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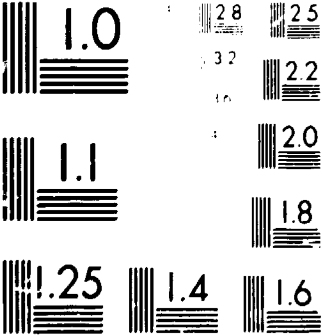

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TECHNOLOGY OF LIQUID FERTILIZER'S PROGRESS, ESPECIALLY CONCERNING ENERGY PROBLEMS

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(The ideas and opinions expressed in this paper are primarily of the author and do not necessarily represent the official views of the UNIDO.)

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References

Introduction

It is just over 20 years ago that the use of liquid fertilizers started its rapid growth to begin with in the United States of America as well as in some European countries. The increased demand was created first by marketing then by farmers rather than by farm machinery equipment manufacturers. Both the fertilizer industry and farm equipment manufacturers adapted their products for this specialized field to meet the growing demand, which should become of interest in developing countries during the next decade.

It is of interest to consider why liquids have been found to be cheaper than solids - whether this is always the case, or whether it is true only in certain circumstances. Major factors leading to the rapid growth of the liquid fertilizers in the United States were:

a) the cheapness compared to application of solid fertilizers, and low cost of raw materials particularly for clear solutions;

b) Convenience to the farmer, uniformity of application;

c) the existence of specialized contract application firms;

d) the ease of preparation of a wide variety of nutrient compositions having product homogeneity.

There are also conditions which are particularly favourable to the growth of use of liquid fertilizers. The major ones are:

i) The presence of large farms with a high fertilizer (particularly nitrogen) demand;

ii) The presence of primary fertilizer factories which can supply raw materials to producers of liquids;

iii) The development of firms specializing in the production and/or application of liquid fertilizers;

iv) Appropriate humidity in the soil either rain fed or by irrigation;

v) Highly sophisticated farming systems.

vi) Some spread of the fertilizer demand throughout the year;

vii) The existence of good rail or road communications; and

viii) The availability of personnel familiar with the operation and maintenance of farm specialized machinery.

The co-existence of all these factors is a prime reason for the very rapid increase in the use of liquids in the United States. In Europe, where these conditions are fulfilled to a lesser extent, growth has been slower, but still considerable. It also explains why even in developing countries where the growth of fertilizer industry has been rapid since the end of World War II, the use of liquid fertilizers is only beginning in the present decade.

Interest in the use of liquid fertilizers by developing countries was shown over the past years by Algeria, Colombia, CSSR, Cuba Hungary, India, Iran, Morocco and Yugoslavia. However, only for Egypt and Cuba, has UNIDO provided technical assistance in this field.

Summary

1. This paper briefly reviews the global aspects of the use of liquid fertilizers, referring to the types of liquid fertilizers presently used in agriculture, including clear liquids such as anhydrous ammonia and their direct application to soils.

2. The existing constraints on growth and the benefits from the use of liquid fertilizers are analyzed.

3. The relative economic factors such as investment costs and costs to customers are outlined with particular reference to savings in energy in producing liquid fertilizers.

4. The relevance to developing countries, their infrastructure, climate, associated problems and a guide to solutions will be outlined.

1) Growth in the use of liquid fertilizers

The rapid growth of liquid fertilizer application started during the late sixties in the United States, as shown in Table I(Ref.1)

Table I (Ref.1)

	million of metric tons (liquids) (gross weight)			
	1960	1965	1971	1976**
Anhydrous ammonia	0.72	1.63	3.72	5.27
Nitrogen solution	0.63	1.72	3.18	5.05
Liquid mixed fertilizers*	0.54	0.91	4.08	3.31
Totals:	1.89	4.26	10.98	13.63

* clear liquids and suspensions

** Data from US Department of Agriculture (USDA)

By 1971 liquid fertilizers (including anhydrous ammonia) accounted for 27 per cent of the total NPK fertilizer tonnage and about 58 per cent of the total nitrogen tonnage used in the US. According to a more recent report a 15 per cent per annum growth rate has been maintained (except for 1975 when the dry weather prevented application in drought areas.)

In comparison, in other major consuming developed countries the following figures are available:

Table II (Ref.1)

Country	(a) millions of tons liquids	
	1965	1970/71
Denmark(b)	0.037	0.160
Canada	0.036	0.074
France (c)	-	0.414
Mexico	0.066	0.174
Spain	0.0094	0.021
UK	0.094	0.219

Table II(a) excludes aqua or anhydrous ammonia.
(b) anhydrous ammonia only
(c) In France the figure represented 7.2% of the N consumed, 2.4% of P_2O_5 and 0.4% of K_2O.

