution scheme is being considered for implementation in 1974 to test the ideal further. A project proposal has been submitted to the World Bank in Washington, and the African Development Bank has also shown interest in financing a credit scheme for stockists of agricultural inputs. These larger projects, if they materialize, are scheduled to start after the testing period.

It is anticipated that credit of 5 000 ksh. for six months will be given to traders at an annual interest rate of 9%. This capital would be enough for 6 tons of fertilizer, 60 bags of maize seed and some insecticides.

As many stockists have not enough storage space in their stores it is necessary to give them a medium term credit of about 3 000 ksh. to build a small store with concrete floor and a corrugated iron roof. Both the availability of more working capital and storage space would enable the stockist to have sufficient stocks on hand at the crucial time when the rains start and all farmers want to buy fertilizer at once. Under present conditions stockists often have only a few bags of fertilizer in their stores, which are sometimes sold out in a day or two. Then the stockist has to organize transport to fetch more fertilizer from the depot. This often takes several days or a week, during which time no fertilizer can be sold to farmers. The result is late planting by a large number of farmers. It is also necessary that the stockist should participate in short training courses to acquire some knowledge of the fertilizers and seed he sells. Some of this training is done by the field representatives of the firms. The staff of the FAO Fertilizer Programme is conducting courses. The Ministry of Commerce and Industry organizes courses in simple book-keeping.

Courses for stockists organized by the FAO Associate Expert, B. Hansen, had the following agenda:

Agenda of the Training Courses for Stockists in Coast Province

8.30 - 9.00 a.m.	Opening and briefing on agricultural policy	District Agricultural Officer
9.00 - 10.00 a.m.	What it means to be a KFA Stockist	KFA Representative
10.00 - 12.30 p.m.	Fertilizers Pesticides Fungicides	FAO Expert Crops Officer KFA Representative
12.30 - 2.00 p.m.	Lunch	
2.00 - 3.00 p.m.	Feeds and drugs for Animals	Animal Health Officer
3.00 - 4.30 p.m.	Finance and Credit	District Credit Officer

These courses must usually be completed in one day, because most of the stockists are not willing to leave their businesses for longer. Meetings should be organized on a divisional basis to avoid too much travelling.

CONCLUSION

The stockist system of supplying inputs to large numbers of small-scale farmers has emerged as the most successful in Kenya. Although there is still room for much improvement, only with the help of the local traders will it be possible to improve agriculture further in small holders areas in Kenya. Not all districts have developed at the same pace as can be seen from the different number of stockists in the various districts. In future, more efforts should be made to appoint more stockists in less developed districts; this will help to accelerate development in the more backward districts.

SCOPE FOR IMPROVING MARKETING AND CREDIT SYSTEMS FOR
FERTILIZERS IN AFRICAN COUNTRIES

Comments and questions regarding five selected fertilizer marketing and
credit systems in Africa

by

H.J. Mittendorf ^{1/}

Introduction

After having discussed problems of fertilizer marketing and credit improvement in principle, on the basis of the paper "Fertilizer Marketing in Developing Countries" ^{2/} a few marketing and credit systems in certain countries were analysed in more depth with the objective of identifying the major constraints and indicating solutions for their improvement. Five countries were selected for this study, because more detailed information could be obtained from FAO field marketing officers in those countries. Information on other countries would be welcomed. In order to facilitate the analysis of these five systems the attached table was prepared, in which the major elements of the marketing and credit systems have been presented in a more or less comparable way. The information is not complete and is only tentative. Participants in the seminar were kindly requested to check the information carefully and to amend and correct it as necessary.

Consumption

As can be seen from the table, Kenya has reached the highest consumption of fertilizers during the past ten years and is far ahead in comparison with the other African countries studied. Zambia is next to Kenya but while Ethiopia is just building up fertilizer consumption, it appears that application in Ghana and Nigeria is at a standstill or expanding only slightly. What are the reasons for the slow expansion of fertilizer in West Africa; could they be the marketing system, the economics of fertilizer use or the development of level of the farmer or some combination of these factors?

Marketing channels

While Kenya and Ethiopia have privately organized systems, in Zambia the marketing of fertilizers is organized by the National Agricultural Marketing Board. In Ghana and Nigeria fertilizer is mainly distributed by the government extension services.

Transport

In order to reduce transport costs full use should be made of empty return trucks. This is particularly possible in situations where fertilizers are integrated into the general agricultural marketing system, as in Ethiopia, where the coffee trucks could transport fertilizers on their way to the producing areas. Transport costs are extremely high in Africa and therefore every effort should be made to use existing capacity to the fullest extent and if possible during periods when transport facilities are not fully utilized. What is the scope for improving transport arrangements and reducing costs by better organization?

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^{2/} By H. Creupelandt, Fertilizer Marketing in Developing Countries, AGL:TPFD/72/7.

Storage

The ultimate aim of an efficient fertilizer marketing system should be to transport as much as possible of the fertilizer to the final consumers, or at least as near as practicable to them and have the fertilizer stored there, which would reduce intermediate storage and handling costs. This, however, requires incentives through discounts to retailers and farmers to purchase fertilizers early and to obtain credit for storage. These incentives have not been adequately introduced under the prevailing systems in Africa. Furthermore, there is no fully developed system for assessing adequately the demand on a regional and subregional basis within the countries.

Credit

One of the major constraints to fertilizer marketing is the difficulty in organizing institutional credit for small-scale farmers. The organization of joint liability groups is one way, but requires considerable supervision. In order to overcome this immediate problem one method would be for the existing retail trade to be incorporated into the fertilizer distribution system but with access to credit to keep fertilizer stocks at an adequate level and provision of supervised credit for farmers. This credit line through the trade, as an alternative to institutional credit, has been developed successfully in many other countries and is apparently a strong element in the fertilizer marketing system of Kenya.

Pricing

In some countries uniform fixed prices are considered as a means of promoting fertilizer application particularly in distant farming areas. This raises, however, the question of whether fertilizer promotion should be subsidized in far distant areas at the expense of producing areas near the market. Furthermore, there is the problem of administering a transport pool system efficiently without permitting malpractices by transport entrepreneurs.

Apart from Ethiopia all the countries subsidize fertilizer prices between 15 and 90 percent. Is this subsidy justified? If we assume that the limiting factor with regard to the use of fertilizers is the farmers' lack of knowledge and inadequate marketing and credit systems, should we not subsidize the building up of extension, marketing and credit services rather than subsidizing the fertilizers as such? In those cases where the government charges considerable export taxes, as for instance in Nigeria, a subsidy is required in order to return to the farming sector part of the income deducted from the sales of agricultural products.

Another aspect in connection with the administration of subsidies is the stage at which subsidies should be introduced into the marketing system - at the import level or at the state level, as in Nigeria? There are many reasons for favouring the injection of subsidies at the import level, since this would probably reduce the administrative costs and would also provide fair competitive conditions for different marketing enterprises.

In most of the marketing systems there are inadequate incentives for early purchasing and the placing of large orders. Any discount to be provided for early purchasing should be at least as high as storage costs to compensate for these, otherwise the traders, co-operatives or farmers will not be willing to stock fertilizers.

Gross marketing margins

It is difficult to provide comparative data on marketing costs and margins in Africa for fertilizers and credit, since the conditions and the services involved differ from country to country. There are countries where distribution costs amount to as much as the fertilizer c.i.f. price; in other words, marketing costs would double the price of the fertilizers if the latter were not subsidized. In one country there are considerable overhead costs for marketing fertilizer, amounting to about US\$28.00 per ton, which appears to be excessive.

Promotion

In all the selected countries extension services are primarily responsible for promotion at farm level. However, it is generally recognized that extension services are still relatively weak in relation to the requirements. Besides, very little is being done at present to organize effective sales promotion campaigns which would boost fertilizer sales. A start is being made, it appears, in Kenya. What recommendations can be made to organize effective sales promotion campaigns?

Conclusions and Recommendations

Under these subheadings a number of points have been raised regarding present constraints to the marketing systems, and proposals have been made as to how these systems could be improved. There is one specific point: many of the fertilizer marketing and credit systems do not include sufficient incentives for those involved to carry out their activities more efficiently and to take a greater interest in sales promotion. This refers particularly to the pricing system, where with regard to discounts better provision should be made for those who are more effective in enhancing sales. There is apparently a great need for more specialized training in fertilizer marketing and credit at different levels, such as at government policy level, at executive level and also at the retail level.

Any further suggestions as to how the fertilizer marketing and credit systems could be improved and built up would be greatly appreciated.

THE ROLE OF COOPERATIVES IN INPUT SUPPLY AND PRODUCE
MARKETING - THE DANISH EXAMPLE

by
V. Johansen ^{1/}

INTRODUCTION

In a situation where growing urban populations demand increasing quantities of food, national governments face the great challenge of forming agricultural policies and infrastructures in such a way as to encourage a more intensive use of available resources for food production.

As the natural resources for food production are usually not expandable at reasonable costs, the most natural approach is to intensify production within resources already developed and available.

The subsistence farmer cannot be expected to worry much about the growing need for increasing food supplies to urban populations. The initial steps to industrialize agriculture must, therefore, come from elsewhere, usually from the government.

The beginning of industrialization in agriculture can well be defined as the time when the farmer starts purchasing commercial inputs for the purpose of increasing production of marketable goods, with the intention of creating a profit for his own benefit..

An increase in production from a given amount of natural resources such as land and available family labour can only be brought about by employing inputs originating from external sources, and the most important ones are probably credit, machinery, fertilizers, concentrated feedstuffs and various improved seeds.

Keeping the subject of this seminar in mind only fertilizers will be dealt with in length, although reference will be made to other inputs whenever appropriate.

THE DANISH BACKGROUND

The process of intensifying agriculture to secure an increased production of saleable products started in Denmark in the Middle Ages several hundred years ago. In those days the average farm unit was basically self-sufficient and only to an absolutely minimal extent dependent upon external supplies. The type of situation which is of interest to this seminar did not really occur until the latter half of the 19th century.

In order fully to appreciate what took place in Danish agriculture at that time, it will be necessary to understand a few basic features of the situation, which can be outlined as follows:-

- a) Commodities previously available for sale were mainly primary products such as grain, live cattle, sheep and wool.

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- b) Around 1880 the price of grain which up to that time had comprised the major part of saleable agricultural products, went down drastically due to the cheap North American grains flooding European markets. From then on marketing of Danish grain in her traditional markets could only take place at considerable losses to the farmers.
- c) The cooperative movement, aiming at establishing the necessary processing plants for all animal products, had been started a few years previously and a desire already existed among Danish farmers to switch from the primary export of grain and live animals to a more sophisticated production of secondary products such as cheese, butter, eggs, processed meat, etc.
- d) By the standards of that time, Danish farmers were well educated as elementary schooling had been compulsory since 1814. Besides, the Folk High Schools, various types of agricultural schools, farm organizations, literature on agricultural subjects, etc. had already had considerable effects on the educational level of Danish farmers.
- e) It was quite evident that intensive animal production was impossible based on the principles of the then prevailing pattern of subsistence farming. The inputs necessary to improve this situation, fertilizers and concentrated feedstuffs, were not available in sufficient quantities (as they had to be imported) due to the absence of the necessary natural resources for producing fertilizers, and lack of a suitable climate for growing high protein oil seeds.
- f) The trading system was a purely capitalistic one, in the hands of numerous private traders whose methods were subject to greatly varying degrees of honesty and reliability. These were, however, quick to discover that a fast expanding market for various agricultural inputs had arisen.
- g) Large quantities of feed grains were needed to maintain and increase livestock populations. As a consequence of low world market prices, Denmark stopped exporting grain in 1882 and started importing considerable quantities of foreign grain in 1883.

It is not difficult to recognize a number of similarities between the Danish conditions of the late 19th century and the conditions facing many developing countries today.

MARKET DEVELOPMENT

During the 18th century populations of most European countries were increasing rapidly, and the export markets for food products expanded accordingly. Denmark was in a good position to supply these markets because the area of developed farm land per capita was much higher than in other countries, and the livestock population was also relatively high.

However, most of the land was exhausted, a high percentage was in idle summer-fallow each year and crop yields were low. Also livestock was generally in a poor condition due to the annual shortage of feed in late winter and early spring. For the same reason, milk yields and weight gains were poor. It was, therefore, evident that a satisfactory production level allowing export of large quantities of food products would require an immediate adoption of various external inputs of which fertilizers and concentrated feeds were the most important.

PRIVATE TRADE

Private traders were quick to realize the growing market for such inputs and the import of fertilizers and oil cakes which had previously been undertaken on a very small scale was rapidly increased.

Although farmers were familiar with the evaluation of grain quality and the corresponding market price, they did not have much experience in judging the quality of these new products. There is historic evidence that very poor qualities of both fertilizers and concentrated feeds were traded at prices far exceeding their real values. Instances are known where fertilizers consisted of more than 30% sand, and commercial feedstuffs were often found to contain high proportions of seeds of various weeds and residues from flour mills as well as sand.

Prices also fluctuated greatly and many farmers wanting to increase production in the field or in their dairy herds were badly cheated when trying to purchase the necessary inputs in the local free market. Furthermore, private traders interested in the sales and distribution of commercial inputs for farmers adopted a practice of forming share companies strong enough to finance the necessary storage buildings, transport facilities and large purchases of the material in question. These joint ventures often developed into local monopolies and this was especially disadvantageous to the small scale farmer who was not able to move very far for his supplies. Finally, many farmers were in debt to these traders, thereby being forced to buy all further supplies from a trader who was at the same time his creditor - and at his price. It, therefore, became clear that a second supplier of these inputs was necessary to compete with the highly unfair practices of the private traders.

COOPERATIVE DISTRIBUTION

The cooperative principle had already been successful in the agricultural processing industry, and towards the end of the 19th century, several creameries and slaughter houses were in operation for the benefit of their members. Also a number of consumers' societies based on the cooperative principle were functioning successfully at that time. It was, therefore, quite natural to transfer the cooperative principle to purchasing and marketing of concentrated feeds and fertilizers.

During the period up to the year 1900 the value of imported feedstuffs far exceeded the value of imported fertilizers, and the first purchasing societies dealt with feedstuffs only. The first regional federation of input purchasing societies also concentrated its efforts exclusively on feedstuffs.

Despite the widespread disappointment which resulted from using the poor quality fertilizer supplied by various private traders, it nevertheless became known that good quality fertilizer was a highly profitable input when properly used. The farmers, therefore, made great efforts to secure dependable supplies through cooperative purchasing societies, operating on a local basis.

THE SUPPLY SITUATION

During the early stages of this development, Denmark had no domestic manufacture of fertilizers of any kind, and there was only one importer. For that reason, local purchasing societies were forced to depend on the same wholesale supplier as the private traders. The bargaining power of these small societies was also limited and no real price advantages were obtained in the early stages of cooperative fertilizer purchasing and distribution; thus, as long as there was only one importer of fertilizers, no particular attempt to reduce prices through bargaining with the foreign manufacturers was made.

Later, the private importer went into the manufacture of phosphatic fertilizers based on rock phosphate imported from Morocco, but the monopolistic supply situation was maintained.

The private suppliers of fertilizers all became increasingly dependent on the only fertilizer importer and wholesale distributor. Shortly after 1910 that company felt itself in so strong a position that it demanded that every local distributor should sign a contract obliging him to buy a certain minimum amount of fertilizers each year for a five-year period. Otherwise, he would not be able to buy anything at all. This was, of course, a most unsatisfactory condition for the farmer who well knew that he had no control over the prices he would be paying for future supplies of fertilizers.

COOPERATIVE BARGAINING POWER

Although the first cooperative purchasing society including fertilizers in its activity had already been formed in 1869, the first attempt to create real bargaining power for the benefit of the farmers was not made until 1901 when 22 local societies agreed to cooperate in future fertilizer purchases. The individual member societies also agreed to accept an obligation not to purchase fertilizers elsewhere, but the same obligation did not apply to the members of the individual societies, who would still be free to deal with private traders.

A real national cooperative federation for the purpose of purchasing fertilizers for its members was formed in 1916 when 1366 local societies with over 70 000 individual members, corresponding to about one third of all Danish farmers, signed up for membership.

This new organization was named D.A.G. (Dansk Andels Gødningsforretning, meaning Danish Cooperative Fertilizer Company).

The main aims of the D.A.G. can be summarized as follows:

- a) To obtain the desired fertilizer types for Danish agriculture at world market prices.
- b) To provide sufficient amounts of proper fertilizers at equal prices to every farmer in the country.
- c) To control the quality of fertilizers entering the Danish market, thereby providing a guarantee for the farmer that only top quality fertilizers would be marketed.

The price question (b) was difficult to solve owing to the differences in internal transport costs from port to consumer. However, during the course of a few years D.A.G. succeeded in making fertilizers available at every major seaport in the country. The price difference between fertilizers of the same type between various places in the country were from now on only due to differences in transport distance from port to consumer, thereby keeping fertilizer price differences at an absolute minimum. Already in 1936 a total of 114 Danish ports were equipped to receive, store and ship out fertilizers. Considering the total size of Denmark which only is approximately 43 500 square kilometres, it is evident that the maximum inland transportation distance is limited.

One of the conditions for societies joining was the acceptance of an obligation to purchase all the fertilizer supplies needed by the individual members for a ten-year period. This may seem like a rigid demand, but it was considered necessary to make the new organization strong from the beginning, and with the local societies themselves forming the governing board, the risk of such obligations being taken advantage of was eliminated. Further, it should be kept in mind that any profit made by the new organization was to be shared among its members at the end of each year according to their purchases.

By 1928, the national federation of Danish cooperatives for the purchasing and distribution of fertilizers in large quantities (D.A.G.) had gained sufficient strength and bargaining power to procure the Danish requirements of desired fertilizer types, at economic world market prices, and to balance the effect of the then emerging formation of trusts by manufacturers of potassium and nitrogen fertilizers.

THE INTEGRATED APPROACH

During the period 1916-64 the cooperative purchasing and distribution of concentrated feedstuffs and commercial fertilizers were handled by separate regional and national cooperative federations. In both cases the customers were the same, and it was rather obvious that such a system could not be the most effective way of distributing these inputs in the long run. As a result of lengthy negotiations between the regional feedstuff suppliers and the national cooperative fertilizer supplier, a national cooperative organization was formed for the manufacturing, purchasing and distribution of bulk agricultural inputs such as concentrated feedstuffs, commercial fertilizers, agricultural lime, feed grain, seeds and chemicals. The new organization was named D.L.G. (Dansk Landbrugs Grovvaeselskab, meaning Danish Cooperative Farm Supply Company). It will be noted that the aims and objectives of the D.L.G. are not limited to the distribution of bulk supplies to farmers.

After the extensive amalgamation of the cooperative supply system in the sixties, a network of modern distribution and processing centres covering most of the country has been established. These centres are equipped with technical facilities for receiving, cleaning and drying of grain; grinding, mixing, pelleting and bagging of concentrated feedstuffs; bulk storage and handling of grain, feedstuffs and fertilizers; bulk distribution of feedstuffs and fertilizers with specialized vehicles and equipment; distribution and application of anhydrous ammonia, solid fertilizers, etc. As a result of these large and more efficient centres some small local distribution centres are being closed down, but this will not cause inconvenience to the farmers as the importance of distance to the supply centre has decreased significantly with the efficient means of transport now available.

Concerning D.L.G.'s involvement in the grain sector it should be noted that the feed compounding activity requires tremendous amounts of feed grains. Therefore, D.L.G. is not only a distributor of feeds but also the largest single purchaser of feed grains from farms with an excess production of that commodity. By 1972 nearly all regional and local cooperative distribution centres had joined the D.L.G. which in consequence, has become a very powerful factor in the Danish agricultural input supply system. In fact, it can safely be claimed that D.L.G. is the price determining body within the system.

The D.L.G. is, therefore, in an ideal position to meet its objectives which are summarized as follows:-

- to supply its members, the farmers,
- with the necessary quantities of inputs
- in the best possible qualities
- in the most efficient way
- at the best possible terms of payment, and
- at the lowest possible prices.

An illustration of the efficiency with which these goals are being reached is the fact that the number of commercially available feed mixtures for various categories of livestock in the period from 1949 to 1965 has increased as follows: dairy cattle, from 2 to 14; pigs, from 2 to 16, and poultry from 4 to 19.

During the same period the number of fertilizer types available have increased to the present number which includes: nitrogen (N), 7 types; phosphorus (P), 2 types; potassium (K), 2 types; PK, 12 types; NPK, 8 types, and trace nutrients (Mg, Cu, B, Mn), 12 types.

THE COMPETITIVE SITUATION

It would be relevant to ask how the private distribution of inputs can survive under conditions which are to such a great extent being dominated by an aggressive cooperative movement. The answer seems to lie in the human hesitation to enter into the obligations involved in a cooperative membership. When dealing with the private supplier the customer has no further obligations when his purchase is delivered and paid for. For a member of a cooperative, the situation is different. He does not know the real price of his supplies until he has received his dividend at the end of the accounting year. Besides, he must take part in all the democratic obligations and processes within his cooperative, and he is subject to election for an often unpaid, but very time-consuming post on the board of directors.

The D.L.G. now supplies Danish agriculture with about 43% of its fertilizer requirements as well as similar proportions of other inputs, and the resulting competition between the cooperative network and the privately operated supply companies sources for Danish farmers dependable supplies of top quality products at fair world market prices.

However, in spite of the very tough competition between cooperatives and private trade in their approach towards the consumers, they are still generally speaking on very friendly terms.

There are several reasons for this, but one of the more obvious ones is the fact that the national cooperative fertilizer distributor, previously D.A.G. and now D.L.G., has never acted as an independent fertilizer manufacturer. Therefore, the cooperative system has always been the largest single purchaser of phosphatic fertilizers being manufactured by the privately owned Danish Fertilizer Company (D.F.C.), which in 1970 was reorganized and renamed Superfos A/S. In the early nineteen fifties, both D.L.G. and D.F.C. were among the founding shareholders of A/S Ammonia which in 1963 completed a large scale manufacturing plant for nitrogenous fertilizers now producing most of the Danish requirements of calcium ammonium nitrate and anhydrous ammonia. The annual Danish fertilizer statistics are published as a result of cooperation between the two sectors of the supply system.

PRODUCE MARKETING

The title of this paper indicates that a similar description of the importance of the cooperative movement in produce marketing should be given. However, to include this would take one beyond the set limits, but it can safely be stated that there are similar great advantages to be gained in the marketing and processing of agricultural products on a cooperative basis as have been outlined for the purchasing and supply side.

It is evident that it would be nonsense to increase agricultural production by creating an efficient supply system if the products could only be disposed of at a lower price or not marketed at all. Therefore, the development of the Danish cooperative system has continuously been concerned with processing and marketing and the cooperative movement has exercised a great influence in all areas of processing, domestic marketing and exports to foreign countries.

Where exporters are numerous, they tend to operate to the advantage of foreign buyers, in that any of these exporters might be tempted to undersell each other. Since no exporter can afford for long to export at a price lower than his purchasing and processing costs, any further reduction in price sought by a foreign buyer would have to be passed on to the farmer by offering lower prices for their products.

With large cooperative export organizations acting as single sellers in foreign markets, this problem is avoided, and with the farmers in principle owning these organizations themselves they will also receive all the benefits of the higher prices thus obtained.

It is worth mentioning that cooperative organizations have undertaken considerable activities in such varied fields as animal breeding, milk testing, purchase and distribution of consumers' goods, insurance, rural electrification, lime exploitation, agricultural equipment, real estate credit institutes, banking, cement manufacturing, housing developments, etc.

The only fields of real importance for agriculture in which cooperatives have not been involved to any significant extent are probably the supply of fuel and lubricants and veterinary services.

FINANCIAL AND BUDGETARY ASPECTS OF
FERTILIZER USE DEVELOPMENT

by
J.W. Couston ^{1/}

INTRODUCTION

The development of fertilizer use on a sound economic basis requires adequate, reliable and up-to-date data. Among the services government should provide for this purpose are the collection, analysis and reporting of essential agricultural statistics. These serve as the basis for estimating the current and future demand for fertilizers by government and the trade, and permit sound planning and budgeting of financial requirements for assuring their timely and adequate supply and sufficient resources for their sale. These latter needs include provision for marketing services, subsidy and price support measures and for credit to the trade and the farmer.

FERTILIZER USE DEVELOPMENT

Current Demand

For proper planning of supplies and financial requirements, current effective demand for fertilizers should be determined by crop and by locality in the country. This requires careful analysis to establish total and local fertilizer needs by nutrient (N, P₂O₅, K₂O, S and possibly trace elements where their need is known) and kind, delivery and storage logistics and credit requirements, on an annual or seasonal basis well in advance of the time of their application. In addition to the current situation there is also a need to estimate longer-term requirements for fertilizers, for the services that go with making them readily available to farmers, and for the marketing of crops. Agricultural and fertilizer data and their economic analysis are essential for these purposes.

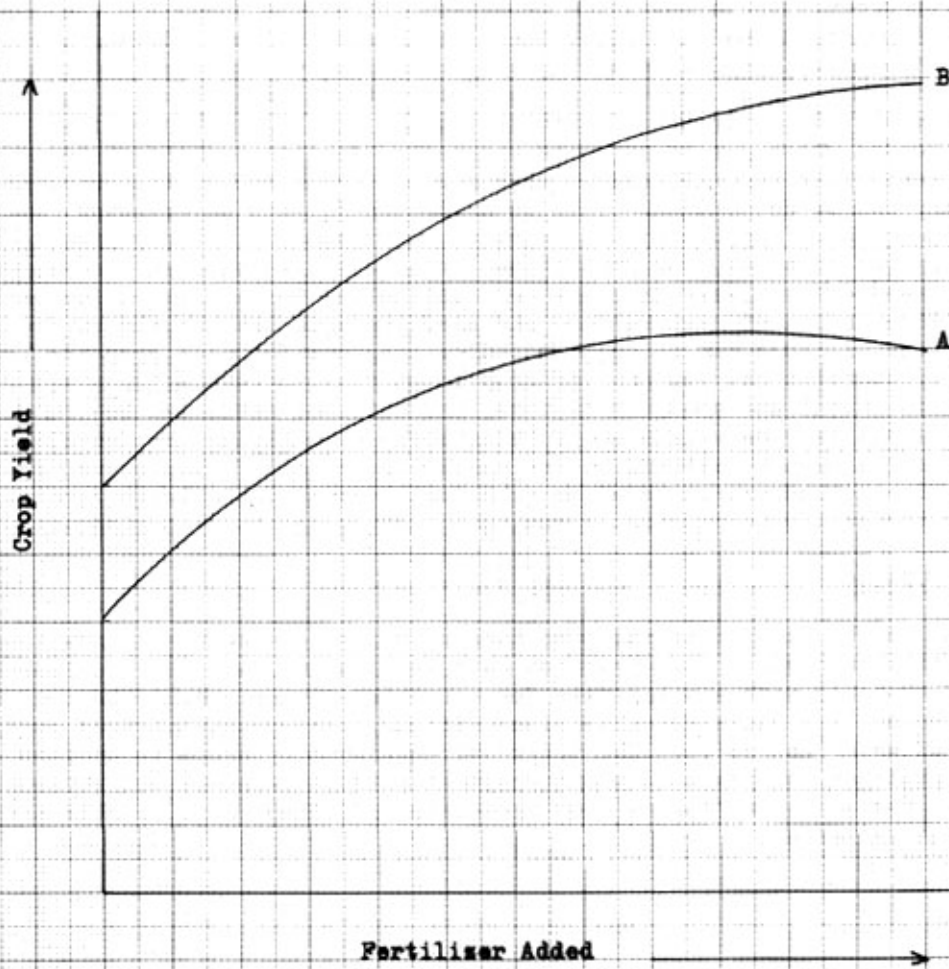
For example, among the crop statistics required for collection and analysis are those on areas, yields, production and portion marketed, on prices paid for inputs and received for crops by farmers, on sources, types, costs, prices, consumption and stocks of fertilizers, on their marketing costs and the marketing cost of crops.

