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United Nations Industrial Development Organization

Distribution:
LIMITED

ID/WG.99/100
26 November 1971

Original: ENGLISH

Second Interregional Fertilizer Symposium

Kiev, USSR, 21 September - 1 October 1971
New Delhi, India, 2 - 13 October 1971

Agenda item II/11

# THE FERTILIZER INDUSTRY OF ISRAEL[1/]

by

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Israel

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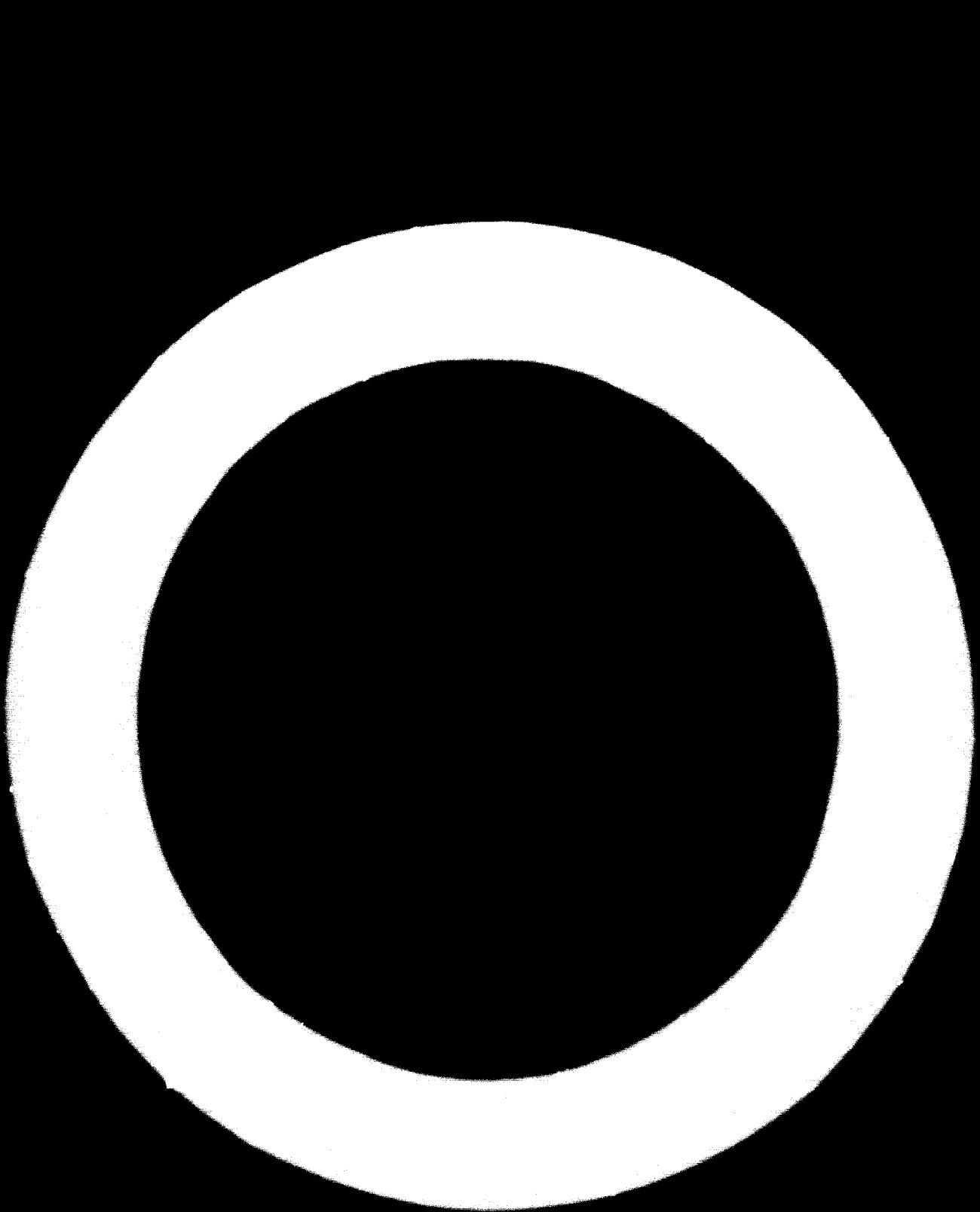