In 1975/76 the total tonnage of liquid fertilizers in France has risen to 600,000 tons per annum representing 10 per cent of the country's fertilizer consumption (Ref.2). The use of anhydrous ammonia fertilizer in Denmark in 1975/76 amounted to 45 per cent of the share of the nitrogen market since 1971 as directly applied ammonia (Ref.3).

It is unfortunate that only in the United States a reasonably accurate record has been kept over the past decade how much of the nitrogen used is applied in liquid form.

2) Constraints and benefits connected with the Growth of Liquid Fertilizers

In examining the factors that contributed to the rapid adoption or change over from solid to liquid fertilizers in some of the developed countries, the most important ones appear to be (i) the presence of large farms with high nitrogen fertilizer demand and a sophisticated approach to the problems of fertilizer application (ii) the presence of primary fertilizer factories which can supply the raw materials to firms specializing in the production and/or application of liquid fertilizers.

The equipment required for the application and distribution of liquids is expensive and must be fully utilized within the region, which some authorities have defined in Europe as 40-50 hectares per day and per applicator. This defines one cost parameter of application, which is independent of the rate of application. Obviously with a reasonable spread of fertilizer demand over the year, full use of the equipment (multiple cropping) will enhance the suitability "on farm condition" for liquid form application.

In countries where there are large farms, or farm co-operatives conditions for the introduction of liquid fertilizers and the organization of infrastructure to support it, are more favourable.

In Colombia due to the efforts and progress made by the Colombian Institute for Soil Testing, the application of fertilizers in solution has recently increased to 20 per cent of the total tonnage. According to recent reports, the majority of solution application takes place by air for large plantations (coffee). However, small farms are beginning to use liquid fertilizers and this is being encouraged by the Instituto Colombiano Agropecuario (ICA) (Ref.4).

The existence of fertilizer factories for primary fertilizers such as ammonia or phosphoric acid is necessary to produce ammonium nitrate and urea solutions,alternatively NP solutions. The cost of importing or transporting liquid fertilizers over long distances has on the whole been prohibitive, and the use of liquids has therefore mainly been restricted to countries with indigenous fertilizer industry and to certain suitable locations. It should be noted, however, that in the past seven years the Netherlands has exported considerable quantities of urea solution to the east coast market of the American continent at competitive prices. Also to overcome increased transportation costs as well as widen the area for distribution of liquid fertilizers pipeline network and terminals are being installed in the USA, providing storage capacity for fertilizer complex having 700,000 tons per year production capacity for non-pressure nitrogen solutions. The system can also be adapted with certain modification to handle approximately 32 per cent urea/water solutions (Ref.5).

The prevailing climatic conditions certainly influence the utilization of liquid fertilizers in a country. Constraints due to cold weather which hampers the distribution as well as the application of liquids are not easily overcome. Solutions salt out by crystallization of some ingredients at about $0^{0}C$. For this reason tropical climates, where multiple cropping is possible, are more suitable for application and full utilization of the equipment employed. As many of developing countries are free from these low temperatures, their climates are very suitable for the use of liquid fertilizers, and a steady growth in the use is to be expected.

For the distribution of liquid fertilizers to the farms and spreading it in the soil, special equipment is required. Good road and/or rail communication is of primary importance to transport the liquids. Special storage vessels and applicators are used which are economic only for large farms and co-operatives and would normally be too expensive for small farmers unless who may, however, be able to overcome this problem by renting equipment.

This is particularly true for the distribution of anhydrous ammonia where special equipment at elevated pressure is used.

The aforelisted constraints explain some of the reasons why developing countries are making a relatively late entry into the liquid fertilizer field.

The technological requirements for the manufacture of solutions are relatively simple and the equipment investment costs are lower than for manufacture of solid fertilizer plants. However, the cost of infrastructure for distribution and training of farm personnel to provide full utilization for the equipment and its maintenance is high.

Various processes have been adopted for the manufacture of liquid fertilizers. They have been referred to as hot mix, cold mix and cold mix suspension processes. From the point of view of process technology the aim has been to increase the nutrient concentration and reduce the water content while maintaining the physical characteristics of the liquids suitable for pumping in conventional equipment. Research work specially by TVA lead to the development of the versatile pipeline reactor to be used for high analysis polyphosphate based solutions. More recently a growth trend was established for suspensions not only based on polyphosphates but for the less costly "wet phosphoric acid" solutions. Suspensions do provide greater grade flexibility for additives like pesticides and micronutrients. This trend, however, has been limited to Belgium and the United States.

3) <u>Economic factors</u>

There are presently a number of economic reasons why the use of liquid fertilizers is likely to find new and interested customers in developing countries that have hitherto been reluctant to enter this field:

a) the marked increase in investment capital and operating costs required to construct a down-stream plant and to produce granular or solid fertilizers from the primary plants;

b) the increased global cost for energy.