Future Demand

Longer term planning (5 to 10 years) requires forecasts of fertilizer use both in light of their application trends as required by technological change, and in connection with food production goals in the frame of the overall economic development plan of the country. Continued research on the physical response of different crops to fertilizers is, therefore, essential. Such research must take into account improvements in and the use of related inputs such as seeds more responsive to fertilizer, better water supply and better management practices as they affect crop yields (Figure 1). Equally important are their economic analysis in relation to all factors influencing the sound and economic use of fertilizers in achieving the planned growth of agriculture.

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Figure 1. Effect of Improved Technology on Crop Yields



These statistical and analytical services are generally provided by government. The most suitable arrangement and agency or ministry within the government to provide them will depend on circumstances. It could be an independent unit or part of the agricultural or national planning office. In any case, the work carried out should be objective and indicate the needs and alternatives for fertilizer supplies and the policy measures and services required to have them used profitably by farmers. One of the first functions of such a unit would be to assess both the current and longer-term fertilizer requirements of the country in terms of nutrients and kinds of fertilizer, so as to plan and make the necessary financial provisions for their domestic production and/or importation. There are different methods of estimating future fertilizer requirements. These include trend analysis, response data, nutrient uptake and fertilizer-food grain conversion factor approaches, to name a few.

Response Data

Given crop production targets, the relationship between these and the supply and use of fertilizer depends on how much fertilizer can contribute to achieving the targets. Ideally, this presupposes reliable agricultural research on the expected responses to different nutrients for each crop under the different soil and climatic conditions of the country. Assuming this information is available and that the average yield increase and the economic return which can be expected under the existing price/cost relationship are used for the fertilizer recommendations made for different crops, the nutrient requirements for the country can be determined. This is a straightforward calculation, either of multiplying the rates of application of various nutrients by the crop area to be dressed to give the desired level of crop production, or of dividing the average increase expected from the recommended fertilizer dressing into the output target figure for each crop to get the fertilizer nutrient requirements and also the area that should be dressed at the recommended rate. A table can be constructed setting out for each crop the fertilizer requirements by nutrient and the area of crop to be dressed (Table 1). Taking into consideration technical and economic factors, the nutrient needs can be transformed into suitable fertilizer materials and formulations, thus giving the fertilizer supply and financial requirements in terms of the ex-factory or c.i.f. import value, farm value and credit, and other services needed to make fertilizers available to farmers, so that they are able to use the recommended dressing in achieving the crop production targets.

Nutrient Uptake

There may not be sufficient response data on which to make recommendations and determine fertilizer needs. When research data are lacking, what is available may be evaluated and compared with similar data for countries having comparable conditions, taking into account the differences in plant strains, the use of improved seeds, availability of water and so on. The uptake of nutrients by crops is another method of estimating fertilizer requirements where response data are lacking, but because of different levels of soil fertility, different crop varieties and other factors, this method generally gives very high estimates.

Table 1. Fertilizer Nutrient Requirements for Major Crops, 1972

Crop	Recommended Fertilizer Treatment (kg/ha)			Crop Area ('000 ha)	Fertilizer Nutrient Requirements ('000 mt)		
	N	P ₂ O ₅	K ₂ O		N	P ₂ O ₅	K ₂ O
A	120	60	60	1200	144	72	72
B	60	80	40	1000	60	80	40
C	100	50	50	800	80	40	40
D	20	80	40	600	12	48	24
E	0	60	30	400	-	24	12
Estimated total fertilizer nutrient needs ('000 mt)					296	264	188

Fertilizer-Food Conversion

The fertilizer-food grain conversion approach relates fertilizer use to increased food grain output on the basis of general conversion factors. The general relationship used is that one ton of fertilizer nutrients produces from 8 to 10 tons of food grains. Assuming a basic dietary requirement of 2 500 calories per person per day, and one ton of food grains providing about 5 000 calories a day for a year, one ton of food grain would be enough to feed two people for one year. It follows that that one ton of fertilizer nutrients would provide enough additional food grains to feed from 16 to 20 people for a year. Thus by combining a generalized yield response to fertilizer use and population growth, an estimate of fertilizers required to achieve food grain production targets can be made.

Projection of Trend

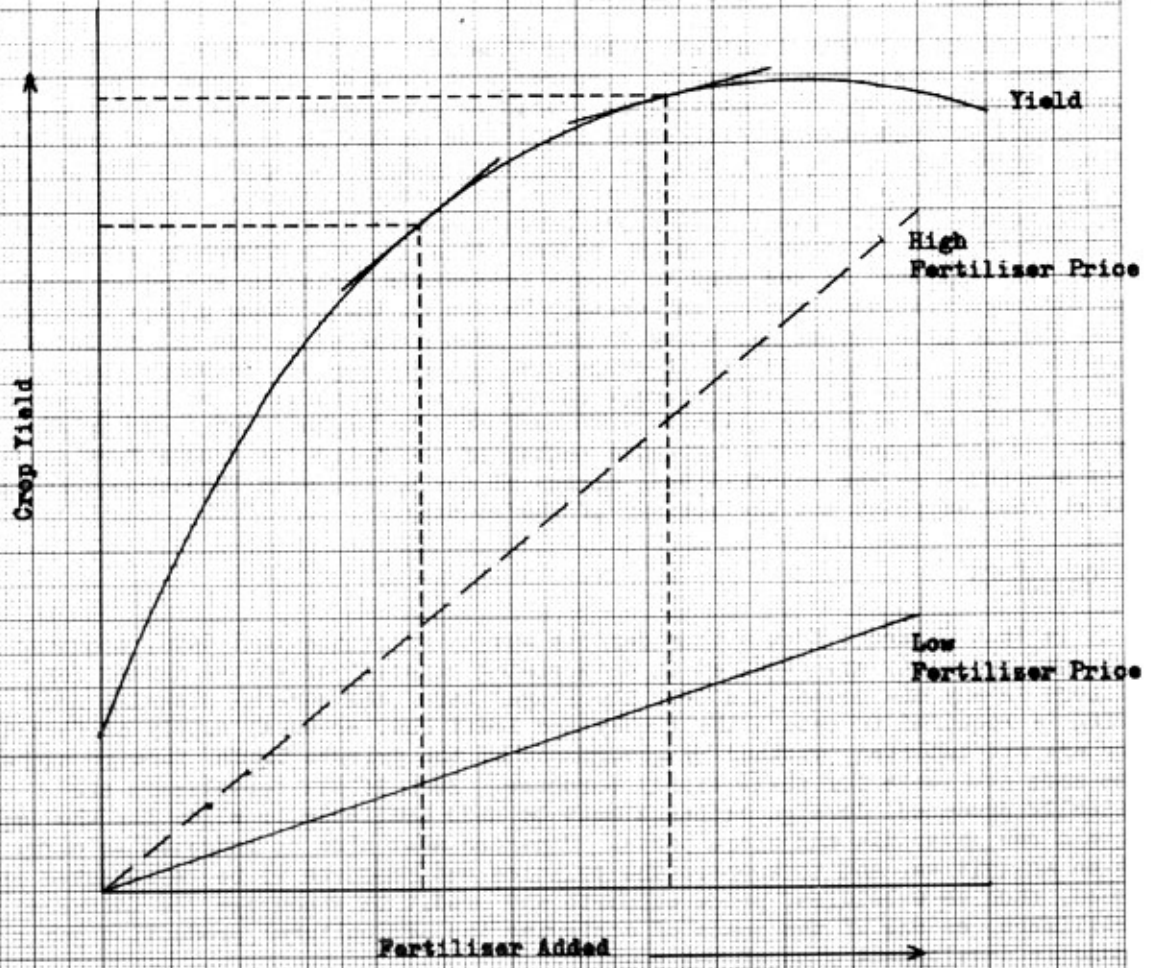
The method commonly used in market research is the projection of the consumption trend. However, the difficulty here is, inter alia, that because of the low consumption levels in some countries there may be no basis on which to estimate the trend of consumption. From the agronomic point of view past or present fertilizer use may not be suited to actual needs, and their projection would result in erroneous estimates. Another difficulty with this method is selecting the period to use as a base for extrapolation. Projecting a very dramatic increase in offtake owing, for instance, to the adoption of new technology by farmers, such as crops more responsive to fertilizer, may in the longer term be very misleading. Closely allied with this is the stage of fertilizer use in a country. When fertilizers are first used, the potential for greater use both in terms of heavier rates of application and crop area dressed, is large. Over a period of time, however, this potential becomes less as more of the crop area is dressed and heavier application rates are used. Crop/fertilizer price relationships may also change, as crop production increases may cause crop prices to decline. The economics of fertilizer use may also change because of an increase in the cost of fertilizer. Either one or both of these price changes may affect the optimum or recommended rate of nutrients to be applied to a crop (Figure 2), and could lead to the reduced use of fertilizer. It might also be that the marketing system and credit available for their sale and use by farmers are inadequate to handle the much larger quantities called for in the agricultural plan estimates for fertilizer use.

Combination of Methods

At this point it must be stressed that the larger quantities are indeed estimates, regardless of the method used in their calculation. Being estimates they should be kept under review and amended as circumstances change, i.e. adoption of new varieties, larger irrigated area, change in price relationships, etc. Furthermore, the present effective or market demand may be (probably is) considerably less than the calculated requirements. If the calculated targets are to be achieved a careful analysis is required to identify the impediments to greater fertilizer use by farmers, and policies and measures proposed and implemented to overcome them.

Perhaps the best approach to estimate fertilizer requirements is a partial combination of the foregoing methods which relates recommended fertilizer use to market demand on a local basis. This may be done by both the private fertilizer trade and government by the collection and analysis of the economic and statistical data mentioned. These include the size and number of farms and their level of income, the crops grown and portion marketed, the area irrigated, the use of improved fertilizer-responsive seeds, recommended and actual rate of fertilizer use by crop, crop/fertilizer price ratio, government measures for price support and subsidies, cash and credit sales of fertilizers, availability and terms of fertilizer credit to the trade and to the farmer, farmers' intentions for fertilizer use the following season. In some countries regional committees consisting of fertilizer producers, dealers and government personnel meet and review the analysis of such data to establish estimates of the quantities and kinds of fertilizer required each season, as compared to the season before. These estimates are then related to those fertilizers which can be supplied by domestic production and those that must be imported. The committees also estimate the financial requirements for the importation and the provision of credit to fertilizer producers, distributors and farmers to obtain, distribute and use the fertilizers.

Figure 2. Optimum Rate of Fertilizer Use as Influenced by Fertilizer Price



Assuming all the fertilizer requirements must be imported, and that on agronomic grounds ammonium nitrate (AN) is the most suitable material to supply the N requirements, triple superphosphate (TSP) to supply those of P_2O_5 and muriate of potash (MP) to supply those of K_2O , the financial needs can be calculated. To do so c.i.f. prices of these fertilizer materials must be estimated or known. From Table 2 it can be seen that at the assumed c.i.f. prices for the fertilizers \$ 122.3 million in foreign exchange must be made available for their importation. Assuming that transport, storage and marketing costs add 30 percent to their value at the farm, and it is estimated that half the fertilizers will be sold on credit provided by government institutions, then an additional \$ 79.5 million in local currency will have to be budgeted to provide credit to farmers. Furthermore, credit funds may have to be made available to the fertilizer importers, distributors and retailers, either through government agencies or the banking system, to help finance their business operations. If there is also a subsidy of say 25 percent on the farm price then an additional \$39.75 million will have to be budgeted to cover its costs.

Timely Ordering

Until fairly recently there was a buyers' market for fertilizers in international trade because of excess world capacity compared with demand. This has changed to a sellers' market owing to the restrictions placed on production by major producers, changes in aid arrangements and increased fertilizer demand in a number of countries. Regardless of whether it is a buyers' or a sellers' market it pays dividends to place orders early to obtain better terms and prices and timely delivery. Many countries, because of delays in tendering, end up paying much higher prices and the fertilizers arrive too late for use in the intended season. This not only adversely affects crop production but may lead to the need to import foodstuffs placing a further drain on foreign exchange reserves, and an unnecessary burden on the economy of the country. This may also lead to problems of unloading at ports when supplies arrive all at once, which may involve large demurrage charges if ships are kept waiting to discharge their cargoes, transport problems and additional storage charges when fertilizers are held over the next season, all of which may ultimately be reflected in higher fertilizer prices. Or it may be, as has happened this year in a number of countries, that some fertilizers are just not available on the international market at any price, with the consequent adverse effects on food supplies and the economy of the country.

CONCLUSION

It is thus apparent that a considerable amount of statistical data, economic analysis and judgement are required in determining expected effective demand for fertilizers in any one season and over the longer term, and careful planning and budgeting is required to ensure the timely and least cost seasonal supply of fertilizers. If they are all imported, whether by government or the private trade, foreign exchange must be made available for their timely purchase. Even if all fertilizers are domestically produced, foreign exchange must be made available to allow for the import of certain raw materials and spare parts. Finances must also be budgeted to carry out promotion activities, and to support the policies and measures to be implemented or continued, such as subsidies, price supports and credit to encourage the increased use of fertilizers, as one of the means of achieving the agricultural production goals of the economic development plan of the country.

Table 2. Estimated Fertilizer Nutrient Requirements and Import Value, 1972

Nutrients	Requirement ('000 mt)	Import Value ^{1/} (million \$)
N	296	59.2
P ₂ O ₅	264	39.6
K ₂ O	188	23.5
		<hr/> 122.3

^{1/} Assuming: 1 mt N = \$ 200 in AN 26% N
 1 mt P₂O₅ = \$ 150 in TSP 46% P₂O₅
 1 mt K₂O = \$ 125 in MP 60% K₂O

THE ROLE OF THE FERTILIZER INDUSTRY
IN FERTILIZER USE DEVELOPMENT

by

K.W. von Burkersroda ^{1/}

INTRODUCTION

The world fertilizer industry is well aware of the importance of developing its products and their use. Development, research and extension are being carried out with the aim of satisfying customers, and thus both farmers and manufacturers share the same interest. In order to attain our common goal, namely nutrients for the growing crops at lowest possible costs, the cooperation between the scientist, the technician and the farmer must be strengthened and intensified.

The participants of this Seminar will hardly need reminding of the history of the fertilizer industry which goes back as far as 1840 when the first patent for the production of superphosphates was registered in England. The first factory to extract muriate of potash from mined crude salts was set up in 1861 at Stassfurt in Germany. At about the same time sodium nitrate extracted from natural deposits in Chile came into use. However, mainly owing to the discovery of the ammonia-synthesis in 1913 in Germany, Chile nitrate became replaced more and more by synthetic nitrogenous fertilizers.

These discoveries and later advances in increasing technology resulted in the development of an important industry, which produces ever-increasing quantities of fertilizers. In the year 1960/61 for instance world production (excluding the People's Republic of China) reached 10.8 million m. tons N, 10.0 million tons P₂O₅ and 8.7 million tons K₂O, a total of almost 30 million tons. A decade later, world production had more than doubled to 64 million tons total nutrients made up of 29.1 million tons N, 18.2 million tons P₂O₅ and 16.7 million tons K₂O.

It is interesting to note that nearly half the world's N-, P₂O₅- and K₂O nutrients in 1970 were produced in Europe and about one third in North America, leaving a little more than 15 percent to the other geographical regions. Although Africa's share of the world production is rather small, during the period 1961-70 production in Africa increased in all of the three nutrients, but mainly in P₂O₅. The latter is attributable mainly to expansion in the export oriented phosphate industry in North Africa. More precisely, Africa's share of world production in 1961 was less than 1 percent in N and 2 percent in P₂O₅, and in 1970 1 percent in N and 2 percent in P₂O₅, and in 1970 1 percent in N, 4 percent in P₂O₅ and less than 1 percent in K₂O. The new potash production came from a recently opened mine in Congo Brazzaville.

Africa consumed during 1960/61 56 000 m. tons N, 68 000 tons P₂O₅ and 39 000 tons K₂O or 163 000 tons altogether (excluding South Africa and Rhodesia) and a decade later used 209 000 tons N, 178 000 tons P₂O₅ and 118 000 tons K₂O, equivalent to increases of 272 percent in N, 162 percent in P₂O₅ and 202 percent in K₂O. This result is very encouraging indeed, however, Africa's total nutrient consumption (N + P₂O₅ + K₂O) of 505 000 tons in 1969/70 accounts only for about 1 percent of the world's total or not even 10 percent of all developing countries in this particular year.

The developing countries with 70 percent of the world's population accounted for only about 13 percent of the total fertilizer consumption in 1970. However, the proportion of the world's population living in developing countries is expected to have risen to about 75 percent in 1975 and to nearly 80 percent in 1980. Thus, the problems involved in

^{1/} International Potash Institute, Berne / Switzerland Agricultural Mission to East and Central Africa.

effecting increases in fertilizer use are very considerable. An assessment of actual fertilizer demand for the developing countries and the developed world in 1980 has been published recently in "Chemical Age". As these figures appear to be reasonable, and as some of the participants in this Seminar might be interested in more details, they are reproduced in Table 1. It is, therefore, sufficient to say that the demand for total nutrients is expected to rise during the period 1970-80 by 65 percent in the developed parts of the world and by nearly 100 percent in the developing countries.

Table 1. Estimated world fertilizer consumption 1975 and 1980 (excluding N.Korea, N.Vietnam and the People's Republic of China) in million m. tons nutrients.

	Developing countries				Industrialized countries				World total			
	N	P ₂ O ₅	K ₂ O	Total	N	P ₂ O ₅	K ₂ O	Total	N	P ₂ O ₅	K ₂ O	Total
1970	4.9	2.2	1.3	8.4	23.8	16.4	14.1	54.3	28.7	18.6	15.4	62.7
1975	7.2	3.6	2.3	13.1	33.8	20.7	18.2	72.7	41.0	24.3	20.5	85.8
1980	9.2	4.6	2.8	16.4	42.5	24.7	22.0	89.2	51.5	29.3	24.8	105.6
1970-80	+84%	+109%	+116%	+95%	+79%	+51%	+56%	+65%	+80%	+57%	+61%	+69%

Of course in the intensity of fertilizer use great differences exist between the developing regions. The heaviest rate of all three fertilizer nutrients is used in Latin America with about 22 kg/ha of arable land on average. It is followed by the Far East (excluding Japan) and the Near East (excluding Israel) with approximately 15 kg/ha for both. With regard to these application rates, it must be borne in mind that many developing countries in Latin America and Asia are already relatively advanced in their general economic development and have reached or passed the take-off stage in fertilizer usage. The lowest application rate (only 2.5 kg/ha arable land) is found in Africa (excluding S. Africa and Rhodesia), where the introduction of fertilizers on a large scale will be required.

THE ACTIVITIES OF THE WORLD FERTILIZER INDUSTRY IN FERTILIZER USE DEVELOPMENT

Although the introduction of fertilizer use is first of all a matter for the countries concerned, fertilizer use development on a multi-lateral level has increasingly become one of the most appreciated forms of aid. Bilateral aid in its various forms is not less welcome. In assisting fertilizer use development the world fertilizer industry also plays an important role along the following lines:

(a) Research into high analysis fertilizers

Because higher nutrient concentration in intermediate materials, straight fertilizers and compounds reduces handling, transport and storage costs, the development of high analysis fertilizers is of particular importance. As a paper on this subject will be presented at this Seminar, it is, therefore, sufficient to note that the industry has made considerable advances in this direction.

(b) Research into plant nutrition and soil science

Still unsolved questions of plant nutrition, related problems etc. are studied by teams of scientists with the most modern equipment on agricultural research or experiment stations established by most of the larger industries.

A typical example of this is the Buentehof Agricultural Research Station of the West German Potash Industry in Hannover, where experts in agricultural chemistry, soil science, botany, physiology, microbiology and tropical agriculture are carrying out basic research in close cooperation with the biometric and documentation departments. Scientists from various industrialized and developing countries often join this team to discuss problems and to gain further knowledge about fertilizer use.

All findings are made available to other official and private institutions dealing with soil fertility and crop production, faculties of agriculture, international organizations, such as FAO, and agricultural extension services throughout the world.

Other examples in this context - given in the nitrogen industry - are the Limburger Hof Research Station of Badische Anilin und Sodafabriken (BASF) in Ludwigshafen. Further stations in the United Kingdom and other fertilizer producing countries.

Participants in this Seminar are certainly aware of the farmer's annually recurrent need for money to spend on fertilizers and also of other production costs burdening his budget. Therefore, every effort must be made, not merely to make a satisfactory profit by the use of fertilizers, but to achieve thereby the greatest possible economic advantage. Considering the annual growth in population, the necessity of achieving this aim is becoming more and more urgent. This applies in particular to developing countries which have no long term experience in the use of fertilizers.

We thus find ourselves faced with two facts which are growing more distinct from one day to the next: on the one hand, a multiplicity of agronomic questions forcing scientists to an ever stricter specialization, and, on the other hand, the necessity for the farmer to work for greatest possible yields through fertilizer use.

Technical specialization alone would result in too restricted progress, particularly if scientific results and experience are not made accessible to official and private organizations concerned with fertilizer use development and improvement of agricultural productivity. Through such channels they often somehow and eventually reach and benefit the farmer. Indeed, every country has some corporations and/or associations that maintain contact among the various interested branches of science, and that foster the popularization of improved farming methods. It must be admitted, however, that the majority of such agencies are purely of local significance.

Due to the increasing multiplicity and complexity of agricultural problems, the nitrogen, phosphate and potash industries have each chosen some time ago to sponsor a respective 'Nutrient Institute' on a wide international basis. These "Nitrogen, Phosphate and Potash Institutes" try to fill this gap and have in common that they are non-profit-making and non commercial associations, and that their objectives are: the collecting, screening, classifying, and utilizing of scientific results and experience from all over the world, in the general field of soil improvement and fertilizer use, in order to give technical and scientific assistance in the form of publications etc. to all organizations concerned with soil fertility and fertilizer use development. With these objectives in mind the N, P and K Institutes have been active in the promotion of research and fertilizer use for at least two decades. Further study trips by agricultural experts or members of these Institutes to developing countries are undertaken for the better understanding of problems and for maintaining active contact, a basis so much needed in any technical advisory service. Finally it is worth mentioning that by taking the three Institutes together, membership totals 212 fertilizer manufacturers from 44 countries, including producers from 8 developing countries in Africa.

The Centre for Nitrogen Studies (Centre d'Etude de l'Azote - CEA) Zurich/Switzerland

This Centre has published a series of monographs on the use of fertilizers on major world crops, eg.:

Means of Increasing Rice Production

The Manuring of Sugar Cane

The Manuring of Coffee, Cocoa, Tea and Tobacco

Progressive Wheat Production

Maize Production and the Manuring of Maize

The World's Major Fibre Crops, their Cultivation and Manuring

Others are in preparation

These books are not aimed at the specialist but rather intended for people interested in a more general understanding of the principles of those subjects and new developments in these particular fields. As the reviews provide new ideas and practical suggestions for obtaining better crops and larger profits they are a useful guide to the development planner and research worker.

Another valuable work of different character published by this Centre is the 'Fertilizer Guide for Tropical and Subtropical Farming'. It covers in about 700 pages the whole field of fertilizer use and aims to explain the underlying principles in a way that will be of practical assistance to Extension and Soil Advisory Officers, even in cases where there are no experimental results or former experience to rely upon. It lists recommendations and fertilizer practices applicable to all major crops in many different ecological regions throughout the world.

The International Superphosphate and Compound Manufacturers Association - (ISMA) London / Paris

This association promotes the production and use of all commercial fertilizers which contain the nutrient phosphate. Founded in 1926, when superphosphate was still a 'miracle' fertilizer, ISMA soon demonstrated the value of international collaboration under a non-commercial roof, and recognizing that superphosphate had become just one - although still the main one - of an ever wider and more sophisticated range of phosphatic fertilizers, it opened its gates to the manufacturers of all chemical fertilizers containing phosphorus.

The Complex Fertilizer Committee is concerned with studies of particular subjects, for instance, the effects of increasing plant nutrient concentrations in fertilizers. Here it is interesting to note that there are developments in the production of high N-P combinations, by henceforth omitting H- and O-atoms. Phosponitril hexamide (50-85-0) and cyclic polyamide (43-74-0) are possibilities already in the research stage, but they are not expected to become important fertilizers before 1980.

The Agricultural Committee initiates and guides the scientific promotion of the use of phosphorus-containing fertilizers, and is concerned with all related agricultural problems. Regular symposia on particular themes provide experts from research and academic circles and ISMA members with an international forum for the presentation and discussion of papers on current research and general progress in fertilizer use. These papers are often reprinted in "Phosphorus in Agriculture", published biannually by ISMA in both English and French. Articles in this publication cover any aspects of the use of

fertilizers and the role of phosphorus in soils and in plant nutrition. A large selection is also devoted to bibliographical abstracts. It is mainly suitable for universities, research and advisory organizations.

For people in practical agriculture who need general information about phosphorus, the brochure: "Phosphorus, Key Element in Plant and Animal Nutrition" is an interesting publication.

The International Potash Institute (I.P.I) - Berne/Switzerland

This Institute has been active in the promotion of potash research and fertilizer use for 20 years, both in Europe and overseas. The periodical "Potash Review" is distributed world wide and has now reached a circulation of well over 10 000 copies. Published in four languages it contains articles on soils, fertilizers and other agricultural topics of particular interest to researchers and qualified technicians. Another regular IPI publication is the "International Fertilizer Correspondent" which is mainly concerned with experience of problems of fertilizer use and crop productivity all over the world. Other publications include the series "Potassium Symposium" in which lectures of the Institute's scientific Congresses are printed in the original language with summaries in English, French etc. Full translations are made from papers delivered at "Potash Symposia and Colloquia" if the subjects covered are of interest to developing countries. For example, "Proceedings of the First International Citrus Symposium" (242 papers in 3 volumes, covering 23 related subjects) or "Transition from Extensive to Intensive Agriculture with Fertilizers" (papers from 34 world known specialists). IPI has also issued a large number of monographs on the manuring of individual crops, mostly tropical and subtropical, and has launched a 'Competition for Young Researchers'. This competition aims to stimulate studies on the importance of potassium to soil, plant, animal and man under the new generation of scientists. Papers sent in by scientists under 40 years of age are judged by a committee of university professors from IPI's Scientific Advisory Council, which also awards the prize of this Institute.

Furthermore, this Institute considers that it is an essential task to send its agronomists, who are trained in agricultural chemistry, for practical work to those countries which are striving on their own initiative and with international assistance to increase their agricultural production through appropriate measures. The representatives of this Institute, within the scope of short or long term missions, provide effective advice for rational use of fertilizers for the particular country or region. The pre-requisite for their advisory activities is an exhaustive study of the local conditions and the limitations in cultivation imposed by nature. An interesting example of this was the long-term POTASCHHEME Project in India. Because of the great impact it had, a brief account on this IPI-mission may be useful.

This project was initiated in 1951 by French and German agricultural experts who were impressed by the efforts of the Indian authorities to increase agricultural production. As far as fertilizer promotion was concerned, they observed that official recommendations called for the application of nitrogen and phosphorus, while potassium was supposed to be available in the soil in sufficient quantities. Only for special crops, such as potatoes, were complete NPK compounds recommended, since other crops had shown no appreciable response to applied potash.

The potash promoters, however, were convinced that it would be necessary to include potash in the fertilizer programme once crop yields in general became higher than the prevailing extremely low level, particularly under conditions of continuous cropping.

How could this be demonstrated in order to change Indian fertilizer policy? The results of fertilizer trials at the experiment stations had shown no positive potash response, but soils on experiment stations are different from ordinary farm soils, being well supplied with compost, manures, green leaves etc. throughout the year. It seemed, therefore, worthwhile to lay down fertilizer trials and demonstrations with N, P and K on cultivators' fields in sufficient numbers to produce reliable results.

With this purpose in mind the Potascheme project was established by IPI, which organized a network of thousands of simple N, P and K demonstrations and trials on food crops in the southern states of India, employing at times as many as 80 trained assistants. Due to the favourable results obtained by this Potascheme, the Government of Bihar and later also the Indian Council of Agricultural Research undertook a similar project with the application of N, P and K on an even much larger scale throughout various states. The significant responses to each of those nutrients thus obtained have eventually brought about a change in the Indian fertilizer policy by calling for a considerably higher ratio of potash to nitrogen and phosphate in the recommended consumption figures of the Five-Year-Development Plans (1970-71 = 2.4 million tons N, 1 million tons P_2O_5 and 0.7 million tons K_2O). IPI's contribution acted here as a nucleus and catalyst. It had served its purpose with the promotion of better yields by means of a balanced NPK application.