The increased investment cost for constructing fertilizer plants has been particularly marked since 1974. Equipment manufacturers in Europe and elsewhere were increasing their prices at a rate of 2½ per cent per month for a period of over one year in line with the general inflaction of material and labour that started with the increase of oil prices.

Indices for fertilizer plants available in Europe have been quoted recently as follows: *

	1970	1973	1975	1976	1980
Ammonia plant	100	124	161	169	200
Phosphoric acid plant	100	130	165	178	205

* These indices include licence, engineering equipment and in case of phosphoric acid plants the associated rock grinding plant.

As the primary source of nitrogen, an ammonia plant would be required for both liquid and solid fertilizer production. The comparison is made only for a urea plant using total recycle process and being relatively independent of the type of feedstock used.

A urea plant having a capacity of 1,720 metric tons/day of prilled urea (associated with 1,000 metric tons/day ammonia plant) required a fixed capital of $56 million at the end of 1974. The same plant is being quoted 12 months later at $67 million close to 20 per cent increased price. While the inflation rate has since dropped in 1977, the same plant would probably cost 10 per cent more as far as fixed capital investment charges are concerned.*

The rate of interest on borrowed capital has also increased. Furthermore the cost of urea produced by such a plant has been estimated by UNIDO as follows based on natural gas feedstock for ammonia at US 50¢/1000 scf or US 1.73¢/CuM.

Design rate 300 days/year	$102/metric tors
80 per cent capacity	$121/metric tons
60 per cent capacity	$154/metric tons

Unofficial World Bank figures claim that the cost of urea/ton from a new plant is expected to be about the same order as shown above for 60 per cent capacity operation. In view of these estimates it appears that potential customers should, before making an investment for a downstream plant to produce prilled urea, review the production costs for the ammonia/urea plant (including 8½ per cent depreciation and 10 per cent profit) which accounts for 60 per cent of the 102 $/ton ex-factory price shown for urea. Unfortunately we have no

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* The division between ammonia and urea is somewhat arbitrary since the two plants use a common site and facilities. The ammonia plant costs include a 10-15 mW power station to make the plants independent of external power supplies. The capital costs:

i) are based on December 1975 prices;
ii) make no allowance for inflation or for interest charges during plant construction;
iii) exclude road and rail connexions to the site, water supply and effluent disposal outside the site boundary, as well as housing and amenities for employees;
iv) include a 10 per cent contingency allowance and pre-operating expenses at 2.5 per cent of fixed capital;
v) refer to plants in developing countries on a "green field" site;
vi) include one month's storage capacity for feedstock/fuel; and for the large plants, storage capacity for 4,000 tons ammonia, 75,000 tons bulk urea and and 10,000 tons bagged urea.

data for making comparison between large nitrogen producing plants producing solutions, alternatively solid products, since up to now most of them have only used part of their urea production for making solutions.

Recently in connexion with the energy crisis in developed countries increased,attention is being paid to energy intensive industry.

In the production of ammonia from natural gas about 40 per cent of the gas is burnt as fuel. The remainder of the feedstock is used to produce hydrogen. The total consumption was about 11.16 million KCal per metric ton of nitrogen. This has been reduced 8.5 million KCal per metric ton of nitrogen utilizing improved technology. Approximately 99 per cent of this energy is supplied by the natural gas feedstock and the remainder by electricity. (Ref.6)

The difference in the consumption of energy between liquid fertilizers and finished nitrogen product in prilled form can be seen from the following downstream plans of ammonia.

Prilled ammonium nitrate	2.2 million Kcal/metric ton
Nitrogen solutions	1.1 million Kcal/metric ton

similarly

Prilled urea	1.35 - 1.41 million Kcal/metric ton
Urea solution	0.83 million Kcal/metric ton

Appendix 1

Table III

Total Energy Requirements for Production of Fertilizers in the United States

Materials and intermediates	Quantity million mt.	Energy requirements million Kcal per mt.	 Total
Nitrogen			
Ammonia	8.25	8.5	70.12
solid urea	0.63	1.35	0.85
urea solution	0.63	0.83	0.52
solid ammonium nitrate	1.17	2.2	2.57
Ammonium nitrate solution	0.63	1.1	0.69
Sub Total			74.75
Phosphate			
Wet proc. phosphoric acid	4.0	2.25	9.0
TSP	1.54	0.25	0.38
Granular MAP/PK	2.45	0.25	0.61
Ammonium polyphosphate solution	0.45	1.26	0.56
Single superphosphate	0.27	0.5	0.13
Sub Total			10.68
Potassium chloride	2.28	1.1	2.5
Mixtures			
Granular homogeneous	8.65	0.15	1.29
Fluid	3.18	0.025	0.08
Bulk Blend	8.65	0.025	0.21
Sub Total			1.58
TOTAL			87.01