IPI has also established scientific missions in other areas with fast growing populations, where food production is lagging behind, but more on a regional basis and sometimes jointly with the Foundation for International Potash Research of Washington D.C. Such missions are now in South America, Near and Far East and in Africa. Because of the long distances separating the individual countries, the activity of these missions is not so much based on the conduct and evaluation of fertilizer demonstrations and trials as on the establishment of contacts and the exchange of information on new developments in agriculture and fertilizer use. In East and Central Africa for instance, we are not only trying to stimulate research into the importance of potash but also to communicate any advance in agricultural technique from one country to another, thus contributing to agricultural progress within this region. When the use of potassium is indicated but neglected in any fertilizer programme, we do not hesitate to draw attention to the possible consequences of potash deficiency on the yield and quality of agricultural products.

Joint actions of the Fertilizer Industry

To return to the role shared by all three nutrient institutes in the development of fertilizer use, there are also cooperative projects worth mentioning. One example are the joint publications, such as "Fertilizers and High Yielding Grain Varieties" and "Fertilizer and Irrigation". Further, and of greater importance, these nutrient institutes, representing most of the world fertilizer industry, being aware of the vital significance of increased fertilizer use in developing countries, have jointly contributed to the FAO Fertilizer Programme since its inception.

During its first decade of operation, 1961-70, the world fertilizer industry, through the FAO Fertilizer Industry Advisory Committee (FIAC), on behalf of which this paper is presented, contributed in cash and kind nearly half of the \$7.9 million donations to this Programme, to which the recipient countries added a further \$8.5 million in services. It should be mentioned that FIAC has since 1960 been a statutory body of FAO. On its Technical Subcommittee, experts of the fertilizer industry are represented. It was founded with the purpose of studying and giving advice to FAO on the planning and the implementation of the FAO Fertilizer Programme. In 1961 this Programme was working in six developing countries in two regions with nine experts and in 1970 in 22 developing countries in six regions with 55 experts, through large numbers of demonstrations and simple trials on farmers' fields and through pilot distribution and credit schemes. This FAO Programme is another example where the industry's contribution acted as a nucleus and catalyst. By 1972 the number of participating countries in Africa has risen to 10, and in view of the success of this programme it is hoped that more African countries will follow.

The fertilizer industry is represented by its experts in several of FAO's Working Groups cooperating with the Fertilizer Programme, such as the Ad Hoc Working Party on Fertilizer Economics, and the Ad Hoc Working Group on Fertilizer Marketing and Credit which produces fertilizer marketing studies, and gives advice on fertilizer marketing to FAO projects and individual countries. Finally the industry cooperates with FAO's Ad Hoc Working Party on Fertilizer Statistics, which publishes the yearly Review on Fertilizer Statistics.

International Courses in Extension Methods and Fertilizer Use, co-sponsored by the Israel fertilizer industry and Government through the Fertilizer and Chemical Development Council in Tel Aviv and by FAO, are held at the Ruppin Institute of Agriculture in Emek Hefe in Israel. The aim of the three month course is to teach both subjects from a practical point of view, thus providing the fertilizer technician with the knowledge he needs to extend fertilizer use in an efficient way. The participants are required to have completed 12 years of schooling and at least two years of Agricultural College. A B.A. or B.Sc. degree is preferred. They should also have at least three years of field experience and should be working in a firm or institution dealing with the promotion of fertilizers or in a research station. Until now more than a dozen such courses have been held with 500 participants from 30 countries in Asia, Latin America and Africa.

The programme further includes "ON THE SPOT Training Courses", organized in most countries. Such courses have been held already in Asia, Latin America and in Africa.

Three different types in extension methods and fertilizer use of 4-5 weeks duration are offered:

- (a) in Soil Fertility and Fertilizer Use for Junior Agricultural Officers, with at least 3 years of experience in the field,
- (b) in Extension Methods for Fertilizer Market Expansion for Subject Matter Agricultural Officers, with at least 3 years of experience in the field, and
- (c) in Extension Methods and Planning of Fertilizer Extension Campaigns for Agricultural Supervisors, with at least 5 years of experience in the field.

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In the preparation of this paper considerable assistance was given by the three largest members of the FAO Fertilizer Industry Advisory Committee (FIAC), namely the Centre d'Etude de L'Azote, the International Superphosphate and Compound Fertilizer Manufacturers Association and the International Potash Institute. Further acknowledgement is due to the Fertilizer and Chemical Development Council of Israel.

POSITIVE SIDE EFFECTS
OF FERTILIZER USE DEVELOPMENT

H. Braun ^{1/}

INTRODUCTION

Fertilizer use development produces many positive effects other than the increase of yields and consequently of farm income. These side effects range from the improvement of crop quality which is of importance for human and animal health, to a positive influence on the national economy. The purpose of the present paper is to foster the awareness of these effects among those engaged in planning, organization and execution of activities in the special field.

In the light of the facts to be enumerated, investment in such activities will appear to be more justified than if the direct effect on yields only is borne in mind.

WHERE SIDE EFFECTS ARE FOUND

Agriculture

Usually judicious use of fertilizer improves the quality of crops which has an effect on human and animal health. The role of phosphorus in the building-up of resistant and healthy skeletons both of human beings and animals may serve as an example of the many known effects.

Other beneficial effects occur in the properties of crops, for example, storage quality, improvement of baking quality, increased content of desired components, e.g. sugar, starch, oil, etc.

Where high yielding varieties are introduced, the development of the use of fertilizers and adequate irrigation are indispensable if the new varieties are to reach their full potential.

In land and water development projects the appropriate use of fertilizers and related inputs helps to accelerate the amortization of the funds invested.

Apart from these direct effects a great number of side effects are produced by activities aiming at the development of the use of fertilizers.

In extension work, fertilizers have the advantage of being effective, both visibly and physically, within a relatively short time, which helps enormously rapidly to gain the confidence of the farming community. Subsequently, advice is more easily accepted and minds are ready for the introduction of other related inputs and improved practices. Thus, fertilizer use development has a multiplier effect on other innovations.

From the social and economic point of view the side effects of fertilizer use development are also of importance.

The calculations carried out jointly with the farmers in connection with the evaluation of fertilizer demonstrations have an educational effect on their attitude towards a change from subsistence to cash farming and in provoking general ideas on economics in farm management.

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Another positive result which can be obtained by proper fertilizer use development is the intensification of production without increasing the total investment in labour. Where population pressure no longer allows shifting cultivation or a bush/forest fallow rotation, the use of agricultural inputs, with fertilizers as the main component, is the only way to maintain and eventually increase soil fertility.

Where population pressure is less acute, the use of fertilizers and other improved practices can replace the bush/forest fallow rotation and the annually recurrent painful efforts in land clearing by a permanent cropping system. Besides the improved economics, this move makes agriculture more attractive, which is a necessity if the rural exodus is to be halted.

Socio-economic and educational aspects are also resulting from the introduction and extension of the use of fertilizers and other related inputs, i.e. the organization of improved input distribution and credit. The promotion of farmers' initiative and a group approach for ordering and buying inputs and their procurement on credit helps to make the impact lasting and to improve farmers' self-confidence and awareness of their responsibilities.

Further positive effects of activities aiming at fertilizer use development can also be expected in the performance of agricultural extension services.

Such actions need intensive staff training if they are to be successful. The knowledge of extension methods, field demonstration and trial techniques obtained in training and the experience gained in the practical application can equally well be applied to other aspects of agricultural extension.

A further significant achievement is the psychological aspect of field work in fertilizer use development. If properly planned and organized, extension work with fertilizers is generally safe from negative results and produces results rapidly. For these reasons, the field extension worker gains recognition by the farmers and increases his prestige as he has something to sell which has an almost immediate positive effect. It is evident that such a success raises the field level worker's self confidence and may thus create, to the profit of other aspects of extension, a lasting devotion to his hard work.

Rural Development

The above facts are already closely related to rural development, but further positive side effects of fertilizer use development can be determined in connection with the betterment of the rural community's situation as a whole.

The use of fertilizers and related inputs increases farm income and, consequently, living conditions in rural areas.

In many countries the rural exodus represents a serious social and sometimes a political problem. If farming becomes attractive enough, the importance of that phenomenon diminishes, eventually even to the extent of a reversal of the movement.

Increased purchasing power of rural communities helps to fight under-employment by the creation of work for artisans and eventually of agro-industries. Better communications, services and recreational facilities can be further consequences of rural development, again providing additional employment and making the migration to overcrowded urban centres less attractive.

National Economy

Increased agricultural productivity due to the use of fertilizers and related inputs may have two principal effects on the national economy; (i) agricultural imports can be replaced by local production, if the ecological conditions allow such a production or if an acceptable substitute can be produced; (ii) agricultural exports can be increased. It is obvious that in the first case the funds required for the import of these commodities will not only remain in the country but much of the money will remain among the rural community. Higher purchasing power of the local population will again be the consequence which will eventually help to create additional local industries. On the other hand, if imports can be replaced by local production, the foreign currency which might be required to purchase agricultural commodities abroad, can be used to buy investment goods which are more productive than food imports.

Higher production of agricultural commodities for export represents an additional source of foreign currency, although the economics of these exports depend upon the fluctuations of the world market.

Activities in fertilizer use development create and increase the demand for fertilizers. To be economic, a fertilizer production unit has to have a certain minimum output which in turn should be related to a minimum home market. If the local demand for fertilizers has reached that minimum level, local production can eventually be envisaged if all other pre-conditions can be met.

A production of food crops which exceeds the average annual consumption helps to maintain a certain stability of price. A surplus can sometimes be stored and used to stabilize prices in years of poor harvests, generally caused by bad weather.

EFFECTS OF INTENSIVE FERTILIZER USE ON THE HUMAN
ENVIRONMENT

by
FAO

INTRODUCTION

During the last two decades fertilizers have become indispensable for growing crops to feed increasing populations. Between 1950 and 1970 world fertilizer use has quadrupled and it is expected that this upward trend will continue.

The increasing use of agro-chemicals has not passed unnoticed and concern has been voiced about the possible side-effects of intensive fertilizer use on the human environment. Considering the importance of applied plant nutrients in stepping up agricultural production it is imperative that any conclusions on the relationships between fertilizer use and the quality of the environment be drawn on the basis of fact. To obtain first-hand information on the results of research and experimentation the Food and Agriculture Organization of the United Nations (FAO) convened a consultation on this subject in Rome to which a group of experts working in this specific field were invited.

The consultation was held in FAO's Rome Headquarters from 25 to 28 January 1972 and was made possible by financial support received from the Swedish International Development Authority. This generous assistance is most gratefully acknowledged.

Expert advice was sought from countries where fertilizer consumption is relatively high since any ill-effects will first appear in areas where fertilizers are intensively applied. Information was also obtained from research carried out by the nitrogen, phosphate and potassium fertilizer industries.

The findings of this consultation^{1/} indicate that the effects of intensive fertilizer use on the environment are mainly positive. It became apparent that when fertilizers are applied correctly contribution to the nutrient content of surface- and groundwaters is small in proportion to nutrients derived from other sources. Where detrimental effects were observed, they were mostly due to improper use of fertilizer which could be corrected by rational soil management practices. In this respect it was noted that the amounts of fertilizers at present used in developing countries are still very low and that local excesses in some of the industrialized countries should in no way prejudice the intensification of agricultural production in the developing world.

FAO will use the material described here in the development of its fertilizer-use programme. The contacts established with research organizations will be maintained so that the most up-to-date information on effects of fertilizer use on the environment can be made to serve agricultural development.

^{1/} The full report of this consultation has been issued as FAO, Soils Bulletin No. 16, Rome, 1972.

A SUMMARY REVIEW

Several countries in Europe and North America have been using fertilizers heavily for a number of years and particularly since 1945. This high level of fertilizer application is essential to supply the necessary food for increasing populations and to meet higher demands for animal and plant products. Effects of fertilizer use on the environment would be revealed first in countries where fertilizers have been used intensively for some time and where consumption is steadily rising. The experience gained in such countries is used below to assess the impact of fertilizers on the human environment, and the development of methods for recognizing and minimizing any undesirable consequences which may be produced.

High densities of human population combined with intensive crop and livestock production have led to the production of organic wastes at a rate too high for natural processes to convert it into ecologically safe compounds. Therefore, both direct and indirect effects of intensive fertilizer use have been reviewed.

Side-effects of an increased food supply

The greatly increased production of food from farms in Europe and North America has involved both the introduction of crop varieties capable of giving considerably greater yields under conditions of high soil fertility, and the upgrading of livestock to give either higher yields of milk or eggs, or much faster growth rates under conditions of high nutritive fodders. Thus the extensive use of fertilizers has had the direct effect, in many farm areas, of greatly expanded numbers of animals fed on diets of much higher nutritive value than in the past. Both crops and animals leave residues behind, but while a large proportion of crop residues that are not consumed by animals tend to be low in nitrogen and to have most of their mineral elements present in relatively insoluble forms, those from animals tend to be high in urea and decomposable organic nitrogen compounds, and much of the mineral elements are present in a relatively soluble form. Furthermore, the typical animal fodder crops are grass, grass-legume or pure stands of pasture legumes which tend to build up the humus content of the soil while arable cropping tends to lower it.

A greatly increased animal population on farms can have undesirable effects on the environment unless very strict precautions are taken. A dairy cow produces about 15 times as much dung as a human being, so quite a small dairy herd will produce as much as a moderate-sized village. Further, the herd is usually kept in a yard for part of the year, or part of the day, so that there will be a large concentration of dung and urine in a relatively small area of land. As long as the animal population per hectare on the farm is low, good management in the farmyard allows most of the animal excretion to be returned to the land at a relatively low rate of return per hectare, and the losses from the farm need not be very large. But the problem of disposing of the manure becomes very much more difficult once the number of animals per hectare exceeds a certain threshold value, and it can become very difficult to prevent soluble inorganic and organic constituents getting washed into either the groundwater or the ditches and streams draining the area.

The intensive use of fertilizers can benefit the environment indirectly in that, by increasing considerably the yields of foodstuffs per hectare, it allows land of low inherent quality, such as steep land, land with shallow soils, and land very susceptible to erosion, to be withdrawn from cultivation without appreciably reducing the total food production of the region. The correct use of fertilizers eases the problem of erosion control on erosion-sensitive land because a strongly-growing well-manured crop, properly managed, gives much better protection to surface soil than a half-starved crop. Soil wash can be a very serious source of pollution of rivers and lakes, not merely because of the silting up of waterways, but because the soil particles most easily washed off the surface are the fine clay and clay-humus particles which are rich in plant nutrients, since they absorb all those fertilizer components that soils can hold in relatively insoluble form. Uncontrolled water run-off from steep slopes or erosive soils also increases flood hazards during periods of heavy rain and drought hazards in periods of low rainfall since this water runs off the land instead of percolating into the soil.

Side-effects of fertilizer residues

Not all the nutrient ions in a fertilizer applied to a field soil are taken up by the growing crop, and the fate of the remainder is very important in any discussion on the effects of their long-term intensive use. Three things can happen to these residues in the soil: they can remain in the soil, they can be removed in the water leaching through the soil or running off the surface of the soil, or they can be lost to the atmosphere by volatilization. The relative importance of these depends on the physico-chemical and biological reactions the ions take part in.

Phosphate anions

When a water-soluble phosphate fertilizer is added to a soil, the phosphate portion is rapidly converted into forms having a very low solubility in the soil water, unless the soil is an almost pure sand or peat low in active iron or aluminium ions. Thus, although the solution diffusing out of a pellet of granular superphosphate placed in a moist soil has a phosphate concentration of about 4 molar (120g/l), its concentration a few millimetres from the granule will probably be about 10^{-5} to 10^{-6} molar (300-30 ug/l), that is, about a million times more dilute. Phosphate is, in fact, an example of a nutrient ion that is extremely immobile in the soil. It is absorbed very strongly by surfaces of iron, aluminium and manganese oxides and hydroxides; it is absorbed by clay particles; and it is precipitated by calcium ions to give calcium phosphates such as hydroxyapatite or, in calcareous soils, calcium octaphosphate. Thus, insofar as fertilizer phosphate is not removed in the harvested crop, it remains in the soil except when the soil is washed off the land by run-off, or exceptionally, if heavy rain falls shortly after the phosphate has been applied to a wet soil surface. Phosphate can, however, occur in higher concentrations in the soil solution of some inundated soils, and high levels of phosphate fertilizer given to swamp rice may raise the concentration of phosphate in the drainage water to levels appreciably above that coming from better aerated soils.

Crops may, in the first year, remove as much as 20 percent of the phosphate added, if growing in a soil low in phosphate and if the phosphate is placed close to the plant, but in normal well-farmed land considerably lower recoveries are more common. Since many progressive farmers add phosphate to their soils every year or every second year, the phosphate status of their soils is now high and they use their phosphate fertilizers either on crops requiring a high level of soluble phosphate for high yields, such as potatoes, or to maintain rather than increase the present satisfactory levels.

It was concluded that only a negligible proportion of fertilizer phosphate is leached from soils into the drainage water, since it is very immobile in most soils. Fertilizer phosphate will, however, be carried into rivers if adsorbed on any soil particles carried off the land by soil erosion, and as soluble organic wastes via fodder plants and the bodies of livestock.

POTASSIUM CATIONS

Almost all potassium fertilizers in use are very soluble in water, but once dissolved in the soil water, they also are subject to absorption by the soil particles. But they are held by a different process from phosphate, for they take part in cation exchange. When potassium ions are absorbed by a clay or humus particle, an equivalent amount of other cations are displaced into the solution. In normal fertile soils the displaced cations are predominantly calcium although they will usually include some magnesium in addition. But these ions are held much less tightly than are the phosphates, so that the potassium ion concentration in the soil solution is usually in the range of 10^{-4} to 10^{-5} molar, though on soils well supplied with potassium it may rise to 10^{-3} molar. If the level of exchangeable potassium is increased by adding a potassium fertilizer, it is commonly found that a proportion of the added exchangeable ions is converted to a form that is much less accessible to the soil solution — the ions are said to be fixed — and this fixation takes

place within the layers of micaceous and vermiculitic clay particles. Since most soils that are not exclusively composed of very strongly weathered minerals contain these types of clay, they have a great ability to hold potassium when soluble potassium salts are added to the soil.

Added potassium that is not taken up by a crop is, in consequence, not very mobile in soils containing much clay. On clay and loam soils it is unlikely that any appreciable amount will move more than 50-70 centimetres below the depth of incorporation. Some crops will, however, take up large amounts of potassium from a soil. Thus, grass crops will remove very large amounts of potassium from the soil if the harvested grass is removed completely. Cereal straw is also fairly high in potassium - although much lower than heavily-manured grass - as are the leaves of many fodder plants, so that a large amount of potassium may be in cycle on farms feeding their crops to livestock. Since most of the potassium excreted by cattle and pigs is in the urine, there is a tendency for there to be large potassium losses from the farm in the liquid manures that get washed away from farmyards and dairies.

It was concluded that only a small proportion of fertilizer potassium can be lost by leaching because most soils hold added potassium sufficiently strongly for only little to enter the soil solution.

CALCIUM AND MAGNESIUM

Insofar as the use of nitrogen fertilizers increases the amount of nitrate leaching out of the soil, this nitrate will be lost as calcium and, to a lesser extent magnesium nitrate. Their use, therefore, involves the regular application of liming materials to non-calcareous soils, in order to restore the extracted calcium and magnesium in the soil and thus prevent acidification.

NITROGEN FERTILIZERS

The effects of adding nitrogen fertilizers to soils on the movement of soluble nitrogen compounds through the soil are complex. The typical nitrogen fertilizers of commerce are urea, ammonia, ammonium salts and nitrate salts; although there is a very restricted use of proteinaceous residues such as wool waste, dried blood and some types of meat and bone waste. In addition, on farms on which livestock are kept, there is likely to be a return of farmyard manure or slurry to the land. Under normal farming conditions, on well-drained soils when the soil is warm, all soluble nitrogen compounds are usually fairly rapidly oxidized to nitrate, and nitrate is not absorbed to any appreciable extent by soil particles. It is, therefore, all present in the soil solution, and will diffuse fairly rapidly through the soil solution, including that within the very fine soil pores.

Some fertilizer nitrogen can be lost to the atmosphere by volatilization of ammonia shortly after it has been applied. When anhydrous ammonia is being injected into a soil, a certain proportion is often not absorbed by the soil but escapes into the air. Again, if urea is spread on the surface of a damp soil with a pH above 6, and the weather remains dry after spreading, it will hydrolyze to ammonium carbonate, which will decompose, giving off ammonia to the atmosphere; and the same loss occurs if ammonium sulphate is spread on the surface of a calcareous soil.

The nitrate can be removed from the soil in four ways: it can be taken up by the crop, it can be taken up by the soil microorganisms and converted into humus, it can be washed out of the soil as nitrate, or it can be denitrified and lost to the atmosphere either as nitrogen gas or as oxides of nitrogen, principally nitrous oxide N_2O .

The technical difficulties in determining the fate of the added nitrogen are, first, that it is not usually possible to determine either the amount of nitrate being leached out of the soil or the amount that is denitrified in normal field soils; and secondly that only a part of the nitrate present in the soil is derived from the fertilizer, for a portion - and in some systems the greater portion - has been derived from the decomposition of some of the

soil organic matter. Furthermore the total amount of nitrate produced in the soil during the growing season is small compared with the total amount of organic nitrogen it contains, and it cannot usually be determined from the change in the total soil nitrogen over the season as it is of the same order of magnitude as the sampling and analytical errors in the total soil nitrogen determinations.

This problem is complicated still further on most farmers carrying livestock because a proportion of forage crops are grown which include leguminous plants such as clover or lucerne, often admixed with grass. These plants have nodules on their roots which fix atmospheric nitrogen, converting it into organic compounds, and some of these are left in the soil. It is common practice for farmers using this type of cropping not to give any nitrogen fertilizer to the first crop after the forage crop has been ploughed in, and even then the amount of nitrate released is more than the crop can take up. In addition, it is now possible to prove that blue-green algae fix atmospheric nitrogen in many arable soils and non-symbiotic nitrogen-fixing bacteria are operative in both arable and grassland soils. A proportion of these organic nitrogen compounds are relatively easily oxidized in the soil; even on farms growing no leguminous crops, a portion of the nitrate present in the soil solution may have been derived biologically from the air.

These complications have the consequence that it is not yet possible to prove conclusively what proportion of the nitrates in streams draining out of well-farmed land has been derived directly from nitrogen fertilizers added to the soil. The evidence from changes in the nitrate content of river waters over the last 10 to 20 years, in regions where fertilizer use has been greatly increased, is poor and inconclusive - poor because of the relatively few streams and rivers draining predominantly agricultural areas whose flow has been gauged and whose water has been regularly analyzed, and inconclusive because the results obtained from the few long-term records of rivers so gauged and analysed have not been consistent. Thus research in Great Britain has shown that of the 18 rivers for which records are available, the correlation coefficient between the amount of nitrogen fertilizer estimated to be used in their catchments and the nitrate leaving the catchment in the river was over 0.7 for only four, but one of the largest of these coefficients ($r = 0.9$) was negative, which means that the increasing use of nitrogen fertilizer appears to have decreased significantly the amount of nitrate leaving the area.

However, this method of judging the effect of nitrogen fertilizer is invalid unless it can be proved that the only factor affecting the nitrate content of river water is the change in the amount of nitrate draining out of fields due to the use of nitrogen fertilizers. This is naturally very difficult to prove, but the possibility that this assumption is valid cannot be ruled out, because the nitrate concentration in the water of some rivers was higher in winter when the flow was high than in summer when it was low; and this is probably a reflection of the concentration of nitrates in the soil water. The reason for the nitrates being higher in winter than in summer is that few English arable soils carry an actively growing crop in late autumn or early winter, yet the soil temperatures are adequate for a moderate rate of nitrate production, and this nitrate accumulates in the soil and in part washes out after enough rain has fallen to wet the soil profile. In summer, the land is carrying an actively growing crop, so that although nitrification is taking place more rapidly than in winter, the crop is drawing strongly on this supply. Thus in western Europe, nitrate losses from the soil are much larger in winter than in summer, and insofar as the drainage waters are not being impounded in reservoirs for long periods, the periods of high nitrate concentration in the water tend to occur when the water is cold and algal activity low. These winter losses of nitrates can be reduced if a fast-growing catch-crop is planted directly after the main wheat or barley crops have been harvested on land that is to be spring sown. However, there was a clear indication that for one English river, in a year with an abnormally wet April, the peak of river flow due to this rain was also a peak of nitrate concentration in the water, due almost certainly to some of the nitrogen fertilizer applied to the land in March or early April being washed out of the soil by this heavy rain.

Very little is known about the losses of nitrate from soils by denitrification. All attempts at drawing up balance sheets for the fate of fertilizer nitrogen applied to crops growing in lysimeters show that, for most soils, a considerable amount - usually around one third - of the added nitrogen cannot be accounted for and is presumed to have been lost by denitrification. Present knowledge on the biological and biochemical processes responsible for denitrification is concordant with the existence of appreciable losses because the first effect of a restriction of oxygen supply is for all the soil nitrate to be reduced to gaseous forms before reduction of ferric to ferrous iron can begin. Field soils are likely to contain many volumes or pockets of soil that rapidly become anaerobic during wet weather, due to compaction by tractors and cultivation and harvesting machinery, so that denitrification can take place actively at intervals during the growing season even in soils that appear to be well drained. Denitrification studies in lysimeters are likely to underestimate the amount taking place in the field, due to neglect of these isolated volumes of compacted soil. This subject of the amount of denitrification taking place in the field, particularly under conditions of high nitrogen fertilizer use, is in urgent need of more intensive research.

It was concluded that nitrogen is the most likely fertilizer element to be leached out of the soil, but there was still no good evidence that its use has had any appreciable effect on the composition of river waters. It was recognized, however, that it is technically very difficult to interpret changes in the nitrate content of drainage in terms of changes in nitrogen fertilizer use, due to our present inability to measure sufficiently accurately the ratio of biological nitrogen fixation, the rate of oxidation of soil organic nitrogen to nitrate, and the rate of reduction of nitrate to nitrous oxide and nitrogen gas. The problem is complicated still further if livestock are kept, for some of the nitrates draining out of the farm will have been derived from their wastes.

Effects of fertilizers on food quality

Fertilizers, and particularly nitrogen fertilizers, will raise the nutritional value of grass for livestock feed; and very high amounts of nitrogen fertilizer can be effectively converted into grass protein during a growing season, provided the water supply is not limiting growth. But, in general, the application of fertilizers to well-farmed land has little effect on either the nutritional quality or the flavour of crops grown for human consumption; and insofar as they have an effect, they are more likely to raise than to lower the nutritional value of food. This is because adding a nitrogen fertilizer, for example, tends to raise the protein content of the crop, though it may not raise the content of all the constituent amino-acids in the same proportion. In the same way, adding a phosphate fertilizer may raise, but will not lower, the phosphate content of the crop. The effect is usually small and rarely of economic significance. There are, however, examples of nitrogen fertilizers, applied at the proper time, increasing the market value of a crop due to the increase in protein content.

The heavy use of nitrogen fertilizers on crops when the leaf is consumed can, however, have an undesirable effect. The effect of moderate dressings is to increase the content of leaf proteins - a desirable effect as they have a high nutritional quality; but at high dressings, some of the nitrate taken up by the plant is translocated to the leaf and concentrates in the leaf petioles, presumably because the biochemical processes for reducing nitrate and incorporating the nitrogen into amino-acids cannot keep pace with the translocation from the soil. The consequences of high nitrate on food will be discussed in the next section.

Heavy nitrogen use can have a number of other undesirable consequences; it increases the liability of crop leaves to attack by a number of pests and diseases; it increases the tendency of cereals to lodge; and it may reduce the quality of the crop in an obvious manner. Thus, too high a level of fertilizer nitrogen is likely to lower the storage and cooking quality of potatoes, and it will make sugar from sugarbeet more difficult to refine. In general, therefore, it is in the farmer's immediate interest to keep the level of nitrogen used below that which will give these complications. But this does not apply to the horticulturist growing salad and leaf vegetable crops, for high nitrogen gives rapid leaf growth and soft succulent leaves: characters which may have a positive market value.

The undesirable effect of nitrogen fertilizer on food quality, which may come from its profitable, short-term over-use, is primarily restricted to the high nitrate content that it may cause in leaf vegetable and salad crops.

Consequences of high nitrates in water and vegetables for human health

A number of medical specialists have expressed concern about the undesirable effects of a high nitrate intake on human health, and in particular on the health of babies up to about 4 months of age. The cause of the concern is due to the effects of nitrite on health, for nitrate may become reduced to nitrite in the intestinal tract, which is then absorbed into the blood stream. Babies below a certain age may be unable to detoxify this nitrite, which combines with haemoglobin to give methaemoglobin, and this reduces the capacity of the blood to transport oxygen. Some medical specialists have also claimed that, even for adults, a high nitrate intake is undesirable because some of the nitrite produced may be converted to nitrosamines, which could, in turn, cause some hazards to health.

The panel of the consultation was not competent to discuss this problem since it contained no medical specialists, but it noted the importance of a critically based assessment of maximum permissible nitrate levels in drinking water and in food, particularly for babies. It was also told that in the United States of America there is an important body of medical opinion which considers a high nitrate intake by babies is not in itself directly harmful, the harmful effect being due to the combination of a high nitrate intake coupled with gastroenteritis caused by coliform and doubtless other pathogenic bacteria. This view is, in effect, that it is due to inadequately purified sewage.

In a short written discussion on the hazards of nitrate in drinking water and vegetables ^{2/} published in 1971, it was stated that, up to the time of writing, there had not been any reports of nitrate poisoning associated with the ingestion of food high in nitrates. It confirmed that in the United States no cases of methaemoglobinaemia had been reported in babies using public water supplies, even when the nitrate content was in excess of the limits set by the United States Public Health Service: all the cases reported involved the use of unpurified private well water.

It was considered that, in view of the fears expressed by many doctors and environmentalists lists, WHO should be asked to make a definite assessment of the hazards to health of various levels of nitrates in drinking water and in vegetables. In the meantime, agricultural advisers should be recommended to take special care in the use of nitrogen fertilizers, leguminous crops and livestock wastes in critical areas where an appreciable hazard to health might arise.

Effect on the composition of river water: Eutrophication

A number of environmental scientists have claimed that the use of fertilizers on farm land has seriously increased the liability of inland water to become eutrophic, causing pollution in lakes and reservoirs both by the algal pigments becoming distributed in the water and by creating anaerobic conditions in the subsurface waters. The panel of the consultation did not contain freshwater biologists, and could therefore only discuss in general terms the conditions necessary for undesirable consequences of eutrophication to become important. They noted that eutrophication need not lead to pollution, and in fact eutrophic waters can be very productive for freshwater fish.

^{2/} This was published in FAO Soils Bulletin No. 13. Rome, 1971, see p. 76. The Bulletin contained contributions from the World Health Organization (WHO), and was made available to all members of the panel of the consultation

The harmful effects of eutrophication may be due to consequences of algae multiplying rapidly throughout the depth of water which receives sunlight, or it may be due to consequences of algal cells and simple aquatic plants multiplying rapidly on the surface of the water, giving a green scum which very seriously reduces the amount of light penetrating the water layers below the surface. This prevents algal cells in these sub-surface waters from photosynthesizing and excreting oxygen in the water, which keeps it aerobic. Furthermore, when the plants die, their organic remains sink into the sub-surface waters or fall onto the bottom where they are further decomposed by bacteria. These bacteria set up severe anaerobic conditions in the water and excrete into it undesirable products of biological reduction processes. In addition, under some rare conditions, a few species of algae suddenly bloom and excrete a brown pigment into the water, which cannot easily be removed by the normal purification processes used by water supply authorities.

The exact conditions that are required for these undesirable effects of eutrophication to occur are not known. The mere presence of phosphate and nitrate above definite threshold concentrations is not sufficient, for these effects can occur in waters of very low phosphate content, although a number of workers consider that the phosphate content is the most important factor contributing to the creation of these conditions. These undesirable effects are not solely due to man's interference with the environment, for they have occurred in regions where man's activity has been minimal. However, it was noted that algae have a demand for suitable carbon sources that is more than several times their demand for phosphorus if they are to make active growth, so that a rapid growth of algae can only take place in water having a large supply of carbon dioxide, and the most likely source of this is from active decomposition of readily metabolizable organic substances in the water. This suggests that water receiving farm wastes or inadequately treated sewage would be much more likely to develop these troubles than water derived solely from percolation through cultivated soils. It was considered very important for intensive agricultural development that more research be conducted on the exact conditions required for eutrophication troubles to occur, so that the essential precautions that must be taken on farms can be established, if farmers are to play their full part in minimizing their onset.

Maximizing the efficiency of fertilizers

Insofar as fertilizers have any undesirable side-effects on the human environment, these will be minimized if fertilizers are used with the maximum efficiency on the farm, for this will reduce the tendency for their over-use. It is naturally in the farmer's interest, as well as the environmentalist's, that research be continued on this problem by agronomists; and in fact research on these problems has always been of major importance in all crop and animal husbandry development programmes. Examples were heard of how the use of the correct choice of fertilizer, correctly formulated, and applied at the most appropriate time, can minimize the amount of nutrients that are liable to be washed or leached into the drainage water. But it also noted that there are often serious practical problems in giving fertilizer at a time when the maximum proportion will be taken up by the crop, due both to the inability to make accurate long-range weather forecasts and to the difficulty of applying the fertilizer without harming the crop.

These difficulties can, in theory, be overcome if fertilizers could be developed in which the nitrogen was held in an insoluble form in the soil, but which released their nitrogen as nitrate into the soil solution during the growing season at a rate comparable to the needs of the crop for nitrate. Compounds of this type, or nitrogen fertilizers formulated with suitable inhibitors to achieve this purpose, are known as slow-release fertilizers. There are still no satisfactory slow-release fertilizers available for general farm use, but this is a problem which is actively being studied both by the fertilizer industry itself and official laboratories.

The recycling of livestock and human organic waste on the farm

Attention was repeatedly drawn during the meeting to the problem of disposing of the waste products of livestock without causing pollution in the drainage of run-off water leaving the farm. Soluble waste organic matter from manure heaps, for example, will carry considerable amounts of phosphate with them, and insofar as more intensive farming increases the phosphate content of the water, this will be due much more to phosphate derived from manure than from fertilizer. As an example of the amount of phosphate in cycle on western European farms, it was noted that the total phosphate content of the fodder fed to livestock was 10 times greater than in the food consumed by the human population. If the nutrients in livestock wastes could be efficiently recycled on the farm, it would be of great importance for the conservation of some of the world's exploitable natural resources, and particularly of the phosphate resources.

The great difficulty in recycling the nutrients in livestock wastes is the prevention of soluble organic compounds getting into the drainage ditches and streams, for this causes very serious pollution. The spreading of manure or slurry on frozen or wet soil in winter or early spring is very likely to be the cause of run-off of these soluble organic wastes; but when the surface becomes dry in late spring or early summer, there is commonly little land available on which these wastes can be spread. If the bulk of organic work is reduced by aeration treatment transforming organic N partly in NO_3 , its application to soil may result in N-losses by denitrification; and it may turn out that with intensive livestock husbandry, attention should be concentrated on recycling phosphate and the other mineral elements, and allowing most of the carbon nitrogen to be converted into gaseous products. It is quite clear that in future farmers following such systems of intensive livestock production will have to be prepared to spend much more money on the safe disposal of these animal wastes.

In some regions sewage sludge, or decomposable household waste that has been composted in a large municipal plant, is spread on the land, which helps to recycle the plant nutrients in the organic wastes of modern human society. The problems of this method of disposal of domestic and industrial waste were not discussed, as they did not come within the consultation's terms of reference, but it was noted that sewage sludges may contain sufficiently high levels of heavy metals for their repeated use to poison the soil. Thus it is essential that, if a policy of sludge disposal on the land is to be adopted, all industrial electrolytic wastes, and other wastes containing potentially toxic elements in a soluble form, be treated separately from normal town sewage.

CONCLUSIONS

1. Fertilizers are essential for high yields per hectare, and for bringing many inherently poor soils into production.
2. The efficient use of fertilizers allows for the intensive cropping of high-quality land, and the withdrawal of low-quality land from cultivation.
3. If fertilizers are used efficiently, there is no evidence that they lower the nutritional quality of food, and under some conditions they will increase it.
4. If fertilizers are used efficiently, and good farm practices adopted, there is no evidence that they harm the soil.
5. The efficient use of fertilizers involves the adoption of farm practices that will allow the crops to make the best possible use of the added fertilizers. These include the correct choice of crop variety, plant population, time of sowing and planting, adequate disease, pest and weed control and suitable soil conservation practices.

6. The addition of phosphate fertilizers to soils has no biologically significant effect on the phosphate content of the water leaching through a soil, unless the soil is almost a pure sand, or is subject to flooding. However, if phosphate fertilizer is added to the surface of a wet soil and heavy rain follows, some of the phosphate may be carried off the soil with the run-off water.
7. The experimental evidence for the proportion of the nitrogen added in a fertilizer that percolates through the soil into the groundwater and streams draining the area is still poor. This is due to the technical difficulty of distinguishing between the nitrates in the water that have been directly derived from the fertilizer and those derived from other sources, especially from the mineralization of soil organic matter. This latter source is often larger than the former.
8. There is still inadequate evidence on the fate of surplus inorganic nitrogen compounds that accumulate in the soil when the amount of nitrogen added as fertilizer is much larger than the amount taken up by the crop. This is because of the complete lack of knowledge of the proportion of this surplus that is lost to the atmosphere by denitrification in different soils that appear to be well-drained. However, if a nitrogen fertilizer is added to a soil in spring before the crop has made appreciable growth, and sufficient rain falls to cause an appreciable amount of drainage to take place, a significant proportion of the nitrogen may be washed out into the drains or groundwater. This is also likely to happen if much nitrogen fertilizer is added in late autumn or winter to crops which are unable to take up much nitrogen at that time.
9. Very heavy use of nitrogen fertilizers on certain salad and leaf vegetable crops may raise their nitrate content to undesirable levels.
10. Water running off the land may carry away fine particles from the soil surface which have absorbed nutrients of the added fertilizer and thus enrich the nutrient content of surface waters. The use of fertilizers therefore should be combined with proper soil conservation practices.
11. The importance of fertilizer for agricultural production warrants support being given to a continued monitoring of its effects on the environment, so that, should any unforeseen undesirable consequences arise, suitable action can be taken to minimize them.

RECOMMENDATIONS

As a result of its deliberations the expert group recommended that:

1. FAO should continue and expand its work of promoting the efficient (and correct) use of fertilizers, to help combat malnutrition by the increased production of high-quality, nutritious foodstuffs, and so help raise standards of living throughout the world.
2. FAO should draw the attention of land-use planning officers to the possibility of withdrawing marginal land, and land very liable to erosion, from cultivation, by increasing production of foodstuffs on high-quality land through the efficient use of fertilizers. Fine surface soil particles washed into rivers and lakes by erosion are a serious cause of pollution due to the plant nutrients they hold.
3. Experimental and extension workers should continue to develop, as a matter of urgency, improved farm practices with a view to maximizing the uptake of nutrients added in fertilizers, as, for example, through the use of high-yielding varieties of crops that are also pest and disease resistant, and through the selection of the most suitable fo:

of the fertilizer, and the most suitable methods of application. In the case of nitrogen fertilizers, more research is desirable on the development of slow-acting nitrogen fertilizers so formulated that the rate of release of their nitrogen as nitrate during the growing season corresponds as closely as possible with the rate of uptake by the crop required for optimum production.

4. More attention should be given to the consequences for the environment of changing the system of agriculture, due to the increased use of fertilizers. Two problems in particular need attention: the effect of such a change on the level of soil organic matter, and on the disposal of animal wastes when a more intensive system of livestock husbandry is introduced. It is especially important to develop systems which allow the recycling on farms of the nutrients present in the animal wastes, and if possible in municipal wastes also, in such a way that there is a minimum risk of the organic wastes themselves entering the drainage system.
5. Cooperative research projects should be developed between agricultural and nutritional scientists on the effects of the level of fertilizers used, and on the methods and times of their application, on the nutritional and market quality of foodstuffs. In particular, there should be cooperative work between these groups and public health and medical authorities to establish acceptable limits for, for example, the nitrate content of different foodstuffs.
6. Recommendations on use of fertilizers should take into account the undesirable effects of their irrational use, particularly when it is excessively high on farms where intensive livestock husbandry is practised, and where wide-spaced crops with a poorly developed root system are grown. They should also take into account the possibility that, in some areas, their rational use may cause depletion in the soil of nutrients not contained in the fertilizers being applied.
7. More research should be undertaken to establish the levels in soils and plants at which some heavy metals present in electrolytic and other industrial wastes become toxic to plant and animal life, and to develop methods for minimizing the harmful effect of any of these metals should they begin to accumulate in the soil due to the use of sewage sludge or from any other causes.
8. More attention should be given to research on establishing the complete nitrogen balance-sheet for fields, with particular reference to the development of new techniques for measuring the magnitude of the various components. It is especially important that more work be done on measuring the losses of nitrogen by denitrification, by leaching and by the volatilization of ammonia from soils.
9. More attention should be paid by research workers to determining the sources of the nutrient elements in all studies on the nutrient content of surface- or groundwaters.
10. More research should be undertaken on the factors that control the population density of algae and aquatic plants in water, to allow a more accurate assessment of the conditions under which farm wastes and percolates may influence the size or rate of multiplication of this population.
11. WHO should be requested to obtain the considered views of public health authorities on the hazards to the health of a community of different levels of nitrate in the drinking water, in view of the statement made that in the United States of America high nitrates in the drinking water have only caused serious trouble in babies already suffering from gastro-enteritis caused by a bacillus coliforme infection.
12. Accurate and adequate ancillary data on the physical environment should always accompany all research reports on the influence of fertilizer on the human environment. The type of data needed for the proper appreciation of such reports should include a description of the kind of soil and its condition at relevant times, the system of farming being practised and the hydrological regime during the course of the experiment. In particular, the correct names should be given to all the soils investigated in regions where a soil survey has been made.

13. Member governments should ensure that their agricultural extension services be kept up-to-date on all research findings relevant to the optimum use of fertilizers, so that their farmers can obtain the maximum benefit from their efficient use, and also that any possible undesirable effects from their misuse can be minimized.
14. FAO should continue to play an active role in assembling information on this topic and in pointing the way to improving the quality of the environment in an increasingly densely populated world. The expert group welcomed the initiative of the Swedish International Development Authority in making this meeting possible and expressed the hope that further support would be extended to this field of work.

FERTILIZER LEGISLATION

Extracts from the Draft Manuscript prepared by

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Need for fertilizer control legislation

The importance of fertilizers for agriculture, for the national economy and for the individual farmer is such that several states have, as early as the end of the 19th century, taken legislative measures in order to control their production and use. Fertilizer use is a continuous farming practice with a major influence on yields and earnings. Small farmers are rarely in a position to examine the quality of a fertilizer and must trust the information supplied by the producer. Given that serious damage can arise from the use of adulterated or inappropriate fertilizers, the quality of which cannot, in any case, be checked after they have been incorporated in the soil, certain means of preventive quality control become necessary. Fertilizer producers have, as a rule, all facilities necessary for controlling both raw materials and product and they have no need for special protection from the legislator. Such protection is necessary, however, for the consumer of fertilizers, and fertilizer production and trade need to be controlled by law.

Initially, when production and consumption of commercial fertilizers were limited to a relatively narrow range of types, the purpose of the legislation was mainly to protect the purchaser from possible fraudulent practices of the manufacturer and dealer. Thus, fertilizers sold under a given name were required to contain such nutrient elements and in such percentages either as prescribed by the law or as declared by the manufacturer himself and accepted by the state authorities. Certain variations, within strict limits, were tolerated by law. Recent scientific and industrial developments in chemistry and agronomy, not to mention commercial competition, have resulted in a multiplication of fertilizer types. This has added a new dimension to the protective role of fertilizer legislation: to provide for the protection of the purchaser against fertilizers which, although they contain the declared elements in the declared percentages, are of little or no benefit to the soil or the crops. The real value of certain modern fertilizers can, in fact, be ascertained only after a series of complex and time consuming experiments, and it is the function of the law to allow legislation only if such experiments have already proved the efficacy of these new types.

Furthermore, the need arises to protect agriculture, as such, from possible harmful substances contained in fertilizers and to guarantee the consumer of agricultural products a high quality. Finally, today, when the issue is so extensively discussed in all quarters, protection of the environment from undesirable effects caused by incorrect use of fertilizers, becomes one of the functions of fertilizer legislation.

National fertilizer laws do not always satisfactorily cover all these points. The last point, particularly, has been inadequately covered, at least, in the major legal texts. Many developing countries still have not enacted a comprehensive body of legal texts regulating fertilizer production, import or trade.

It should be borne in mind that the enactment of legislation is the result of a strongly felt need in a given national context to regulate a vital sector of the national life and economy, and now that the production, import and use of fertilizers is developing from day to day, the need will also be felt in these countries for the introduction of modern law texts covering the more recent aspects of fertilizer trade and use.

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Form of fertilizer legislation

Fertilizer laws typically follow a linear pattern from an original enactment of broad scope and in general terms through a succession of more specific texts often amending what has gone before. The lapse of time between one enactment and the next varies and rarely does one find the basic Act followed by Regulations written that same year.

The original general text, usually does not deal only with fertilizers: it often regulates other issues of a related nature such as animal feedstuffs or chemical farm requisites. Typical of this is the Swiss legislation. The sequence starts with a very broad text, the Federal act relative to the improvement of agriculture and the maintenance of the peasant population (Agriculture Act of 3 October 1951), the title of which is self-explanatory. The "Ordinance on trade in agricultural auxiliary materials" of 4 February 1955, amended by Order of the Federal Council of 3 November 1959, issued pursuant to articles 4 and 70 of the Agriculture Act specifically governs trade in agricultural requisites, including fertilizers; the section on fertilizers in the Handbook of agricultural auxiliary materials promulgated by the Federal Department of Finance of 31 January 1962, as amended on 26 May 1972, deals exclusively with fertilizers as do also the two Orders of the Federal Council of 10 July 1964 on the constitution of reserves of phosphate and potassium fertilizers.

The Egyptian legislation illustrates the opposite case. Here a single Act governing trade in fertilizers (enacted on 15 February 1956) was followed by the enforcement Regulations, which were issued exactly one month later.

The two examples illustrate extremes of legislation procedure. The number of texts or the time elapsing between the dates on which they were enacted are matters of little consequence. What is important is the division found in all the countries studied between a basic legal text, usually called Law, Act, Decree, Ordinance, etc., and, as it were, a secondary legal text, enacted under the first and by virtue of the powers conferred by it. These are the Regulations of the Law, Act, etc.

The first text sets out the legal principles which govern the manufacture, marketing, sale, etc., of fertilizers. It prescribes what must be done and institutes penalties for nonobservance of its provisions.

The second type of text explains how the principles set out by the first shall be put into practice. These texts include the technical instructions necessary for the enforcement of the basic law and provide the details which cannot be contained in an instrument the main purpose of which is to establish principles. But, even so, these technical instructions are sometimes rather difficult to incorporate into a legal text. The more usual practice is therefore to produce them in annexes to the Regulations. These annexes or "Schedules" in the English legal terminology are increasingly found in recent legislations not only in Common Law countries but Belgium, the Federal Republic of Germany and others.

Another difference between the basic text and the Regulations concerns the issues they cover. The basic text seldom governs only fertilizers; more often it regulates the manufacture, importation and sale of other products intended for agriculture. Thus, in El Salvador, the basic text covers chemical and biochemical products for use in crop and animal husbandry; in Belgium, pesticides and requisites for agriculture, horticulture, silviculture and stockbreeding, in France, fertilizers and pesticides; in India, all the essential commodities; in Kenya, fertilizers and animal feedstuffs; in Malawi, fertilizers, farm feeds and remedies; in Italy, all products essential for agriculture; and in the United Kingdom, fertilizers and feeding stuffs. In Egypt, however, in the Federal Republic of Germany and in New Zealand the basic Act covers only the production of, and trade in, fertilizers.

Regulations on the other hand tend to be different for each item (fertilizer, feed-stuff, etc.) or, in the case of Regulations covering two such items, as for instance in the United Kingdom, different provisions, or different parts of the schedules, or different schedules, set out the technical points relevant to each item.

A further difference between the two sources of fertilizer Regulations discussed here (the Act, Law etc., and their Regulations) is to be noted in the enacting authority. Thus, while the first normally emanates from the legislative body (parliament, general assembly, legislative commission, etc.), the second is issued by the appropriate executive organ (council of ministers, federal council, minister etc.) of the country.

Scope of Regulations

The main reason for the enactment of fertilizer control legislation is the protection of the fertilizer user and through him of the agricultural economy of the nation.

Fertilizer use in various countries has greatly increased in recent years, at the same time, experiments, technical development and scientific progress have resulted in new and more complex types of fertilizer often intended for specific plants, soils or climatic conditions. But if the farmer and his farm are to profit from these new fertilizer varieties, a delicate and precise combination of fertilizer materials within a container must go together with a simple and easily understood description of the content and its use on the outside of that container. Furthermore, the composition of the fertilizer offered for sale must comply with the approved official standards and must really contain the elements which the label on the container indicates. The containers must be of a material that not only protects the product itself against deterioration due to weather conditions, but also protects the user and the environment against the possibly harmful substances the product may contain. The legislator must accordingly concentrate on the following issues:

(a) Control of the various types of fertilizer offered on the national market

This is normally achieved either by requiring the registration of the article offered for sale with a government service (usually the Ministry of Agriculture) or by establishing a comprehensive list of registered fertilizers and restricting production and sales to products named in that list. The setting of standards of composition as well as the requirements of a licence for fertilizer manufacturers or sellers also offers a means of effective fertilizer control.

(b) Guarantees for the purchaser

This issue concerns the various provisions regarding the packaging and labelling of fertilizers as well as the statutory statements and other advice notices which the seller must convey to the purchaser at the time of sale.

(c) Enforcement

This is done by appointing control officers, by authorizing the inspection of premises where fertilizers are stored or offered for sale and by establishing methods of sampling and analysis.

(d) Penalties

To punish contraventions against provisions regulating the above mentioned matter.

Definitions of Fertilizers

Before any provision regulating these issues is drafted, the national legislator has to decide what is understood by fertilizer or what should be included in that term.

From a technical standpoint, a fertilizer is any substance that is added to the soil to supply those elements which are required for the nutrition of plants. Generally the term 'fertilizer' is used for 'fertilizer material or carrier', meaning any substance which contains one or more of the essential elements (carbon, hydrogen, oxygen, nitrogen, phosphorus, sulphur, calcium, magnesium, potassium, iron, manganese, molybdenum, copper, boron, zinc, chlorine, sodium, cobalt, vanadium, silicon).

Control of types of fertilizer offered on the national market

The reason for control is mainly to protect the fertilizer consumer (farmer) from fraudulent practice and through him to protect the national economy which will have to bear the results of bad agricultural production due to the use of an inadequate, or wrong type of fertilizer. It must be added here that measures of control also provide protection for the honest manufacturer who otherwise would have to suffer from the unfair competition of the dishonest producer. The ultimate aim of the control measures is to secure for the user a product with the correct quality for the intended use. Control measures are therefore primarily quality control measures.

Legal provisions regarding products

Legal provisions may require either that all articles offered to the user as fertilizers are registered with a central service (governmental or under government control) or that only those articles can be offered for sale which are listed by the law, normally the Regulations made under the basic Act.

Legal provisions regarding manufacturers and dealers

While certain countries have set up very strict regulations regarding the authorization of manufacture of, and trade in, registered or approved fertilizers, others do not seem to consider such an authorization or issue of particular importance. In fact, the matter is one related to the country's policy on fertilizer control. If strict control is thought necessary, then those directly involved in the production, import and general trading in fertilizers must be known to a central service in order that the competent authorities shall be able to follow and control their professional activities as far as fertilizer production and trade is concerned, and these agents should then be properly registered and should be obliged to apply for a licence before undertaking any such activity.

Standards of composition

The way in which standards of fertilizer composition is dealt with by national legislation depends mainly on the method adopted by the country in regulating the control of fertilizers put on the national market. If the method is that of the comprehensive list of pre-registered fertilizer, then the list itself, in an appropriate column, gives certain indications as to the composition of the product.

Guarantees for the Purchaser

The control measures which we have discussed in the previous section can do no more than ensure that the fertilizers manufactured in a way complying with the relevant legal provisions are in conformity with the established standards and are suitable for use. This, however, is not enough. The ultimate purpose of the fertilizer is that it be applied to the appropriate soil, under the appropriate climatic conditions and will supply the necessary nutrient elements to the appropriate kind of plant.

This will not be so if two main points have not been taken care of: that the purchaser knows as clearly as possible what he is buying - that is to say, the exact type of the fertilizer contained in the package he buys - and also the potential uses of the product and what quantities might be used for a certain kind of crop in a given area under given climatic conditions; that the product, manufactured according to prescribed standards will not lose its specific qualities by the time it is used as a result of bad storage conditions, tampering with, unsuitable containers, etc.

Enforcement

The enforcement of fertilizer legislation is vested with national government services or administrative bodies and officials who sometimes are especially designated for the purpose but more often have functions that are much wider, quality control of fertilizers being only one part of them. Appointment of control officers as well as their relation to the service responsible for fertilizer control enforcement will be further discussed below under the section entitled "Institutional Aspects".

Enforcement measures consist mainly of three activities closely related to each other: inspecting of premises where fertilizers are produced, stored or offered for sale or examination of books and other documents (invoices, statutory statements, etc.) related to the manufacture and trade of fertilizers; sampling of fertilizers; and analysis of the samples thus taken. The various national legislations regulate these three activities in a substantially similar way. Inspection, as a rule, is not dealt with in an extensive manner but is covered by provisions contained in the basic laws and the regulations of the countries concerned. Sampling is also regulated in these texts but detailed descriptions regarding the method of taking and dividing samples are usually found, if they are given at all, by the national legislation, in schedules of the regulations. The same is true also of methods of analysis.

Penalties

Contraventions of the legislation on fertilizers incur, as a general rule, the punishment of the person responsible, in the form of a fine and/or imprisonment and of administrative proceedings regarding the product itself.

The fertilizer legislations of various countries foresee their own systems regarding penalties. It is nonetheless possible to identify two broad categories according to the body responsible for the administration of the penalties, sub-divided into two further categories, according to how sanctions are meted out for the various offences. Special categories of sanctions also exist, viz. the so-called administrative sanctions, and penalties for offences indirectly relevant to fertilizers.

a. Authorities inflicting penalties:

Under this aspect, the countries can be divided into two categories: those which establish that contraventions of the fertilizer legislation are tried and sanctioned by the relevant court, and those which leave these sanctions to be applied by government or administrative bodies.

b. Number and amount of penalties

In applying this criterion, countries can be divided into two further categories: those which institute different penalties for the different offences regarding fertilizer legislation and those which provide for the punishment of any of these offences by the same penalty.

c. Administrative sanctions

These are applied in several cases either to supplement penalties, or irrespective of these. Such sanctions usually take the form of the withdrawal of a licence, suspension of

the operations, cancellation of the product from the registry, seizure or confiscation of fertilizers and even the destruction of products where these are known to be spoiled or toxic.

d. Penalties for acts indirectly relevant to fertilizers

These are also instituted in certain countries and refer generally to the unauthorized disclosure of information regarding secrets connected with fertilizers, e.g. their analysis, manufacture, trade, etc.

From what precedes it will be clear that the main offences contemplated by the various national fertilizer laws and made the object of sanctions are those related to: a) the quality of the fertilizer manufactured, imported or sold (compliance of such fertilizers with the prescribed standards of the labels and the statutory statements which accompany them) and b) the enforcement of the provisions of the law (obstruction of inspectors and sample takers, misleading or false information regarding fertilizers, withholding of relevant documents, etc.).

Institutional aspects

The administration of the legislation on fertilizers is, as a rule, entrusted to the Ministry responsible for agriculture in the respective country.

In countries with a federal structure, even when the fertilizer legislation applies to the whole of the federal territory, the individual states are made responsible for the administrative matters resulting from these provisions. The services of the appropriate Ministry are then authorized to appoint the enforcement and control officers such as inspectors, samplers and, less frequently, analysts, to register fertilizers and manufacturers, importers or dealers in fertilizers and to issue the prescribed licences.

In certain cases, however, some or all of these functions are already delegated, as it were, by the law to specialized bodies or local authorities acting under the supervision of the responsible Ministry.

For more detailed information refer to FAO Soils Bulletin No. 20, "Fertilizer Legislation".

TRAINING AND INFORMATION IN
FERTILIZER USE DEVELOPMENT

by

P. Koren ^{1/}

INTRODUCTION

Appropriate fertilizer use will not evolve in a country merely because new production plants are installed. A good deal of work must be undertaken in setting up an efficient organization to market the fertilizers and the agricultural products, to ensure that it is available to the farmer in the proper quantities, at the proper time and in the proper form, and to stimulate the farmer himself to become aware of the value of fertilizer and of the best way of using it.

Yet, in 1970 the developing countries with 70 percent of the world's population accounted for only about 12 percent of fertilizer consumption. By 1980 the proportion of the world's population living in the developing countries is expected to have risen to about 74 percent and by the year 2000 to just under 80 percent.

FAO's provisional indicative World Plan for Agricultural Development, which was presented at the Second World Food Congress at the Hague in June 1970 showed that fertilizers are the most important single input required to achieve the plan's targets for developing countries.

Integration and coordination are required, however, at many levels: principally at the national or government level, the regional or wholesale level, and the farmer's level.

The farmer's level is clearly the most difficult to reach, since this level comprises not only the largest number of individual potential fertilizer users, but in many cases also the highest proportion of persons who have received little education.

Nevertheless, it is precisely the farmer whose behaviour and approach to fertilizers is decisive for the success of every national fertilizer use scheme.

What a peasant farmer needs to know in order to increase his returns

Experience indicates that substantial help can be given to subsistence and small farms without requiring large inputs of new technology or investment. On the contrary, the capacity to become a more productive farmer, or a successful one, that is, to acquire a greater yield, or to switch to another crop, and thereby acquire more income is often available on the spot, or in the region where the farmer lives. Indeed, such information is often more useful and acceptable than ideas thought to be imported from a distant and dissimilar place. The change itself may be as simple as row planting instead of broadcasting, chicken coops instead of free-ranging poultry; or a change in the variety of corn or the use of chemical fertilizers. In view of the economic condition of most farmers in these countries, such inexpensive, simple and easily evaluated changes may be the first opportunity of a real change and of widespread success.

Thus, the people engaged in helping farmers on this level need not be highly skilled agricultural experts. The expertise needed is in knowing how to locate sources of information, new ideas, or different methods, and in knowing how to induce local farmers to try them. In short, the agricultural extension worker must be as much a publicist as an agriculturist, and it is in this direction that the content of the training courses has moved. Stress is on methods of conveying information to others, through lectures, demonstrations, use of audio-visual aids and mass media printed material, etc.

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THE REASON FOR EXTENSION TEACHING

Today, most enlightened governments have realized that without a stable, productive and contented agricultural population, all other efforts towards economic development may fail. No country can afford to neglect its rural population, and the reasons are plain to see:

First, every country needs an ample and dependable supply of basic foods for the whole nation, and that includes town dwellers who generally do not produce their own food. In a country where the farmers are discontented or not very efficient, this basic food supply is endangered.

Second, where there is a great difference between the standard of living of country people and that of town dwellers, many of the best young men will tend to leave agriculture and drift to the cities. But the city is not always able to absorb them and then, frequently, the result is overcrowding, slums, unemployment, vagrancy and social unrest.

Third, it has been found that besides producing food, a modern farmer can also grow industrial crops. These provide valuable raw materials for many and diverse agricultural industries, which help to provide employment for growing populations and to increase national wealth.

These are some of the important reasons why governments have begun to take an interest in the farmer, and extension services have been created all over the world. It is no longer good enough for a farmer to learn his trade from his father and carry on in the same old way. Farming must be progressive and efficient, just like any other industry, or else the whole nation is likely to suffer. But the first requirement for progress is knowledge. The purpose of extension-teaching is to bring this knowledge to those who need it.

Knowledge must be searched for and thought out; that is why there is a need for research institutions. Researchers, on the other hand, will not know what kind of knowledge to look for, unless someone tells them what the problems are. Farmers generally have little opportunity to compare their practices with those of others, and often they are not even aware that things could be better.

Therefore, extension workers have first to help farmers define their own problems. Once the problems have been clarified, the extension worker can present them to researchers, so that they can look for possible solutions. Very often they know the answer already from previous experience, and there is no need for special research. But again, the extension worker has to bring the solutions to the farmers. He has to translate abstract formulas into clear, understandable language, and show how, when, and where the new knowledge may be profitably applied.

Thus extension teaching is a necessary link between the farmer and the researcher, and the extension worker must cooperate with both to create the link and strengthen it. Without it, researchers may study problems that have little practical value, and farmers may struggle with difficulties for which solutions have long since been found.

BASIC KNOWLEDGE

Because there are few extension workers, each one must know whom to teach, so that knowledge will be passed on. Each should know when to teach an individual, when to teach a group, or when to use mass media.

Agricultural extension from the practical point of view, means bringing about a change of behaviour and if we speak about training of agricultural technicians (To train the trainers'), or about the training of farmers, what we really want in the long run is to get the trainees (trainers or farmers) to do something that he does not actually do at present, or to do the same thing in a better way. In any case, the most common mistake is to believe that it is only a question of agro-technical knowledge. The change of behaviour depends on at least three factors: knowledge, attitude and means.

If we want the farmer to use a certain kind of fertilizer, (a) he has to know about it and its purpose, (b) he has to desire to use it in spite of his conservative way of thinking, the tradition, etc. and (c) the fertilizer must be available on appropriate terms (supply, price, time, etc.).

- (a) Defining Objectives: We must establish annual fixed goals for programmes, or for certain activities. We have to define exactly who ought to do what, when, where and how much, etc., as a result of the extension we are planning. The job done by an extension worker is measured by the results. It is convenient to determine exactly the date for completion
- (b) Evaluation: Evaluation ought to be made constantly and reassessments made. This is the best way for us to learn ourselves. We must define, what we want to do, plan how to do it, evaluate the results and analyse why we did not completely meet our goal. Many times, this does not depend on us (money, climate, etc.). The most important thing besides trying to reach the goals is to know why they were not reached and thus do it better in the future.
- (c) The Group: We have to know whom we teach and therefore to know the social position of the individual within the community. We have to know the various groups and sub-groups and how they are inter-related and who are the important people of the community.
- (d) The Individual: We have to bear in mind, which are the forces that influence the attitudes and the behaviour of the individual and how to convince him to change his behaviour in the appropriate direction.
- (e) Communication: Here it is interesting to know how an idea is passed on from one person to the other; the steps of this process and the mistakes which might result from a failure in the process.

In any society there is a flow of information, we ought to know in which way this information is being extended, in order to learn how to introduce innovations.

Methodology of extension

Teaching of theoretical and practical knowledge to an individual can be done through visits to his house or his field, interviews and personal letters.

We can convey theoretical knowledge to a group, lectures and discussions and other group methods, using audio-visual aids. We have to plan the activities of the group and for this purpose we will have to prepare and plan the audio-visual aids for them and use them in the best possible way.

Practical knowledge for the group will combine various methods. We will teach theoretical knowledge, then give a practical demonstration, and finally teach them individually. These methods are: demonstration plots, field trips, demonstration day, etc.

Planning extension

The planning of a campaign will be based on thorough knowledge of the theoretical principles of extension and their various methods.

We will plan the introduction of innovations into a society in various steps. For that purpose, we will begin with collecting data; the problems of the farmers will take into account the human and economic factors establishing the aims and objectives.

Planning the working schedule: Apart from the introduction of innovations, there is also daily work to be done, such as solving seasonal problems of the farmer: planting, plant protection, harvesting and attending to animals. Time needed for these activities must be taken into consideration while making out annual working schedules so that we will know in advance what we shall do every month of the coming year. For every activity which can be planned ahead, we should set clearly defined annual goals.

THE EXTENSION WORKER'S JOB

It would be misleading, however, to regard the extension man simply as a go-between, a kind of retailer of other people's ideas. In fact, he is and has to be much more than that.

First of all, he has to be a good agriculturist in his own right, otherwise he will not recognize a farming problem when he sees one, and farmers will have little confidence in the solution he brings them.

Second, like an interpreter, he has to speak in two languages: the farmers' day to day language of practical down to earth matters, and the highly specialized technical language of scientific research. Failing that, he cannot translate farming problems to the scientist, nor can he translate research findings to the farmer.

Third, he has to know some psychology and sociology; he has to know how to deal with people. It is no simple matter to make people change age old practices and ways of thinking. Most of us are reluctant to air our problems in front of strangers, nor will we readily accept advice on matters which we think we know already. It takes great tact and deep understanding of human nature to deal equally successfully with simple peasants and with sophisticated research workers.

Finally, the extension worker must have in him something of the pioneer; he must be dedicated to his job, and be capable of deriving satisfaction from helping others.

COMMUNICATION IN AGRICULTURAL EXTENSION

The simplest process of communication involves at least two persons. Learning may conveniently be divided into passive (received through the senses, sight, hearing, etc.) and active (speaking and doing).

In order to learn, a person has to gain experience and this we cannot do on his behalf. All we can do is to plan experiences for him and assist him in gaining them. The extent to which we have succeeded in our teaching effort will be measured by the change of behaviour of the trainee in the appropriate direction.

It is necessary that the trainee should be aware of the problem. There is no chance to learn anything, if we do not feel the need of it.

There is a risk in passive learning that a person might fail to understand and therefore will not be able to use this knowledge in similar situations.

Four factors form the process of communication:

1. The source: i.e., the speaker or the extension worker;
2. The receiver: i.e. the audience or the farmer (trainee);
3. The message: i.e. the contents of the knowledge that is passed on;
4. The channel: i.e., the words, symbols, pictures, etc., through which knowledge is transmitted.

There are six steps in the process of communication:

1. Creation: We must have a clear idea in mind what it is that we want to communicate. This is 'creation'.
2. Encoding: We will translate the abstract idea in our mind into symbols, which will be understandable, be it words, drawings or movements.
3. Transmission: This we do by speaking, etc.
4. Reception: The other person will perceive these symbols.
5. Decoding: He will then interpret these symbols and transform them into an abstract idea (creation of idea).
6. Results: One ought to evaluate the process of communication: The trainee should give us back what he has got, in order that we may evaluate the process. He ought to give us the same idea which we have passed on to him, or another similar one.

It is important to emphasize, that only the first five steps will generate a process of communication. Step No. 6 will only check the results.

Mistakes we can make:

- The idea may not be clear in our mind, before we pass it on.
- The code might not have been understood (it has not been adequate) e.g., words with double meanings; words that were not clear enough; caricatures or drawings that were not clear enough.
- We have to make sure that both the source as well as the receiver see the same thing. There are words with many meanings. We must use the term that means to the receiver the idea we want to pass on; for that purpose it is necessary to know his way of speaking.
- The transmission of symbols may not be clear enough. It might be, that the source does not speak clearly enough. Or not loud enough, or does not show what he intends to show; in that case, the receiver does not get the message adequately.
- In the reception, there might be problems of physical or mental interferences (he does not want to listen; is not interested; has got other problems; is not prepared to absorb the ideas; there is too much noise; lights that disturb, etc.).

The farmer does not have to learn; it is our job to teach. If a farmer does not learn, this does not mean that he is a bad learner, but that the extension worker did not succeed in his teaching effort.

Mutual learning

In mutual learning there are two people who learn from one another. In the same way this may occur between a person and a group. Good learning means always an exchange of knowledge. There is an effort in two directions; mutual learning may occur between two individuals (interviews, conversations) or among groups (meetings, discussions).

Through mutual learning, knowledge is being acquired from the other person; one's own knowledge is not lost but accumulates. This is one of the advantages of exchanging knowledge. We give and we receive.

In extension, we get more through giving. The ends to which we use mutual learning are:

- To learn: We ourselves learn.
- To teach: We teach others. We convince them to change attitudes through mutual learning. We can change their attitudes and behaviour, because we do not speak to them but talk with them. Therefore, they are more agreeable and disposed to accept our suggestions and ideas.
- To assist others: We assist others through understanding. Actually, we learn to understand their problems and therefore we are able to help them, trying jointly to solve their problems.

It becomes clear then, that we cannot teach people but assist them to learn. For this purpose, we must know, how they perceive the situation.

Using the method of mutual learning, we will raise the level of learning from listening to talking. If we want people to speak up we must listen to them and that does not mean we will be silent. When we are silent, we are not always listening.

Three points emerge:

1. We do not pick up everything;
2. We only pick up what we want to, and not what we do not want to
3. Understanding is selective.

During a discussion, while other people are speaking the following happens:

- a. At the beginning, we listen;
- b. We plan what we want to say while the other is speaking;
- c. Sometimes, we pick up something of the final part;
- d. In the end, we reply about what we felt he should have said.

If we have a discussion amongst various people and can speak up from time to time, we use our time in planning an elegant reply, without listening to what the others say and then we say what we wanted to say.

How can we help people listen in a discussion? by summing up in short what other people said, so that the rest will listen. However, there is a risk that people will not listen, knowing there will be a summing up at the end.

Generally, we talk too much and use more time than necessary. What is it that we must learn, so that a conversation will be short? Propose an idea and later speak up once more. This will permit a true exchange of ideas. A discussion must be free.

We ought to speak briefly. Get straight to the point, let others talk, try to listen and speak in such a way that the other may listen and reply.

Motivational elements of changes in attitude and behaviour

Extension

By this term we understand "the informal training of adults, aimed at bringing about technological changes in their behaviour" which will result in raising their standard of living.

We say that it is 'informal' because it is not something compulsory (as e.g. school); a person may accept it or leave it. The intention is to raise the standard of living, if this is very low, we should not say that we can do nothing; we should try, at least, to raise it to some extent.

To raise the standard of living, there are various steps:

- Introducing technological changes or innovations which must be within reach: capital investments, marketing facilities, better farming methods, usually lead to:
 - Higher yields which should bring about:
 - An increase in farm income which should result in:
 - The desired standard of living.

Behaviour

This is any action performed by a person or a group, that can be observed through the sensory perception of others.

Behaviour is based on three pillars:

- a. Attitudes
- b. Knowledge 

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graph LR; Knowledge --- Theoretical; Knowledge --- Practical;
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- c. Means

These three factors are interrelated.

To change behaviour, it is necessary to know which pillar ought to be changed. This will depend on each case. In some, the attitude must be changed; in others, the knowledge; in others adequate means are missing. If any one is missing no change of behaviour will take place.

- a. Attitudes are based on perception: We see a situation and interpret it according to previous experience and behave accordingly.

Two people might react in a different way when facing a similar situation, as a result of different previous experience.

We cannot always trust our senses. This is due to the fact that what we see is based on previous experience and on our feelings.

The farmers too, behave in accordance with their previous experience. The problem consists in that usually our experiences and theirs are different.

Perception of the source

People combine the knowledge acquired with the personality of the one who passes it on to them. If someone speaks well about something which the other likes, he will approve of that person, but if someone we like defends something we dislike, we have a conflict.

Motivation:

Two forces are active in motivation:

- a. Forces of attraction;
- b. Forces of repulsion.

These two forces, (attraction and repulsion) are always in conflict. Extension work will be successful only if we can identify the various motivating forces which influence the farmers' attitudes and take them into consideration.

TRAINING AND EXTENSION METHODS

The Lecture

The lecture can be defined as a verbal extension method in which one individual conveys knowledge to a group of listeners. Certain advantages and disadvantages are associated with it.

The advantages are that:

- The lecture provides a means of conveying much knowledge within a short space of time.
- Through the lecture, a large group of people can be reached at once.
- Abstract ideas, and subjects with which the audience is not familiar, can be dealt with in a lecture.

The disadvantages are that:

- Audience retention of subject matter is poor.
- The audience remains more passive than in other methods of disseminating knowledge.
- The lecture cannot be a vehicle for the instruction of the audience in skills.
- Since the lecturer all too often assumes that in order to teach his subject he has only to knot it, the lecture is rarely properly prepared, and as a result, is quite frequently badly delivered.
- The lecture alone is rarely effective in changing the attitude of the audience to a given problem.

The lecture is a good method of communication when a large group is to be instructed, when time is limited, and when the subject matter is either abstract or foreign to the audience. From the foregoing we may conclude that it is a good method for introducing another extension method. For example, a discussion might be introduced by a short lecture.

As with any other teaching method, we should consider, first and foremost, the four basic elements involved in the planning of any extension activity:

1. Aim: The objective of any extension is to bring about a change in the behaviour of the persons instructed. The change we wish to bring about as a result of our teaching should be clearly defined. The aim of the lecture will be a part of the objective as stated above. This aim should be worded in such a manner that it expresses a behaviour, i.e. that it should express the action the participant

should be able to perform at the end of the lecture. For instance, at the end of the lecture, participants might describe in their correct order the various operations involved in cotton sowing, as well as enumerate the tools required to perform these operations.

The only means of checking whether our lecture has been effective, is its aim. Thus, we shall be in a position to check whether the aim has been reached, only if the latter has been worded in a categorical and unequivocal manner. In other words, our lecture will be good and effective if its aims have been attained by the audience.

2. Audience: Even when we have an identical aim in mind for different audiences, we may, according to the educational level and the actual needs of the audience concerned, change both the material presented and its method of presentation.
3. Communication Techniques: They should be adapted to the audience and to the aim. The lecture may be subdivided into a number of points or stages that are expounded in a chosen order. Communication should not be necessarily oral or one-way. The lecturer may, for example, decide on a short discussion or a small demonstration in order to teach one or several points of his lecture. It goes without saying that all these communication techniques can be illustrated with all visual aids the lecturer considers necessary.
4. Technical Conditions: The three elements outlined above will dictate the technical conditions necessary for the success of our lecture. However, the available means and technical conditions may sometimes influence the above mentioned elements.

Points for evaluating a lecturer or discussion leader

a. Appearance and habits:

- Stands quietly and at ease.
- Does not play with chalk, ruler, keys, etc.
- Does not comport himself with arrogance.
- Displays interest in the subject.
- Does not criticize superiors and others.
- Has a sense of humour.
- Is self-confident.
- Is emotionally well-balanced.
- Adapts gestures to subject and circumstances.
- Dresses neatly but not gaudily.

b. Knowledge:

- Knowledge of the subject.
- Extensive professional background.
- Extensive general background.

c. Structure of the lesson:

- Clearly defined objectives.
- Subject suited to the audience.
- Opening and introduction to suit the subject and the circumstances.
- Main part of the lesson develops by stages and in logical order.
- Summary and conclusion suit the subject and the circumstances.
- Lesson develops from easy to difficult material.
- Proofs and reasoning are convincing.

d. Communication:

- Instructor is sensitive to the atmosphere in class.
- Encourages participation of the audience.
- Is considerate of the feelings of his audience.
- Does not allow students' interest to flag.
- Is able to take care of hecklers.
- Does not engage in dialogue with one participant.
- Is prepared to listen to ideas of participants.
- Succeeds in launching discussions among the students.
- Is sincere.
- Knows how to kindle students' enthusiasm
- Succeeds in stimulating students to do their best.
- Makes the group feel that decisions taken are his own.
- Tries to be of the class and not above it.
- Is able to overcome difficulties of communication.

e. Presentation:

- Instructor adheres to programme and objective.
- Opening is interesting and arouses audience attention.
- Keeps to the time schedule.
- Does not jump from one subject to another.
- Knows how to make use of the outline.
- Delivery is simple and presented in plain language.
- Does not use unclear terms.
- Makes efficient use of the different types of question.
- Continually tests students' absorption of material.
- Adjusts subject development accordingly.
- Sums up material at intermediate stages, when necessary.
- Effectively combines different methods of instruction.
- Adapts material to the students' needs.
- Questions are so formulated as to be clear and easily answered.
- Abstract concepts and ideas are fully explained.
- Aims at developing students' thinking power.
- Broadens scope of students' interest.
- Uses clear, easily understood language.
- Speed of delivery is adapted to the audience.
- Delivery is not monotonous.
- Changes tone to indicate emphasis.
- Summing up is clear, convincing and easily remembered.

f. Visual Aids:

- Are suited to the subject.
- Are suited to the audience.
- Are suited to local technical facilities.
- Are brought into play at the right moment.
- Are sufficient but not superfluous.
- Are prepared in the correct size and shape.
- The investment of labour and money is justified by results.
- The lecturer handles them confidently.
- The main points of the subject under discussion are well emphasized by use of the aids.
- Use of the aids is effectively integrated into the lecture.
- The aids stimulate the audience into action.

g. General:

- The instructor is able to create a pleasant general atmosphere.
- Takes care that technical facilities are adapted to pedagogic needs.

VISUAL AIDS

Planning of visual aids

- a. Examine each point of your outline; ask yourself where can you improve the communication value by using some visual aids. In deciding what to use, ask these questions while considering each point in relation to the audience you are addressing:

- Is this part of the lecture important for achieving your purpose?
- Is that point difficult to explain without the use of visual aids?
- Do the visual aids help in making it stick in the memory of the listeners?
- Is it easier to persuade the audience with the help of visual aids?
- Does the use of visual aids make presentation more lively and more interesting?

- b. List exactly what you plan to use, then ask yourself the following questions:

- Where can I get the necessary aids?
- Will I have to make it myself?
- Will it cost me too much?
- Will I have time to make it?
- If I order it, will it be here on time?
- Does the office have the materials I need?
- Will I have the visual aid on hand for practice?
- Will I be able to hang it up, display it, plug it in?
- If it is a projector; will I be able to operate it?
Can I find someone to do it while I do the talking?
- Will it be clearly seen?

- c. Practising the speech with visual aids

- Try to have all visual aids present when practising.
Practise arranging them.
- Practise using a pointer if necessary.
- Follow the general procedures of previous practice instructions.

- d. Presenting a speech with visual aids

- Be ready before entering the meeting place.
- Put your visual aids in order, in positions where they will be seen. Don't place devices before the audience for their observation prior to the point of your speech where you want to introduce them.
- Don't get tied to the mechanics of your own aids. Remember you are talking to the audience and the aids are aids only. If an aid overwhelms the speech, dominates it, draws constant attention to itself, it is a poor aid.

- e. Checking after presentation

- Were the devices really useful?
- Were they well planned?
- Were they used well?
- Could they be plainly seen?
- Did they suit the subject-matter?
- Did they help in achieving the main purpose?
- Were you too dependent on the aid?
- Did they distract attention
- Did the audience react favourably?
- Did you get audience feedback?

The Blackboard as a Teaching Aid

The blackboard is one of the cheapest, simplest, most popular and effective visual aids to teaching. Correct use, which requires only brief training, will ensure maximum profit from the board, not only in schools, but also in agricultural extension work.

a. Advantages of the blackboard:

- Simple to use in comparison with other visual aids. Every instructor can easily master the method.
- There is hardly a subject to which the use of the blackboard cannot be applied successfully.
- The experienced instructor can adapt the use of the blackboard to any audience and any level.
- The blackboard can be used to introduce subjects at required intervals according to the tempo of the lecture.
- The blackboard enables one to develop the subject gradually, as the lecture progresses.
- Any alteration can be made, an error can be erased without difficulty, and without interrupting the lesson.
- Use of the blackboard is flexible. Part of the subject may be prepared on it before the lesson, the remaining part of the board being used to develop the subject during the lesson. Furthermore, a special section of the board may be reserved for a 'reminder' - to note questions, problems and memoranda during the lesson.
- The blackboard does not usually require special arrangements, does not use electricity, as do many other types of equipment. It may be used almost anywhere.

b. Materials of which a blackboard is made:

In a classroom or regular meeting place, one of the walls may serve as a board if properly plastered, planed and painted.

For portability, a board may be prepared from plastic cloth, stretched over two sticks. A firm wall behind the cloth is needed while writing.

The measurements of the board always depend on the subject, but as a rule it may be said that the blackboard should not be too big. When a portable board is used, sometimes two to four boards are needed. Size and number is determined by:

- size of the study group;
- distance between the board and furthest seat;
- requirements of the subject being studied.

c. Location and preparations:

Proceed according to the following paragraphs, step by step.

- Include in your lecture outline notes on the manner of using the board. Intricate drawings, formulae or tables must be included in the lecture outline.
- Before the lecture, set up the board in a suitable position. Walk around and test visibility from every point in the meeting place. At this stage, decide where to stand during the lecture. Also prepare duster and chalks.
- If the subject matter calls for it, or if you have not complete confidence in yourself, rehearse briefly some of your drawings or other details.
- Examine the size of your lettering from the back rows.
- Afterwards, clear the board well. Notes from a previous lecture should not be left on the board, even if you do not intend to use the blackboard, as this disturbs the concentration of your listeners.

- Complex drawings and diagrams on which you do not want to waste time during the lesson should be prepared beforehand. They may be covered with paper and then be revealed at the right moment. Remember that preoccupation with the board on your part is a waste of audience time and tends to reduce attention.
- Plan the arrangement of the audience before its arrival. Take into account that visibility is not good from an acute angle to the board. Do not hesitate to point out a better place to a participant.
- If the meeting takes place outside, the sun or other source of light should be behind the audience or slightly to one side. If anyone should have to make an effort to see, it is better that it be you.

d. Layout:

It is common knowledge that an audience can remember well the full picture as it appears on the board. You should, therefore, attach particular importance to your layout; it should be clear and easy to remember.

- Divide your board, (at least mentally), into two parts: one to be used for the subject, the other for incidental notes, questions and comments from the audience.
- As a rule, the board should be used from top to bottom and from left to right, except for special cases, when the subject calls for a different procedure.
- A lengthy subject should be divided into visual sections, to make understanding easy.
- Do not overcrowd the board with superfluous, irrelevant matter.
- Erase immediately incidental explanations and leave only key points.
- For example, underline; use circles and squares; use colours; beware of exaggerating.
- To indicate movement, direction, etc., use arrows or other easily recognized symbols.
- Layout is a matter of experience and, in some cases, borders on art. But, however you decide to divide your board, think about it in the beginning and throughout your lecture. Pre-planning will prevent situations in which you will find yourself short of space, when you will have to erase essential points in order to make room.

e. Readability:

- First rule: letters and digits must be simple, not decorated. Most lecturers alter their handwriting when using the chalkboard. The change should be for simplicity and clarity, not for speed and intricacy.
- Printed capital letters are easier to read than script.
- Distinguish, by size or type of lettering, between headings and subheadings and text.
- Leave ample margins.
- Test the size of your lettering, using the following rule of thumb:
Letters two inches in height are readable at a distance of fifteen feet;
Letters three inches in height are readable at a distance of twenty-five feet at most.
- Space between the lines is no less important than size of letters. Ideally the distance between the lines should be at least equivalent to the size of the letters.
- Illustrations accompanying notes should be as simple as possible.
- After the lesson, do not immediately erase what you have written on the board. Stroll around the meeting place, look closely at the board, and ask yourself about improvements for the next lesson.

f. Behaviour during lecture:

- Don't talk while drawing on the board. Your words will not be clearly understood. If necessary, interrupt your writing from time to time and explain to the audience what you are doing. Keep up the interest.
- While talking, always face the audience.
- Always stand beside the board. Do not obscure the blackboard.
- Use a pointer to show details and attract attention.

- Behave quietly, don't be nervous. Do not play with chalk or pointer; put them away when they are not in use.
- Stop talking while you make erasures.
- Test your behaviour and you will find other ways of improving it.

g. Summary of rules:

- Get everything together before the meeting.
- Simplify use of the blackboard.
- Do not overcrowd the board
- Check the lighting.
- Plan the layout.
- Use colours where necessary.
- Write and draw on a large scale.
- Erase what you no longer need.
- Prepare complicated equipment beforehand.
- Use a pointer and duster; do not use your hands.

The Flannel-Board

The flannel-board is a popular and effective visual aid. Here are some of its advantages:

- Adaptable to almost any subject and audience;
- Stimulating;
- Simple to use, alone or with other visual aids;
- Inexpensive;
- Enables development of the subject at the desired pace.

a. The preparation of a flannel-board:

The board is simple to prepare. Flannel cloth, a woolen blanket fixed to a stiff background, will give the best results. For the use of regular sessions a number of boards of some light material, such as cellotex, can be prepared for special purposes; portable folding boards of hardboard or thick cardboard can be made.

The size of the board is determined by the size of the audience and by the space needed for the development of the subject.

A blanket, well stretched between posts or trees, may be used under field conditions, but the lecturer will do well to take the wind into consideration.

The flannel-board should be tilted backwards at an angle of 10 to 15 degrees.

b. Illustrative material:

The illustrative material used with the flannel-board is varied and depends on the imagination of the person preparing it. In any case it requires only simple preparation. (Ready-made pieces can also be used for many purposes).

Material in use are:

- Flash-cards
- Cut-outs
- Symbols
- Objects made of plastic, foam, cork, etc.
- Figures and silhouettes
- Photographs
- Cloth cut-outs.

c. Planning:

Determine the central subject of your lecture, or that section of it which you want to illustrate with the help of the flannel-board. Ask yourself the following questions:

- Where can I add interest?
- Which points need visualization to make them better understood?

Plan the order of presentation of your pieces according to the progress of your lecture.

It is advisable to make a sketch of your pieces as they will appear on the board, so that you will be able to visualize their appearance on the flannel-board. You will sometimes find that you can make changes in the plan and introduce new ideas.

Use the flannel-board together with a real object or with other visual aids.

The Observation Trial

a. Definition and use:

The observation trial is a device whose function is to prepare for the work of the extensionist. It consists of a number of plots of land in the fields of certain farmers, where the extensionist puts to the test the results obtained at the research station.

The observation trial represents the intermediate stage between the trial at the research station and the demonstration, which is aimed at extension in the strict sense. The observation is widely used for the following reasons:

- Research on a given subject is conducted only in one station. Research is very costly, and simultaneous experiments cannot therefore be conducted in a number of stations.
- Research conducted in one region does not necessarily hold good for another, where the soil or the climate is different. Therefore, we prefer to test the results of scientific research in the regions which are interested in the particular crop. This task is performed by the regional extension workers in cooperation with the research workers who are charged with the supervision of the observation plot and with the analyses of the results obtained from it. An observation trial would be used when, for example, the results obtained on an experimental plot, concerning some new varieties of groundnut have to be tested. Of all the varieties which were tested at the research station, two seemed to give greater yields than the local variety. Before the new strains are extended, they must be tested in a number of observation trials belonging to groundnut growers in the region, to make sure that the new varieties are really better than the old.

b. Types of observation trial:

We shall indicate two types, according to the method employed:

1. A trial with a design identical to the one previously carried out at the experimental station, that is to say that each treatment is repeated a number of times. This method has some merits but might not be easily applicable on average farmers' fields as it generally requires a great number of plots and, consequently, paths or bunds between them. The feasibility of carrying out such observation trials may greatly depend on the level of instruction and attitude of the farmers as well as on the background and experience of the extension workers.

2. A trial where each treatment is performed only once, but several are laid out in a relatively limited area, with similar environmental conditions which allows grouping of the results and their statistical analyses.

c. Planning:

Having defined the problem, the operation must be planned, and the sites and farmers selected according to the following criteria:

(i) Choosing the Site:

Three important points must be borne in mind;

1. The fertility of the soil.
2. The uniformity of the soil over all the area, so that the results will be significant.
3. The crops of the preceeding years must have been the same as those which are to be put to the test.

(ii) Choosing the Growers:

The farmers who are to grow the trials should meet the following criteria:

- They must be convinced of the importance of the project for themselves and their friends.
- They must be prepared and know how to carry out all the crop husbandry operations in a precise manner and at the desired time.
- They should be influential and enjoy the esteem of their neighbours.
- They must agree in advance to accept group visits to their land.

(iii) Cooperation with the research worker:

Having chosen the sites and the growers, the extension agent accompanied by the research worker, will visit the selected sites and the two will examine them. They will draw up the plan for the project, taking into account the information gathered so far, to achieve the aim of the operation, i.e. to obtain valid results. The cooperation of research workers at the planning stage is of great importance because:

- They have already conducted experiments in research stations on the crop in question.
- They are specialists in the planning of scientific experiments and are trained to draw conclusions from the results.

d. Implementation:

Having planned the project in cooperation with research worker(s), the extensionist will proceed to carry it out. This will involve:

- (i) Division of the land into plots in accordance with the plan. Placing of signs on stakes to indicate the treatment used, the number of the test, etc.
- (ii) Planting:
Fertilizer application and planting will take place in the presence of the extension worker. He will weigh fertilizers and seeds to the exact quantity, and make sure that they are equally spread over the plots.
- (iii) Instructions:
The extensionist will issue all the instructions (oral and written) to the grower, on the tasks to be carried out until his next visit.

- (iv) **Frequent visits:**
The extensionist will make frequent visits, in the course of which he will examine the plots closely, noting every detail on the vegetation, diseases and parasites. He will have errors corrected and will issue instructions.
- (v) **Results:**
At harvest, the extensionist will be present and weigh the yields obtained from each plot, and will note the figures, in accordance with the plan of the project and report all data required.
- (vi) **Profitability Study:**
After the operation, the extensionist and the grower will draw up the financial balance sheet, taking into account supplementary expenses incurred through additional labour, materials and incidental losses. The total outlay minus the price obtained from the sale gives the net benefit from the experimental crop, which can then be compared with those of the neighbouring plots of the same area which have been grown in the traditional manner.

e. **Conclusion:**

We have seen that the observation plot represented the intermediate stage between the experimental plot at the research station, and the demonstration plot which is aimed at extension. Although the observation plot is primarily for experimental purposes, it can serve the purpose of extension, if the results are conclusive.

One could, for example, organize a field trip to the observation plot to arouse the interest of the growers. The extensionist could also, on the basis of the results obtained and the conclusions drawn by the research worker, prepare a lecture on the subject, showing photographs or colour slides taken on the observation plot. In this way, it will prove easier to convince the growers of using the new method, by means of the demonstration plot the function of which is to extend the new method.

Group demonstrations and field days

a. **Definition and description:**

The demonstration considered as an extension activity is a teaching method the purpose of which is to show how to carry out a definite operation or series of connected operations on a given subject. Thus it will be possible to use the demonstration to rouse interest in a given extension subject.

b. **Advantage of group demonstrations:**

The demonstration of the subject to the participants makes it possible for them to judge of its excellence and entails at the same time an exchange of opinions among them that will convince them of the truth of the subject and the importance it has for them.

c. **Stages of preparation:**

An agricultural demonstration has a number of stages. The accurate carrying out of these stages according to their order will ensure the attainment of the aim.

- Convincing farmers to come to the activity.
- Convincing them of the importance of the subject for them.
- Acquiring the basic knowledge, necessary to the demonstration.
- Introducing the subject as a whole.
- Teaching every stage in detail.
- Conclusion of the matter taught and evaluation.

d. Subject of the demonstration:

An extension officer who is about to prepare a demonstration ought to wonder first of all whether the subject is topical and suited to the participants; whether the farmers are in a position to acquire the equipment necessary to carry out the operation on their farms; whether the educational level of farmers is suited to the demonstration of the subject; whether the subject was sufficiently tested in the conditions prevailing in the participants' farms.

In a planned demonstration it is possible to teach numerous and various subjects but the extension method should be suited to the subject.

For example, it is easy to demonstrate (in a convincing way) any subject the results of which are quickly obtained, e.g. an efficient working method. On the other hand, it is more difficult to demonstrate subjects the results of which will only be obtained after a certain time, as for instance, soil conservation methods or animal breeding.

The visit of the Extension Worker to the farm

a. Introduction:

A visit to the farm is the direct form of extension work; it is for the extension worker, the method. A visit increases the farmer's faith in the extension services and gives the extension worker a good opportunity to interest the isolated farmer in the operations of the service.

A visit to the farm is an excellent method, but an expensive one. It requires careful planning, a clear definition of aim and a prior evaluation of its results. In order to be useful, the visits ought to:

- Have a clear aim,
- be well planned,
- be of a friendly and business-like character.

b. The aim:

You probably visit farms for one or a number of the following purposes:

- To get acquainted with the farmer, the farm, the problems of the farm.
- To plan a demonstration.
- To examine the fields, see the results of various methods of cultivation.
- To consult local leaders and members of the local committees.
- To stimulate cooperation and participation.
- To exchange opinions on agricultural plans and policy.
- To introduce new methods on the farm.
- To respond to a request for instruction, to solve farm problems.

A sensible use of the visit is an important part in your work plan. A good use means: make those visits in places which will derive the greatest advantage from them, give you a chance to become acquainted with the greatest number of farms and not limit your visits to small groups of people. Young and new farmers will greatly benefit from your visits. Make sure you visit those who need your presence most.

c. Planning the visit:

The success of your visit depends, to a great measure, on your preparation for it. You have to collect all the available information concerning the farm - size, type of soil, kind of crops, etc.

It is still more important to know the farmer and his family beforehand. It is useful to know the story of his life, his family situation, his understanding and knowledge, his prejudices and spirit of enterprise. You will receive additional information about the farmer when you ask him questions at his home and in the fields.

Plan far ahead. Keep a calendar of visits; arrange visits in geographic groups in order to save time and money. If the visit is particularly important, or is to last long, plan it well in advance.

d. The Visit:

When visiting a farm, you are the teacher as well as the bearer of ideas and facts. Thus, you perform an important function. You will do well by keeping the following rules in mind:

- Emphasize again and again the purpose of your visit.
- Be sure that the talk doesn't veer off the main subject and doesn't turn to gossip.
- Be sure that your instruction fits the particular farm you are visiting.
- Remember that the farmer is your host and you are his guest.
- Be modest, forgiving and careful in your proposals.
- Be flexible.
- Be careful to give out only necessary information on other farms.
- When you finish your visit - move on to another farm.

Tell the farmer immediately what you came for. An opening such as, "I just dropped in because I had nothing else to do," will lower the importance of your work in his eyes. On the other hand, he will respect you more and will consider himself more respected if you'll say: "I came to see you about ..." or, "I wanted to meet you."

If you don't know the man well, speak with him in the beginning on matters and problems which he brings up, but steer the conversation in the direction which you planned beforehand. Your task is to give him concrete help. Try to give him alternative proposals pointing out the merits and faults of each. Get full information before you make recommendations. Don't set yourself up as a final authority; quote others. Bring examples from the work of others and immediately emphasize their success.

If you don't know something, admit it, but then find the answer and contact the farmer again. Do this on time.

Don't take too much of a busy man's time. Make your visit matter-of-fact and business-like. Finish your job and be on your way.

Be flexible. If the farmer wants to show you something new on his farm, find time to see it. Encourage him; your encouragement and praise will stimulate him to further efforts.

If you have met the farmer only a short time ago, invite him to classes and demonstrations. Explain to him in what ways the extension service can help him.

Once you have said goodbye, be on your way. You can stop on the road to write down your remarks.

Since visiting farms is such an important part of extension work, you ought constantly to strive to improve your techniques. Advising farmers is an art; you have to know how to praise them, how to accept their remarks, and even criticism. You must remember that, on the whole, people tend to respond positively when asked to give practical help or advice in extension work.

A good instructor will show leadership in his visits to farms. He will listen sympathetically to the problems and ideas of the farmers; he will try to teach them and give them instruction. He will not take advantage of his visits to increase his personal prestige.

e. Requests for visits:

If the farmer invites you to visit him, your task will, of course, be easier. Most visits, however, are not the result of invitations. Other forms of instruction - such as group meetings, radio broadcasts, bulletins, demonstrations, will arouse the farmers' interest and make them ask for visits of extension workers. In many cases, invitations will follow when farmers receive information on a specific extension service.

NEW DEVELOPMENTS IN FERTILIZER TECHNOLOGY

by

Robert G. Mueller ^{1/}

INTRODUCTION

The Tennessee Valley Authority (TVA) was created in 1933 during the administration of Franklin D. Roosevelt to work in a very depressed region of the United States of America, the Tennessee Valley Region. The area is composed of parts of seven states and is about half the size of Kenya.

The agency was further given a nationwide responsibility namely to develop and introduce new and improved fertilizers. Some old, government-owned nitrate plants constructed in Alabama during the first world war to make nitrate for explosives were given to TVA for use in the fertilizer programme. The facilities were also to be used, as needed, to make munitions in time of war.

In meeting its fertilizer obligations, TVA has developed at Muscle Shoals, Alabama, a National Fertilizer Development Centre, which has also, in many ways, become an international centre for fertilizer information.

It was decided early that TVA's role in fertilizers would be one of research and development: to search for new fertilizers and ideas, which would be patented; to help develop these new processes and products and then to license them to industry for further development and production. The licensing of TVA's processes is not exclusive to industry in the U.S.A. No patents are taken out in other countries; thus, developments are also freely available to industry worldwide.

Although TVA holds the patents for many of the fertilizer processes used in the United States today, we do not sell the products normally found on the U.S. markets. We do not sell urea, ammonium nitrate, triple superphosphate, diammonium phosphate or normal NPK grades that are readily available to the American farmer; the user must buy these from industry. TVA manufactures, but only in small quantities, such products as ammonium polyphosphates, urea ammonium phosphates, various base solutions for liquids and suspension fertilizers and numerous high-analysis fertilizers that contain significant amounts of secondary nutrients and micronutrients. It is also beginning to manufacture controlled-release N fertilizers. TVA's objective is to make fertilizers that fit crop needs and reduce nutrient losses through volatilization, run-off, or leaching so that a higher percentage of the applied N fertilizer can be used by the crop. At present, in the United States and Europe, much attention is being focused on the potential contribution of fertilizers to eutrophication.

TVA's goal has been primarily one of working through research and development to make fertilizers that are cheaper and of better quality. In the past improvements were achieved principally by increasing the plant nutrient content of the fertilizers, making them of higher analysis and improving on fertilizer processes to make them more efficient.

Plant nutrient contents of fertilizers in the U.S.A. have been increased from an average of 20% in 1940 to over 40% today. Fertilizers have also decreased in price to the American farmer and are the only major input to have done so.

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At the National Fertilizer Development Center there are a Division of Agricultural Development, a Division of Chemical Development, and a Division of Chemical Operations. Employees total about 1 100 people and a professional staff of scientists and engineers that number over 200. Disciplines include chemists, chemical engineers, agronomists, economists, marketing specialists, transportation specialists, communication specialists, etc.

TVA has a small International Fertilizer Development Staff that coordinates technical assistance programmes with developing nations. Members of this staff call on individuals from all these disciplines for help in solving problems and advising those in the developing countries on problems related to fertilizers. This is done at the request of the U.S. Agency for International Development; various UN organizations, including FAO; the World Bank, Regional Development Banks, and the governments and industries of the developing countries.

Since 1964 TVA has responded to requests from some 25 countries and have sent some 60 teams utilizing over 60 different people as team members.

In addition, TVA offers training courses and assists in organizing or conducting training courses in the developing countries. Since 1965, TVA has trained over 300 participants in courses on fertilizer production, distribution and sales. It has also, during the past five years, improved its library to give it better coverage of matters pertaining to fertilizers. TVA also encourages the use of this facility either by direct visits or through correspondence.

It makes numerous studies that are of worldwide importance and interest. As one example it tries to keep an up to date record of fertilizer production capacities, in operation, under construction and being planned. Then, by working with FAO statistics on fertilizer production and use, it can have available a better picture of fertilizer production in relation to demand. All this information is accessible by computer methods and it can easily be made available to anyone who wants it.

From this information TVA's projections show that world consumption of plant nutrients is likely to rise from the 1971 level of 68 million metric tons to more than 105 million metric tons by 1980. Growth rates between 1971 and 1975 should be about 6% per year. Over the longer term, the rate is expected to average 5% per year from 1972 to 1980. By 1980, nitrogen use should exceed 51 million tons, P₂O₅ over 29 million tons, and K₂O almost 25 million tons (Table 1).

Rates generally will increase faster in developing than in developed regions, but may not equal the rapid gains of recent years. The world fertilizer market is maturing to a point where in many areas the greatest impact of increased use may have already been achieved; in such areas, the future increases in agricultural productivity will depend to a greater extent on the optimum combination of all farm inputs.

World nitrogen supplies should easily exceed forecast demand, with little overall improvement indicated by 1975 in the supply-demand balance. Capacity is being increased at a declining rate in developed regions, but developing regions are expected to continue to expand capacity rapidly. Nitrogen supplies in developing regions will therefore more closely match demand in the next four years; achievement of significantly higher operating rates could lead almost to self-sufficiency in nitrogen.

Phosphate capacity is not expanding as fast as demand is expected to increase; however, a wave of construction of new capacity may be coming which could result in excess production. Although the developing regions have planned significant increases in capacity, they will not be able to meet expected demand and continued trade in phosphate materials or intermediates such as phosphoric acid can be expected.

The world potash production potential remains more than adequate to supply anticipated demand. Potash use and trade will remain primarily in the developed regions. Some improvement of the potash market is foreseen as capacity additions are at a minimum and a steady increase in demand is expected.

Table 1. Consumption of plant nutrients (N, P₂O₅, K₂O)

Region	1965		1971			1975			1980		
	Total demand (mil tons)	Market share (%)	Total demand (mil tons)	Annual growth '65-'71 (%)	Market share (%)	Total demand (mil tons)	Annual growth '71-'75 (%)	Market share (%)	Total demand (mil tons)	Annual growth '71-'80 (%)	Market share (%)
Developed Regions											
North America	10.5	25.7	16.1	7.3	23.6	19.9	5.4	23.2	24.5	5.0	23.2
Western Europe	12.5	30.5	16.7	4.9	24.6	18.9	3.0	22.0	21.8	3.0	20.1
Eastern Europe	8.9	21.7	17.8	12.3	26.2	23.5	9.5	27.4	30.0	5.9	28.4
<i>Total^a</i>	<i>35.5</i>	<i>86.7</i>	<i>54.8</i>	<i>7.5</i>	<i>80.4</i>	<i>67.1</i>	<i>5.2</i>	<i>78.2</i>	<i>81.8</i>	<i>4.5</i>	<i>77.4</i>
Developing Regions											
Asia ^b	2.1	5.0	5.2	16.6	7.6	7.1	8.3	8.3	9.0	6.4	8.6
Africa	.7	1.6	1.1	8.9	1.6	1.3	4.6	1.6	1.6	3.8	1.5
Latin America	1.4	3.5	3.1	13.8	4.5	4.6	10.7	5.3	5.8	7.4	5.5
<i>Total</i>	<i>4.2</i>	<i>10.1</i>	<i>9.4</i>	<i>14.6</i>	<i>13.7</i>	<i>13.1</i>	<i>8.7</i>	<i>15.2</i>	<i>16.5</i>	<i>6.5</i>	<i>15.6</i>
Communist Asia	1.3	3.2	4.0	19.8	5.8	5.6	9.0	6.5	7.4	7.1	7.0
World	41.0	100.0	68.2	8.8	100.0	85.8	5.9	100.0	105.7	5.0	100.0

^aIncludes Oceania, Japan, Israel, and South Africa

^bExcludes Communist Asia (Peoples Republic of China, North Vietnam, and North Korea).

Table 2 illustrates the past trends and projections in NPK production and consumption in developing African countries (including South Africa).

Table 2. Past trends and projections in NPK production and consumption for Africa

Year	Consumption			Production			As % of world consumption
	N	P	K	N	P	K	
1967	452	176	116	163	331	0	1.6
1968	476	207	119	150	391	0	
1969	540	218	118	144	446	0	
1970	587	239	131	163	426	67	
1971	665	309	150	197	426	160	1.6
1972	684	311	167				
1973	712	337	178				
1974	739	362	183				
1975	764	383	193				

While Africa's annual growth rate of fertilizer consumption 1965-71 has averaged 9% its world market share has remained the same (1.6%). These figures reveal a small tonnage that is in relation to Africa's size and population.

Africa and Brazil are now about equal in consumption and production of fertilizer. Brazil's consumption is growing at 15% to 20% per year. The reasons are many, but at some time Brazil's recent experiences would be of value to African planners, particularly in the areas of rural credit, foreign investment policy, fertilizer education, etc.

Until 1968, Egypt was the only African country, other than South Africa, producing nitrogen. However, several new ammonia plants have since been constructed elsewhere, mainly in North Africa, and Egypt no longer dominates the region's supply pattern. Developing Africa has only 10% of total nitrogen capacity in the developing regions. By 1975, it should have 13% of the total. However, because of its current limited demand, Africa is the only one of the three major developing regions that could become self-sufficient by 1975, even should plants operate at only 60% of capacity. Location of capacity away from areas of potential heavy use implies that producer nations will face stiff competition for these African markets.

Improving operating rates to 80% would create an apparent surplus of over 250 000 ton N by 1975. Consumption forecasts for Africa have been heavily weighted by the lack of a significant long-term growth in use in Egypt. Other African nations have experienced much higher rates of increase and the potential exists for further rapid gains. A significant gain in the demand for nitrogen could quickly take up any surplus production within the region.

With regard to phosphate, the developing countries of Africa have a total estimated production capacity of more than double their current consumption. Long a major exporter of phosphate rock, this region has also established phosphate fertilizer production facilities at mine or port sites to convert phosphate rock to finished materials, also for the export market. A steady increase in trade between 1965 and 1968 was recorded; however, in the last two years increased domestic consumption and lower production rates reduced the trade balance to 130 000 tons of P_2O_5 in finished goods form.

Capacity additions in the next few years will be more in line with projected demand levels, allowing this region to maintain its current balance of trade. Increased trade can only be achieved with improvement in operating levels well above the poor performance of the past two seasons.

Fertilizer products of immediate and long term potential

Urea, high-analysis compound fertilizers, and diammonium phosphate are experiencing, and will continue to experience, the greatest acceptance and offer the greatest growth potential in Africa of all the fertilizers on the market today. These projections are based in part upon the analysis presented in the Introduction, in part on trends of use by product that have occurred in the past 10-15 years, and on new fertilizer capacity scheduled to be built in Africa in the next 3-5 years.

Although special local situations may dictate otherwise, the materials in decreasing order of immediate potential in Africa are as follows:

Urea

a. Potential

Urea is the highest N-containing solid fertilizer material commercially available. Its high analysis permits considerable savings in shipping and distribution costs. Because of

this, plus the fact that solid fertilizers have better growth potential in Africa than liquids due mainly to the simplicity of shipping and handling dry materials and the common absence of sophisticated equipment, urea has proved attractive to a large number of farmers and fertilizer manufacturers.

For these and other reasons, urea has played an increasingly dominant role as the main nitrogen fertilizer in the world in general. (Figure 1). Although these generalizations hold for a given region, the degree of dominance of urea within a country is somewhat dependent upon the amount and type of other existing nitrogen capacity.

When properly applied, urea has been shown to be equal or nearly equal to ammonium sulphate as a source of N to many crops, including maize, wheat, and rice (Engelstad & Hauck, 1966). In those instances where response to urea was less than to ammonium sulphate, the differences have been attributed to either the sulphur component of ammonium sulphate or to the improper use of urea. No other single-nutrient fertilizer has captured the attention of agricultural and fertilizer production specialists as has urea. In most areas, it has already become, or is rapidly becoming, the leading fertilizer used in the developing world.

In spite of this potential and current rate of acceptance, urea has certain inherent problems that must be overcome if it is to continue its current rate of growth. This is particularly true in those regions lacking sophisticated capabilities in handling fertilizer and modern methods of tilling soil. The more significant of these problems are first the hygroscopic nature of urea which often results in poor handling properties, either as straight material or in blends, particularly under hot, humid conditions (Figure 2). This causes problems in bulk blending, bulk transport, and mechanical bulk spreading. Unless corrected, this disadvantage could restrict its use. Second, nitrogen is lost through volatilization as ammonia when urea is surface-applied to soils, especially in warm climates. This is a major problem when the product is not incorporated into the soil immediately after application (Burton & De Vane, 1952; Volk, 1959, 1961). As much as 60% of the N applied as urea may be lost in this way. Even on flooded rice, urea has occasionally been shown to be greatly inferior to ammonium sulphate as a source of N to the crop (Patrick, personal communication, 1970). The reasons for this have not all been identified. These problems are real and will be more apparent as fertilizers become more available and farmers have an opportunity to compare various nitrogen sources in supplying the needs of the crop.

Although it has been suggested by some that the biuret content in all urea produced should be less than 0.3%, it is now believed that this is important mainly for citrus crops when urea is applied as a foliar spray. Extensive tests on other crops suggest that biuret levels in foliar-applied urea can approach 0.7% and not be harmful, and that 2% biuret is acceptable if the urea is applied to the soil (Goralski *et al.*, 1966; Hartsig, 1958; Jones *et al.*, 1955).

Ammonium Phosphates

Various types of ammonium phosphate are available (11-48-0, 18-46-0, 16-20-0, 16-48-0, 13-39-0). For reasons that will be apparent later, it is difficult to determine whether consumption of ammonium phosphates or complex (N-P-K) fertilizers will experience a growth rate second only to urea. It is the author's opinion that, the overall rate of use of fertilizers is still relatively low in many of the developing countries of Africa, ammonium phosphates (N-P) will receive great attention.

a. Potential

It is difficult to forecast the role that ammonium phosphates will play in the total phosphate market in Africa, although their popularity has increased greatly in recent years and, on a world basis, they promise to replace normal superphosphate in 1973 as the chief phosphate fertilizer. This growth has occurred primarily in the developed countries where bulk blending has become very popular (Figure 3) (Wellman Lord Inc., 1967).

FIGURE
MARKET SHARE OF MAJOR FERTILIZER PRODUCTS-NITROGEN
(WORLD)

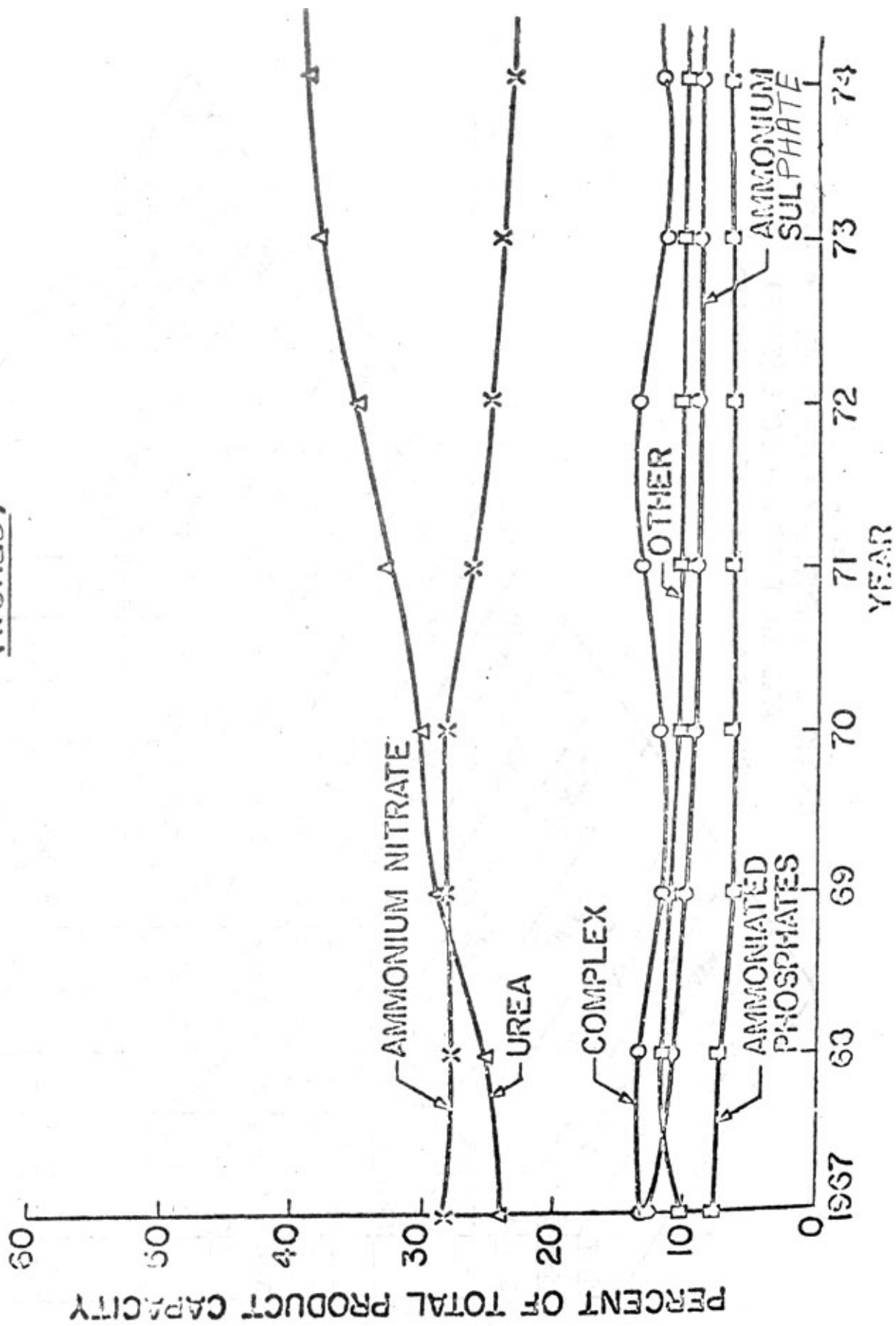
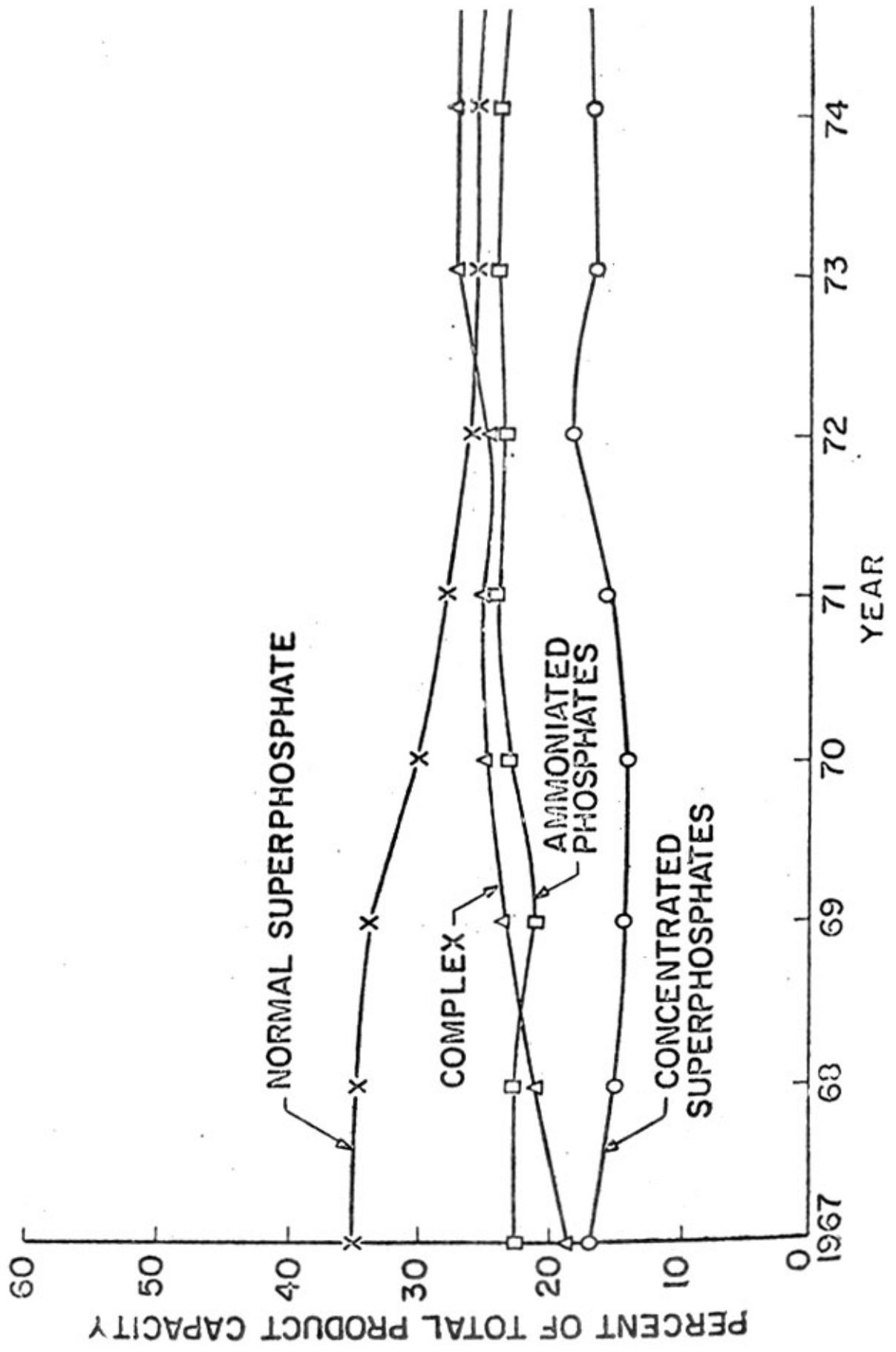


Figure 2
**CRITICAL HUMIDITIES OF FERTILIZER SALTS
 AND MIXTURES AT 30°C.(86°F.)**
 (VALUES ARE PERCENT RELATIVE HUMIDITY)

49.7	CALCIUM NITRATE		AMMONIUM NITRATE		UREA		SODIUM CHLORIDE		AMMONIUM CHLORIDE		AMMONIUM SULPHATE		DIAMMONIUM PHOSPHATE		POTASSIUM NITRATE		MONOCALCIUM PHOSPHATE		POTASSIUM SULPHATE		POTASSIUM NITRATE		MONOCALCIUM PHOSPHATE		POTASSIUM SULPHATE		UREA-AMMONIUM PHOSPHATE		NITRIC PHOSPHATE		AMMONIUM POLYPHOSPHATE				
23.5	59.4																																		
57.7	45.3	72.7																																	
-	18.1	45.6	75.2																																
-	51.4	51.9	57.9	77.2																															
-	62.3	-	56.4	71.3	79.2																														
-	59*	-	62*	-	72*	82.8																													
22.0	67.9	66.9	60.5	75.5	71.5	70*	83.0																												
31.4	59.9	64.5	65.2	67.9	69.2	-	78.6	90.5																											
52.8	58.0	63.8	65.2	-	75.8	78*	72.8	59.8	61.6	68.8	75.6																								
46.2	52.8	69.1	65.1	75.9	87.7	76*	-	67.8	88.8	87.8	79.0	-																							
76.1	69.2	73.3	71.5	71.3	81.4	77*	-	87.8	79.0	-	93.6																								
-	-	-	-	-	-	-	45*	-	-	-	-	-																							
-	-	-	-	-	-	-	50*	-	-	-	-	-																							
-	-	-	-	-	-	-	-	-	-	-	-	-																							

NOTE: VALUES FROM LITERATURE FOR PURE SALTS EXCEPT AS NOTED BELOW:
 † TVA EXPERIMENTAL PRODUCTS (CONTAIN IMPURITIES)
 * APPROXIMATE VALUES OBTAINED BY TVA

FIGURE 3
MARKET SHARE OF MAJOR FERTILIZER PHOSPHATE PRODUCTS
WORLD



The direction in growth of ammonium phosphates depends on whether bulk blends or complex (N-P-K) fertilizers become popular. This in turn is dependent upon the type of phosphate capacity already existing within a country. Where little or no phosphate capacity exists, ammonium phosphates may well prove very popular, first, because their high analysis and good handling qualities make them easy to import, and second, as consumption increases, large, efficient units for production of monoammonium and diammonium phosphate (MAP, DAP) might be established within the country. Thus, this would provide a basic ingredient essential to the start or continuation of a blending industry.

Where blending has been accepted, such as in the U.S.A., a phenomenal increase in 18-46-0 and 0-46-0 has been observed, the former now supplying 50% to 55% of the P_2O_5 used in the United States. Where substantial superphosphate capacity already exists within a country, it may well be used directly in small N-P-K granulation plants. Under these circumstances, the potential for ammonium phosphates will be quite limited.

b. Agronomic and Chemical Properties

The term 'ammonium phosphates' encompasses a wide variety of fertilizers produced by the ammoniation of phosphoric acid, often in mixture with other materials. Because of their binutrient content, low hygroscopicity, high analysis, excellent handling qualities, 100% water solubility of nitrogen, and near 100% solubility of phosphate, they offer the considerable advantages of lower transport and application costs and a quick-acting effect on crops.

Ammonium phosphates are particularly suited for direct application in situations where substantial amounts of basal or band-applied phosphorus and small amounts of nitrogen are required. As more sophisticated application equipment is developed, they will be banded rather than broadcast at time of planting for such crops as wheat, maize, and sorghum. Where conditions permit, these materials will increasingly be applied to rice soils during seedbed preparation. Since all the nitrogen in the ammonium phosphates is in the ammonium form, they are particularly well suited to rice (Harre et al., 1972).

In contrast to urea, there are few physical or chemical problems associated with the use of ammonium phosphates in the humid tropics. They can be shipped in bulk in hot, humid regions with little or no difficulty, are compatible with a wide range of other fertilizers and can be applied to the surface of the soil with less danger of loss of either N or P. There is at least one problem, however, usually associated with diammonium phosphate; when banded at high rates in contact with or close to the seed under dry conditions, it can release free ammonia in sufficient quantities to retard seed germination or injure young seedlings (Albred, 1962). This can be easily avoided by placing the fertilizer, by hand or with special banding equipment, at least 1 to 2 inches to the side and below the seed.

Chemically- or Physically-Combined High-Analysis N-P-K Fertilizers

a. Potential

Complete high-analysis N-P-K grades (more than 30 units plant food) of fertilizer have been accepted by consumers in Africa, and their consumption has grown faster than that of any other fertilizer in tropical and subtropical countries such as Japan, Taiwan, Philippines, Korea. In Brazil, N-P-K complexes supply 70% of the plant nutrients sold.

The frequency of potash deficiency is less than one-tenth that for nitrogen and one-third that observed for phosphates. With intensification of farming, including use of new and higher yielding varieties, responses to potash will become more frequent, particularly on organic sandy and laterite soils; thus N-P-K compounds or mixtures will be in demand. As already discussed in the section on ammoniated phosphates, the acceptance of N-P-K grades is dependent upon the potential of bulk blends. Where bulk blends have good potential demand for physically-mixed N-P-K grades which include ammonium phosphates will probably

increase. In regions where bulk blends do not have great potential, such as in parts of Africa, use of the chemically-combined compound fertilizer will grow.

Regardless of whether they are blends or compounds, N-P-K grades will be of high analysis. Products are now available to make complete fertilizers in either form containing at least 40 units of plant food.

b. Chemical and Agronomic Properties

The products are usually granular. Colour is variable in blends but generally greyish if chemically combined. They usually contain more than 30 units of plant food, and are available in a number of ratios. They are chemical or physical combinations of two or three major nutrients, 100% water-soluble N, and 50% to 100% water-soluble P depending upon the choice of phosphate materials and production processes. The agronomic properties of these products are based upon the form of the individual plant nutrient present.

Triple Superphosphate (0-46-0)

a. Potential

Triple superphosphate is a high-analysis phosphatic fertilizer that has become more important in the last 20 years. Its use in Africa is expected to increase substantially from its current 5% share of the total phosphate market; by 1972, it may hold 20% of the market for the developing portion of Africa.

Triple superphosphate is most economically produced when a supply of phosphate rock is nearby and the phosphoric acid is produced in large and continuously operating plants.

b. Agronomic Properties

The phosphorus is almost entirely water soluble and is readily available to most crops under a wide range of conditions. Its low sulphur content (3% or less) relative to that of normal superphosphate is easily overcome by applying a sulphur-containing material to the crop at some other time. This fertilizer is free flowing in either run-of-pile or granular form and lends itself readily to ammoniation. This is a particularly important characteristic for those countries that must import phosphate but have their own ammonia facilities. Finally, it is a relatively low cost source of P_2O_5 , and its high analysis permits additional economies in handling, shipping, and distribution. In spite of all these apparent advantages, most if not all of its good qualities are equalled or surpassed by ammonium phosphates, particularly DAP. This, coupled with its incompatibility with DAP or urea in blends, limits its future growth potential.

New Potential for Old Products

Without exception, all the new fertilizers mentioned are higher in N, P, or K than their predecessors but contain little or no sulphur and certain other essential nutrients. Because of this and the proven beneficial effects of sulphur, particularly on wheat, maize, sorghum, and certain pulses, it would seem appropriate to reassess the potential of some of the so-called low-analysis fertilizers. Two of these are ammonium sulphate and ordinary superphosphate.

Ammonium Sulphate (21-0-0)

a. Potential

Because of its low nitrogen content (21%, all ammonium nitrogen), the downward trend in use of ammonium sulphate was predictable (Figure 1). In most fertilizer research tests, and in many government fertilizer education programmes, it has been replaced by other nitrogen sources, usually urea. Under present and probably future circumstances, this

decision is justified; per unit weight of N, urea is a more economic choice. Nevertheless, the relative competitive situation for ammonium sulphate is changing. Most of the ammonium sulphate produced today is a byproduct, usually of the steel or caprolactam industries. The loss of domestic and export N markets to urea has been substantial (Anon., 1970). This, coupled with increased emphasis on pollution control, has led to a variable supply of ammonium sulphate in recent years.

Pan Granulated Urea Ammonium Sulphate

Considering the good agronomic characteristics of ammonium sulphate and the more fragile physical characteristics of urea, TVA about two years ago felt that a compromise material might be developed which would incorporate the favourable characteristics of each.

The mixed product would have a higher nitrogen content than ammonium sulphate, contain available sulphur, and possibly have better physical properties than straight urea. TVA initiated studies to determine if a suitable and relatively simple process could be developed to produce such a material. The studies were carried out in a pan granulator as described below.

This process was studied in a large pilot plant in which the production rate was about 0.45 t/h (Figure 4). Most of the test work was carried out for production of a 40-0-04S material, although some tests were made of a 35-0-0-10S grade. In these tests, a concentrated urea solution was prepared by melting urea prills in steam heated tanks. This solution was fed to two spray nozzles arranged to deliver solution to the moving bed of recycle. The solid ammonium sulphate was added to the urea prills prior to melting. This method appeared to be superior to feeding the ammonium sulphate directly to the granulator. By use of a concentrated urea solution no dryer is needed; granules flow from the pan granulator to the cooler and screens, and the oversize is crushed and mixed with recycle fines. The granules were rough in appearance compared with pan-granulated urea, but this should not detract from its use in bulk blending or direct application.

Pan-granulated urea-ammonium sulphate of 40-0-0-4S grade would, on the basis of small-scale storage tests, have to be conditioned (preferably with a high-efficiency conditioner such as diatomaceous earth) to remain in satisfactory condition in bulk or bag storage for longer than a month. Precautions should be taken when the material is stored in bulk because, like ammonium nitrate, it is somewhat hygroscopic. Protection could be provided in the form of a tightly closed building, plastic pile covers, or dehumidified storage. The critical relative humidity is in the range of 55% to 60%.

Urea-Single Superphosphate

Single superphosphate (SSP, 0-20-0) is often a very economical source of phosphate in many developing countries, and it is also a source of sulphur. In many cases, it is a good means of using byproduct sulphuric acid. However, owing to the relatively low analysis (20% P₂O₅) it is more costly to bag and ship over long distances than the higher analysis materials such as diammonium phosphate (DAP, 18-46-0), monoammonium phosphate (MAP, 11-55-0), or triple superphosphate (TSP, 0-46-0). TVA in cooperation with AID has been testing the production of urea-single superphosphate based compound NPK granular products for these situations. Many countries market phosphates on the basis of water solubility. When single superphosphate is ammoniated, the water solubility is significantly reduced. Therefore, the process studied involved little or no ammoniation.

Generally mixtures of urea-single superphosphates or triple superphosphates have been avoided because of the possibility of formation of an adduct which releases water and renders these fertilizers tacky and wet during processing. Some work has been done in India on this process. Also, some products are made in Great Britain and Japan containing urea and unammoniated or lightly ammoniated single superphosphate.

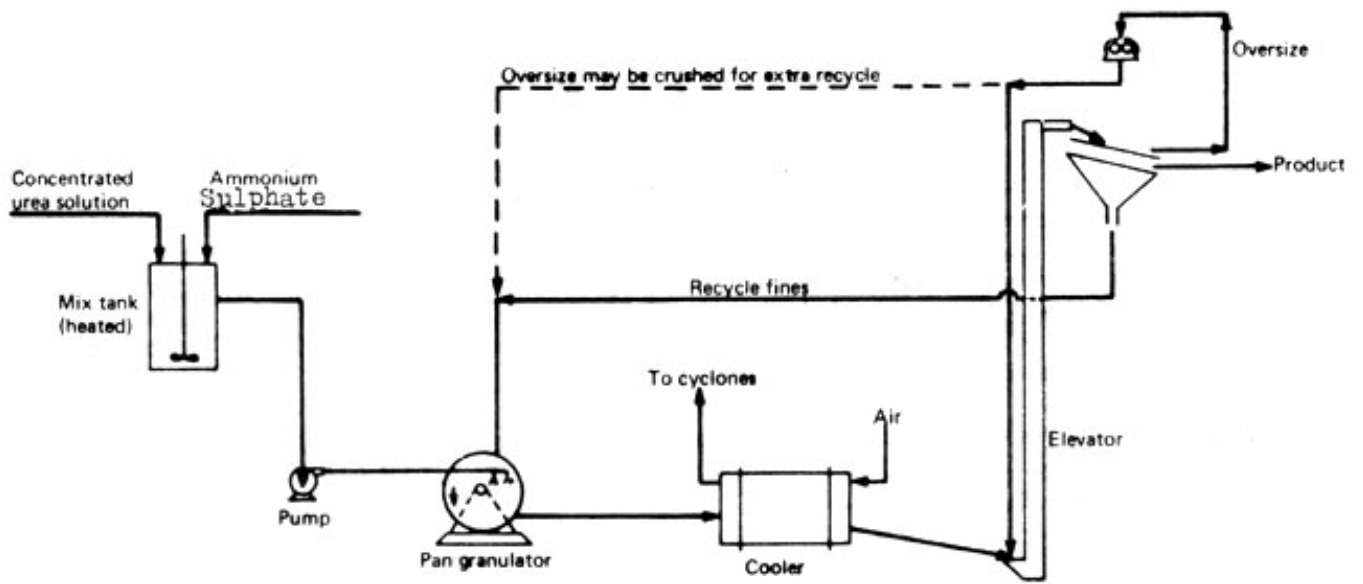


Figure 4. Flow diagram for pan-granulated urea-ammonium sulphate

a. Process

The flow diagram for production of urea-single superphosphate based granules is shown in Figure 5. In order to make relatively high analysis grades, it is necessary to supplement the single superphosphate with other phosphate materials such as diammonium phosphate or monoammonium phosphate.

b. Results

Granulation was quite poor with test conditions for a 14-14-14 and a 10-20-10 product. In both formulations, there was a tendency towards either undergranulation or overgranulation.

From data obtained thus far at TVA, the granulation of compounds based on urea and single superphosphate without ammoniation appears to be difficult. It appears that some specific equipment changes would be required for formulations of this type. The drying and feeding of hot single superphosphate to the granulator may be helpful. The use of a small quantity of ammonia in the granulator eliminates many of the operational problems, but lowers the phosphate water solubility to about 80%. TVA plans to conduct further studies of the process.

Granulated Urea Rock Phosphate

Granulated urea rock phosphate is a homogenous mixture of urea and finely ground rock phosphate. Urea provides the granulating medium for binding together the small rock particles. In order for the rock phosphate to be available to crops, it must be either applied in a finely ground form or in one that can rapidly be converted to its original finely ground form. This last is accomplished by the rapid dissolution of the urea in water which causes speedy disintegration of the granules to provide finely ground material. Obviously, the handling, storage, transport, and application characteristics of granulated materials are preferred to those of a dusty material such as ground rock. Two grades of materials were produced, 26-13-0 and 18-18-0.

Figure 6 shows one process used for production of the urea rock phosphate granules in the TVA pilot plant. Tests have been conducted in two types of granulation equipment, a pan type and a rotary drum granulator. Results were superior when the pan method was used.

Some developing countries use rock phosphate for direct application, and complaints have been received regarding handling and application of the finely ground rock. Various methods are being sought to granulate the powder, among which the use of urea would be very convenient.

Further tests are needed on ways to granulate urea rock phosphate. For example, the use of crushed urea prills and finely ground rock with steam granulation in a rotary drum should be tested. Also, a pugmill might be used for this process. Inclusion of other materials such as a small quantity of water-soluble phosphate for early crop response might be helpful.

The products are being tested agronomically for rice and much interest in such products is being shown in Indonesia. However, the agronomic effectiveness of ground rock is dependent on its reactivity and TVA is evaluating various rocks in this respect. A report is available which discusses the relative reactivity of selected rock phosphates.

Urea with improved physical properties

The attractiveness of urea as a nitrogen fertilizer could be increased even further if simple and inexpensive methods could be found to improve significantly its physical properties, especially for handling, storage, and transport in humid areas. A urea that is readily compatible with granular triple superphosphate for bulk blending would be helpful.

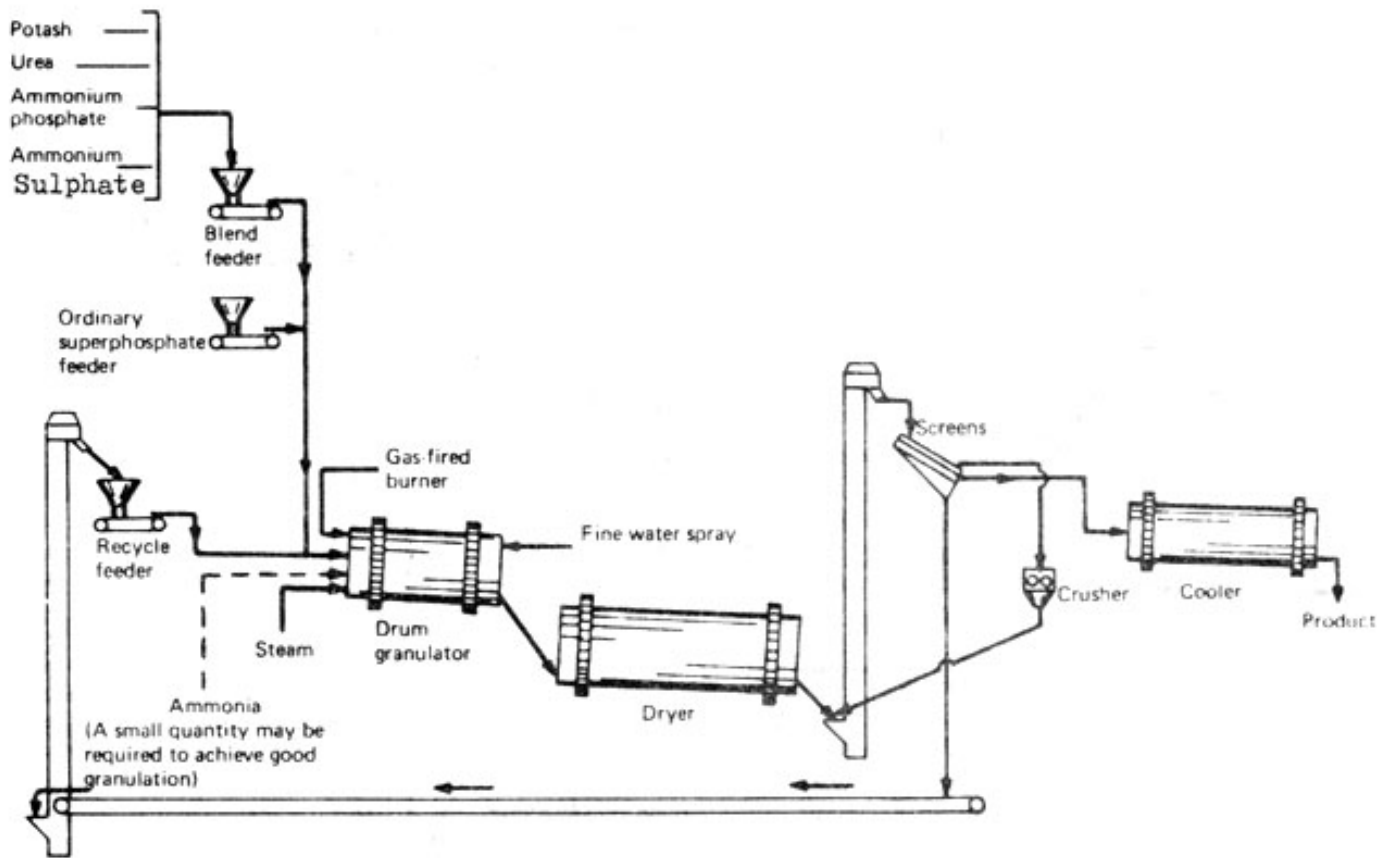


Figure 5. Flow diagram for urea single superphosphate based granulated products

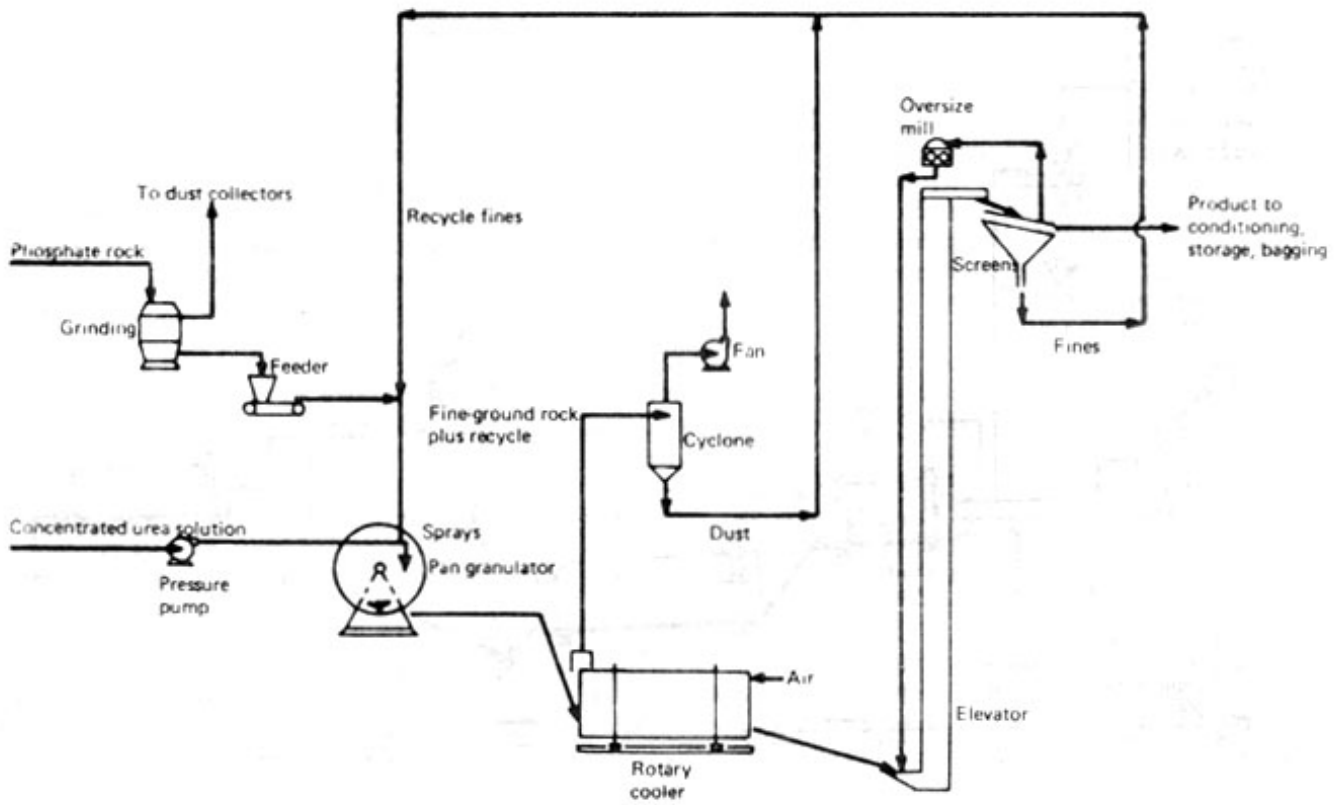


Figure 6. Flow diagram for urea-phosphate rock granules

This, of course, would be attractive for industry in the United States as well as in developing countries. With these objectives, TVA has been conducting tests to evaluate various materials that could be applied to urea after the product has been air-prilled, spheroidized, or pan-granulated. This mainly involves application of a coating to the particle surface in small quantities with evaluation of this coating as a moisture barrier. This work is not part of the sulphur-coated urea project of which the object is to control the dissolution rate of urea in the soil, although thin sulphur coatings may be effective under some conditions.

Numerous materials including oils, waxes, and resins have been evaluated. The materials are applied, usually in the form of liquids, to the urea particles while tumbling in a rotary drum.

Several types of coating were promising as materials to retard moisture absorption at 32°C (90°F) and 90% relative humidity. Normal sulphur-coated urea (20% coating) was outstanding and only absorbed 3 and 17 mg/cm² in 4 and 24 hours, respectively. Other materials such as Bunker C fuel oil, mixtures of paraffin and oil, and mixtures of petrolatum, resin, and paraffin were effective in the laboratory tests.

Work is continuing on improvement of physical properties of urea with the object of finding a coating that will be effective in quantities small enough to give a 45% nitrogen product, that will limit absorption to a degree equal to the above coatings, but will cost only in the order of \$1.50-\$2.00/ton for the coating material, not including the cost of application. One material that appears especially promising is a 1% coating of a mixture of wax (62°C (143°F) melting point) and Bunker C fuel oil which would cost no more than \$0.50/ton. One possible disadvantage of this material is that a discoloration of the urea is noted when this material is used.

As pointed out previously, an improved urea would have good potential for developed as well as developing countries. Perhaps the largest need is for a urea product that could be blended with unammoniated granular triple superphosphate. However, almost any treatment, coating, conditioner, or whatever, will increase product cost. No one seems prepared to say what increased cost can be tolerated, although some have suggested that a product containing as little as 40% nitrogen and costing 10% more per unit of nitrogen might be acceptable. Sulphur-coated urea, prepared to control the dissolution rate of nitrogen, has been shown to be compatible with granular triple superphosphate as well as being resistant to extremes of humidity and temperature, but the cost of this type of coating would not be acceptable solely for improvement of physical properties.

Anhydrous Ammonia

Anhydrous ammonia is by far the highest analysis N product commercially available anywhere in the world. Because of its high analysis, it can be shipped great distances to its point of use at competitive prices. Anhydrous ammonia has one major disadvantage - a high vapor pressure at ordinary temperatures. It must be transported and stored in pressure containers, generally with a minimum working pressure of 265 lb/in². Unless injected into irrigation water, anhydrous ammonia must be injected as a liquid into the soil with special equipment where, beneath the soil surface, it vaporizes, reacts with the soil water, clay or organic fractions, changes to the ammonium form and is retained by the system.

When properly used, anhydrous ammonia is equal to any other form of ammonium nitrogen but does require special management or its agronomic performance can be affected (Engelstad & Hauck, 1966). Ammonia applied either pre- or post- planting should never be placed in close proximity to the seed or young roots; otherwise, as in the case of urea or diammonium phosphate, germination or growth can be retarded. Depending upon the amount injected, losses of ammonia can result if the ammonia is injected at too shallow a depth in soils low in moisture, clay content or organic matter or when tracks left by the injector knife fail

to close because of insufficient or excessive moisture. In general, anhydrous ammonia requires special equipment for handling, which is very expensive in developing countries.

Prospects for use of nitrogen solutions
and ammonia in developing countries

It is generally accepted that dry fertilizers offer the greatest potential in the developing countries of the world. Many believe the immediate potential for ammonia and nitrogen solutions is quite limited.

These assumptions are probably correct based primarily on the general acceptance of dry fertilizers. Their simplicity of handling, compared to the more sophisticated system required for liquid materials, makes them more readily accepted in a country which lacks mechanization. However, to stop here would be an oversimplification of the situation and would not reflect the true potentials for nitrogen solutions and ammonia.

Although dry fertilizers, particularly urea, ammoniated phosphates, and complete N-P-K compounds will be the dominant force in the developing country market for some time, ammonia and nitrogen solutions, particularly aqua ammonia and non-pressurized solutions, could very well make substantial advances in the next few years. This will occur for at least three reasons which are: (1) labour shortages are developing in certain regions, thus placing a premium on increasing efficiency of handling agricultural inputs, (2) adaptation to non-pressurized aqua ammonia or non-pressurized solutions requires only a very limited amount of sophisticated equipment, (3) because of the tendency for ammonia producers to look for additional markets for excess ammonia, they will actively strive to develop these markets.

Under these conditions, prospects are good for acceptance of one or more of these materials as agriculture becomes mechanized. The major potential for extended use of nitrogen solutions exists mainly in large estate areas that are the principal earners of foreign exchange and which grow rubber, oil palm, sugarcane, or where these holdings are old, in need of rejuvenation or perhaps conversion to crops such as rice, maize, or wheat. Potential also exists in certain areas of smaller land holdings. Of particular promise are areas where farmers are willing to pool equipment and farm their land co-operatively. Under these circumstances, nitrogen solutions can offer savings in both labour and cost per unit N. An additional potential, its success dependent upon government policy and development of regional projects, is aerial application of non-pressurized nitrogen solutions. There are vast areas of Africa where crops are grown under uncertain moisture conditions. In these areas, farmers often use only a very minimum of fertilizer. Where optimum rainfall occurs, usually when growth of the crop is well advanced, additional nitrogen could prove to be profitable. Under these conditions, it might be profitable to apply, by aircraft, 12-30 kg of nitrogen per hectare, to take quick advantage of the more favourable water supply.

Low-pressure solutions and high-pressure anhydrous ammonia, although widely accepted in the U.S.A. and Europe, offer limited potential for direct application in Africa.

Considering that these materials are of high analysis, particularly anhydrous ammonia, the special equipment needed to take advantage of this offsets any advantage accrued in labour saving or low-cost nitrogen. The exceptions to this are areas where landholdings are substantial and individual fields are sufficiently large to allow for the economic use of this relatively sophisticated equipment.

This is particularly true where labour is short in supply and/or nitrogen losses are occurring where urea is currently applied to the surface soils. Under those circumstances, urea solutions and anhydrous ammonia in particular seem attractive.

Polyphosphates

A very significant advance in phosphoric acid manufacture, a basic ingredient of many phosphate fertilizers, has led to the development of a new family of polyphosphate fertilizers, many of which are now being tested by TVA and others.

Ordinary phosphoric acid (54% P_2O_5) may be concentrated to super acid which, depending upon whether the electric or wet process is used, ranges from 68%–80% in P_2O_5 content. To our knowledge, neither super acid nor products made from it are available commercially in the developing world. Nevertheless, some offer immediate potential in selected areas and will be discussed in brief.

a. Superphosphoric Acid

More than 10 years ago, TVA developed a method for producing concentrated phosphoric acid, usually referred to a 'superphosphoric acid'. This new product contains over half its phosphorus in the pyro and more condensed forms; the remainder is in the standard ortho form. When made by the standard electric furnace process, the P_2O_5 content is 76% or more. Table 3 illustrates the difference between furnace acids of ordinary and superphosphoric concentrations.

The main advantages of super acid are its high analysis (almost 50% more P_2O_5 than ordinary acid), its low corrosion rate (less than half as rapid as ordinary acid) and its ability to sequester impurities often found in wet-process acid, an advantage in making liquid fertilizers.

b. Ammonium Polyphosphate (Liquid 10-34-0, 11-37-0; solid 15-62-0, 12-57-0).

The term 'ammonium polyphosphate' refers to material containing condensed phosphates either as solutions or solids and produced by ammoniation of superphosphoric acid. These have proved to be favourite intermediates for making liquid fertilizer.

Ammonium polyphosphate can also be produced as a solid by ammoniation under pressure (Kelso et al., 1968).

Work in the United States (Terman and Engelstad, 1966) has led to the conclusion that there is no clear-cut difference between monoammonium phosphate and ammonium polyphosphate (APP), although both are superior to concentrated superphosphate.

Of the materials in this family, solid ammonium polyphosphate (15-62-0 or 12-57-0) offers the greatest potential for use in developing countries. This is because (a) it is a high-analysis, binutrient fertilizer, and (b) it can be shipped in the solid form to intermediate points where it can be readily converted to a liquid (10-34-0) if and when the situation should warrant.

For these reasons, solid APP has good potential in the same regions offering good opportunities for nitrogen solutions and bulk blends. The solid APP (imported) together with the locally-produced nitrogen solution could serve as the nucleus of developing a low-cost liquid industry. It could also serve as a high-analysis, binutrient component of a bulk blend.

c. Urea-Ammonium Polyphosphate (Solid; 30-30-0, 39-13-0, 19-19-19 or varying grades; all nitrogen in urea or ammonium form; phosphate 100% water soluble and 50% soluble in the non-ortho form). Agronomically, this product is as good as MAP or DAP. This coupled with its high analysis, simplicity of production and low production costs make it a product with good potential in Latin America, Asia, and Africa.

Table 3. Properties of Ordinary Phosphoric Acid and Superphosphoric Acid made from Electric-Furnace Acid

<u>Parameter</u>	<u>Type of Acid</u>	
	<u>Ordinary</u>	<u>Super</u>
Acid concentration (% P ₂ O ₅)	54	76
P ₂ O ₅ content (lb/U.S. gal.)	7.1	12.2
Percentage of P ₂ O ₅ , as poly acids	0	51
Viscosity (Centipoises)		
at 40° C	12	400
at 100° C	4	45
Corrosion rate (mils/yr)		
mild steel at room temperature	523	230

FERTILIZERS IN THE FUTURE

Ultra-high-Analysis forms of phosphorus and their agronomic value

Over a long period, efforts to develop new products in the fertilizer industry have mainly been directed towards further increasing the concentration of the primary plant nutrients. Ammonium polyphosphate (APP) (15-62-0) is the most concentrated solid fertilizer currently available. Very long-chain APP and ammonium tetrametaphosphate of approximately 14-73-0 grade have been prepared and tested on a laboratory scale. It now appears that the 14-73-0 grade is close to the limit of high-analysis with orthophosphates or condensed phosphates. On this basis, further development of ultra-high-analysis P or NP sources must, of necessity, be concerned with new forms of P with covalent N-P bonding and little or no oxygen in the molecule.

Although the actual chemistry of these products has not been worked out in various systems, in theory, products of this type may react with soil water through chemical or biological action to yield conventional forms of P and N in the soil.

Ultra-high-analysis fertilizers have been defined as those compounds that contain more than 100% plant food on an oxide basis (usually N-P basis although more emphasis will be placed on N-P-S systems). There are four basic groups under study: vapour phase reaction products, phosphonitrilics, cyclic metaphosphimates, and linear polyamides (Terman & Allen, 1969; Russel, 1970; Hignett, 1970).

a. Vapour phase reaction products (NH₃-P-O).

One of the more promising routes to ultra-high-analysis P sources is the direct reaction of NH₃ and P in the presence of water soluble P and N. Results obtained thus far are encouraging, particularly from a production standpoint. Greenhouse tests have revealed that these products are 30%-50% as effective as conventional N-P sources. Under the present level of technology, at least 50% of the reaction products (usually very long-chain polyphosphates) are inert. Modification of the process might offer a combined quick-

and slow-release action sought in slow-release fertilizers. Interest in this product lies in its use as an intermediate which probably would be converted to solutions at the point of distribution.

(b) Phosphonitrilic Hexaamide Compounds

One of the highest nitrogen component N-P compounds that shows some promise is phosphonitrilic hexaamide (55-92-0), an N-P ring compound. It contains no oxygen and very little hydrogen. Greenhouse tests suggest that the unsaturated phosphonitrilic ring apparently yields available P at rates sufficient for optimum growth. The nitrogen component appears to be completely available to the crop.

(c) Cyclic Metaphosphimate (27-60-0). In contrast to the phosphonitrilic compounds, cyclic metaphosphimate ring structures are not subject to microbial attack, and do not readily release their N and P; thus they must be considered very stable in soil systems. Further processing, such as breaking the ring by chemical or thermal action, is necessary before this material proves attractive for use as a fertilizer.

(d) Linear Polyamides

Another potential route to ultra-high-analysis sources of P is the synthesis of linear polyamides and thiopolyamides.

Three of the four compounds shown in Figure 7 include substantial amounts of sulphur. All contain little or no oxygen. This and the S content results in a much higher content of plant nutrients. The phosphate availability of these compounds decreases with increase in molecular size. With the exception of thiopolyamides, the nitrogen sources were as effective as ammonium nitrate. The thiopolyamides were slightly toxic.

Although commercial production of any one of these ultra-high-analysis products is probably 10 or more years away, they offer promise of becoming the fertilizers of the future, provided certain technological difficulties can be overcome. Furthermore, when their plant nutrient contents are expressed on an elemental basis, many of the products tested approach the theoretical (100%) limit for high-analysis products. While initial agronomic tests appear very promising, a very concentrated effort on methods of synthesis will have to be made before ultra-high-analysis compounds, particularly polyamides, can be produced at reasonable cost. In spite of these restrictions, the fundamental chemistry is being investigated and prospects are good for the appearance of new ultra-high-analysis fertilizers within the next 20 years.

SUMMARY

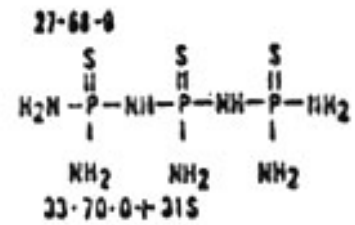
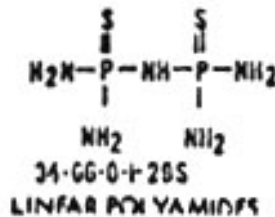
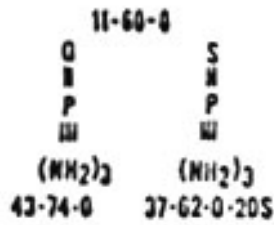
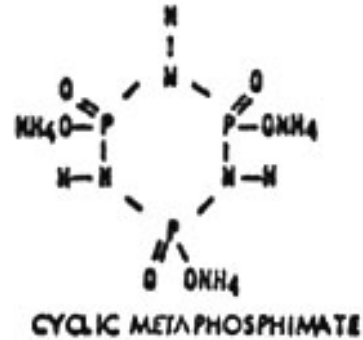
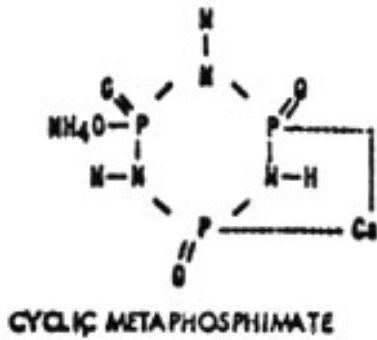
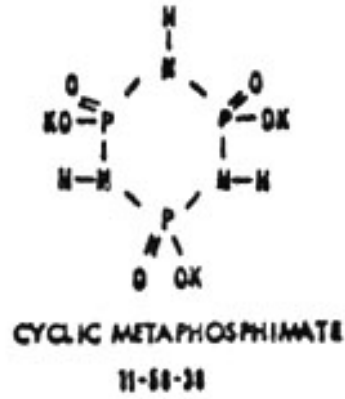
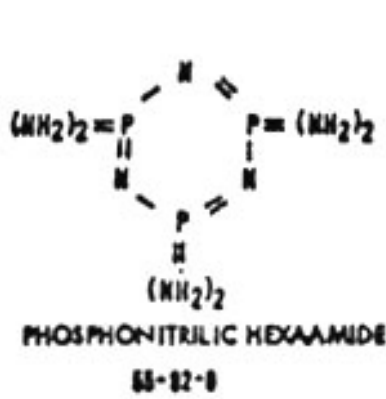
The problem TVA faces as promoters of fertilizer production and use could be summarized in Table 4.

Table 4. Consumption of fertilizer in certain regions, 1969

	Consumption (kg)	
	Per Capita	Per Hectare
Western Europe	61.9	158.9
North America	66.2	67.7
Latin America	9.0	20.7
Asia	4.8	21.2
Africa	4.2	6.4

Figure 7.

STRUCTURAL FORMULAS AND ANALYSES OF ULTRA-HIGH-ANALYSES



LINAR POLYAMIDES

Only 10 years ago, noted social and agricultural scientists of the developed nations forecast impending disaster for many of the developing nations. These predictions were based on the assumption that the world and the developing nations, in particular, were rapidly outstripping their food producing capabilities. Disaster in the form of famine on an unprecedented scale was forecast to occur by 1970. Nevertheless, this famine has not taken place, nor do people still look at the food situation in despair. Great hope has been kindled by the start of a green revolution which, if it continues its momentum, gives promise of continued meeting of food demand in most of the world.

Although credit for much of this success, no doubt, must go to the development and widespread use of high yielding varieties of rice and wheat which incidentally are very responsive to fertilizer, credit must also be given to an equally great development that has occurred in fertilizer technology and fertilizer use.

During the nineteen sixties, strides were made in fertilizer technology of a magnitude equal to those made in the breeding of the high yielding varieties of rice and wheat.

Engineers succeeded in designing and building fertilizer plants capable of producing 1 500 ton/day of ammonia thus making low cost nitrogen a reality. Transport facilities and marketing systems were also developed, thus assuring amounts of fertilizer at a price that makes its use profitable even at rather high rates per hectare. These and many more developments have gone a long way towards initiating and maintaining the pace of the green revolution.

To continue to keep the green revolution alive, TVA feels that the future opportunities are:

A. Developing fertilizers for tropical soils

Controlled release fertilizers

Improved phosphatic fertilizers

Addition of needed secondary and micronutrients to macronutrient fertilizers

B. Future teams

Requests will probably require expertise in: Marketing organization

Production capacity planning.

C. Guidance and cooperation with other proposed technology centres similar to the National Fertilizer Development Council of the United States in developing countries.

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POSSIBILITIES FOR ASSISTANCE IN
FERTILIZER USE DEVELOPMENT

by

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FAO Activities

During the last 15 years assistance of various forms in fertilizer use development has become increasingly important in FAO's programme, which consists essentially of the Field Programme and the Regular Programme.

The main objective of field projects is to provide countries with the necessary information on soil development and conservation and to assist in introducing technically and economically appropriate types and quantities of fertilizers into practical agriculture on a large scale, with particular emphasis on small farms. In accordance with the requirements of the countries the work is carried out along the following lines:-

1. Research on soil fertility, soil management, fertilizer use, soil chemistry and related fields and on the effects of fertilizers on the human environment.
2. Field experiments in research stations and under farming conditions.
3. Studying the economic factors affecting fertilizer use and finding ways and means to overcome obstacles.
4. Transfer of research results to the extension services and farmers.
5. Fertilizer Pilot Schemes as examples and incentives to improve marketing and credit facilities.
6. Long-term planning of fertilizer use development which might eventually lead to local fertilizer production.

Field activities are carried out by UNDP financed projects (small scale and large scale, at present number 27) and by the FAO Fertilizer Programme (22 projects with 15 pilot schemes). The UNDP projects are prepared and carried out in the framework of the UNDP country programming and within the financial limits of the Indicative Planning Figure (IPF).

UNDP (Small Scale)

This type of assistance usually provides one or two experts as advisers to Governments for special fields of technical activities. The programme also provides a limited amount of equipment and one or two fellowships, and has a duration per project from two to six years. Under this programme, fertilizer use and promotion projects were started in the early fifties and have operated in 24 countries.

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UNDP (Large Scale)

These are intended to provide preinvestment assistance to Governments. They are primarily in applied research and investigation; however, for some years, in Special Fund projects on soil fertility and fertilizer use, strong promotion components have been included. UNDP's contribution to these relatively large projects usually includes a team of five to seven international experts; equipment and supply for the field and laboratory work including vehicles; for projects with a fertilizer distribution component, adequate quantities of fertilizer; and finally, about ten or more fellowships for the training of local staff. The minimum duration of large scale projects of this type is three years, but most are for five years or more. Such projects have been, or are being executed, e.g. in Iran, Republic of Korea, Philippines, Thailand and Pakistan, Ghana and Argentina. Apart from field experiments and demonstrations, special attention has been given to the establishment or strengthening of services required for fertilizer use, and the development of sound fertilizer recommendations. Governments are also assisted in developing policies for fertilizer supply, and assistance is given to pilot schemes for fertilizer distribution. Emphasis has been placed on combining fertilizer use with the use of improved high yielding varieties and with better methods of cultivation, irrigation and pest control. These intensive projects have contributed considerably to an extraordinary increase of fertilizer use.

For instance, in Ghana a large scale UNDP project carried out by FAO, in cooperation with the Ministry of Agriculture, is providing assistance in the following fields: soil fertility, soil chemistry and soil testing, agronomy and in the development of infrastructure for the distribution of fertilizers to farmers, with emphasis on cooperatives. Accordingly, the FAO team consists of six experts in the various fields of specialization, and a number of consultants for specific problems are being provided. The aim of the project is to build up an organization under the Ministry of Agriculture, and related field organizations, which can introduce fertilizers into agriculture on a countrywide basis.

In the Philippines a large scale project carried out jointly by the staff of the Philippine Bureau of Soils and the international team of FAO, has laid out 5 500 fertilizer trials on all the major food and cash crops, with special emphasis on rice, maize and coconuts. Detailed fertilizer recommendations for each province and main soil series and for the high yielding and traditional varieties have been worked out, at the range of 40-30-0 or 40-30-30 for local varieties, 60-40-30 for improved varieties and 90-40-30 for high yielding varieties. The project has assisted in re-equipping and upgrading eight regional soils laboratories. A plant nutrition laboratory and greenhouse were established and research has been organized there on the nutrient requirements of rice, maize and coconuts, and tests of various strains of *Rhizobium* spp. on legumes have been carried out. A field check of 33 benchmark soils was carried out and suggestions were made for improving soil mapping techniques. The fertilizer marketing and credit situation was studied and proposals for improvement were presented. The project reviewed the organization and staffing of the Bureau of Soils and recommended its reorganization to improve the planning, coordination and practical orientation of research. A detailed proposal for a Division of Fertilizer Promotion, to be created in the Department of Agriculture, was worked out. This would be responsible for the coordination of all activities in fertilizer use development including dissemination of recommendations to farmers, fertilizer legislation, coordination of imports, local production, marketing, warehousing, pricing and long term developments. The project in the Philippines has not only provided a sound technical and economic basis for fertilizer use but it has also stimulated it. The fertilizer consumption was 97 000 tons (N P₂O₅, K₂O) in 1964 when the project started, and had reached 226 000 tons in 1970/71.

The FAO Fertilizer Programme is not financed by UNDP but by direct contributions to FAO from the World Fertilizer Industry and governmental and non-governmental organizations. The Programme started in 1961 and is at present working in 22 countries. In principle, the Fertilizer Programme uses the following lines of approach:

1. Experimental work under farming conditions for developing rational fertilizer formulas.
2. Demonstration and extension work.
3. Economic studies in connection with field work.
4. Pilot schemes for fertilizer distribution.

The Programme is essentially very close to the practical requirements of the countries, using existing research results and implementing them in agricultural practice.

Regular Programme

The main purpose of the activities under FAO's Regular Programme is to advise in the formulation of field projects, to give technical support, and to provide the member countries with additional information and assistance as requested. Regular Programme activities include:-

1. Studies of technical, economic and marketing aspects of soil fertility and management, and in fertilizer use.
2. Publications on all activities and on the results of field activities, also on consultations and different types of meeting.
3. Conferences, sessions, seminars, consultations.
4. Commissions, missions.
5. Working Groups, particularly on fertilizers and related inputs, on fertilizer economics, on fertilizer marketing and credit, and, in cooperation with UNIDO and IBRD, on fertilizer development planning.
6. Soil Data Bank for the computerized storage analysis and retrieval of field results.
7. Coordination of fertilizer use development planning.
8. Liaison and cooperation.

These activities are carried out by expert staff in FAO Headquarters, in cooperation with the regional and field project staff, with other organizations and with the help of consultants. It should be obvious that each type of activity under the Regular Programme is closely interrelated with the field activities.

Inter-relations between activities

In the context of the various countries' development programmes, assistance given by FAO in fertilizer use development is always closely interrelated with the general requirements in agriculture and with other projects (multilateral or bilateral) in the same or in related fields. For instance, FAO's form of assistance in a project of the Fertilizer Programme is in field experimentation, demonstrations and extension work. In bilateral projects FAO is placing emphasis on the improvement of fertilizer distribution to farmers by supplying larger quantities of fertilizers, and by assisting in the improvement of distribution facilities. Depending on the situation, the various activities of a project can also be phased, emphasizing the technical aspects during the first phase and shifting the emphasis to distribution and credit problems during the second phase. A project of the Fertilizer Programme can also be followed by a more comprehensive UNDP large scale programme, as is the case in Ghana, or it can be followed by bilateral assistance with a wide scope for development

activities, as, for instance, in Ethiopia. Assistance in fertilizer use development can also be combined with, or followed by assistance in the gradual development of local fertilizer manufacturing. In a few cases the World Bank (IBRD) has expressed interest in a large scale investment project for inputs, following a successful FAO assisted fertilizer-use development project.

How to obtain assistance from FAO

The basis for receiving assistance from FAO, as well as from other UN organizations, is a request from the country which is submitted through established channels.

The origin of the request within the country can come from different sources, for instance, from an officer working in soil fertility, research or extension or from a high ranking officer in the Ministry of Agriculture. The request is usually discussed at an early stage with representatives of potential aid-giving organizations, for instance, with the FAO Country Representative and with FAO experts in the country. After the country has expressed its intention to ask for an assistance project (e.g. by a Letter of Intent to FAO or UNDP) a preparatory mission can be sent to the country. The mission assists the country in formulating the request in detail, including the technical, organizational and budgetary aspects.

As far as UNDP projects are concerned, it is also important to discuss with the UNDP Representative, at an early stage, how the project would fit in with the jointly established UNDP country Programme, which contains not only the operational guidelines but also sets out the availability of funds within the Indicative Planning Figure (IPF). IPF indicates the amount of funds reserved for the country by UNDP for development projects for a period of five years. Once an understanding of the project within the above framework has been reached, the respective authority (usually the Ministry of Agriculture, but in some countries the Planning Commission) submits the request to the local UNDP office for final approval by UNDP Headquarters, New York, with a copy to the respective UN Agency; in the case of agricultural projects this is FAO.

In the case of the FAO Fertilizer Programme, the financing is not done by UNDP but by a Trust Fund administered in FAO Headquarters. The financing of this type of project is therefore outside the indicative planning figure provided by UNDP.

Assistance by the FAO Fertilizer Programme is based on a request from the country directly to FAO through the local FAO representative and the preparation of the request is similar, including the possibility of assistance from a preparatory mission.

When planning the request for a project, it should always be remembered that in addition to the contributions requested from UNDP or FAO, the request should also spell out the counterpart contributions of the particular country to the project. This calls for a provision to be made in the budget of the Ministry of Agriculture well in advance. Generally speaking, the development of an assistance project is a time-taking procedure which might involve up to two years or more from the first discussion of the idea to the actual start of operations. The importance of the time factor should, therefore, not be overlooked.