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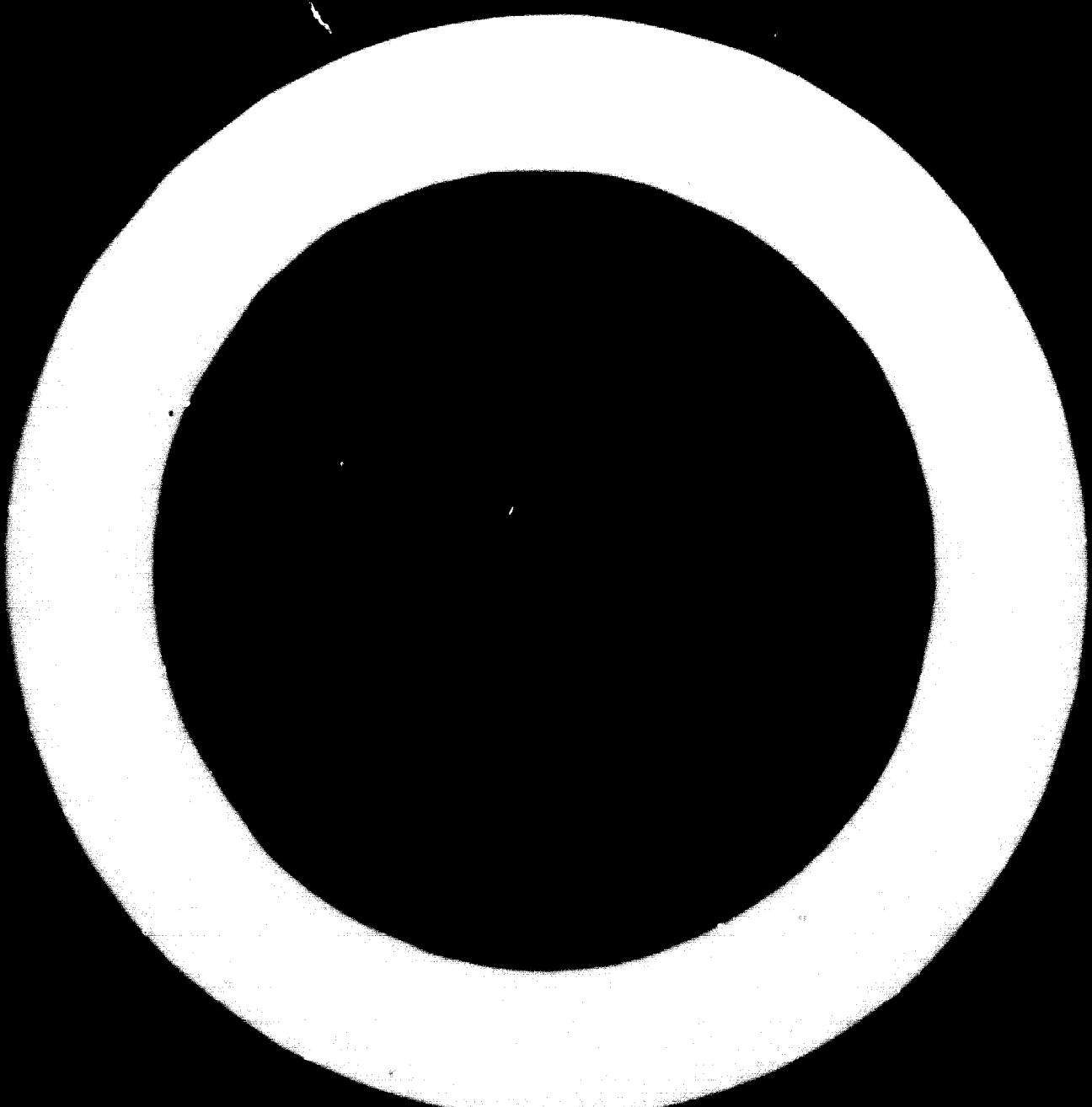


Introduction

The basic conditions for the development of a modern chemical industry, and in particular of a fertilizer industry, in a developing country are:

a) The availability of sufficient quantities of raw materials

b) Sufficient manpower with advanced technological training

c) Capital

Before and especially after the establishment of the State of Israel substantial quantities of potash, phosphate rock and limited quantities of natural gas have been found in the country. These raw materials in conjunction with the gases of the petroleum refineries justified the establishment of an extensive fertilizer industry and the manufacture of basic products essential to the country's development.

Whereas the natural gas and refinery gases are sufficient for the production of nitrogen fertilizers to cover the local consumption, the waters of the Dead Sea and the large phosphate deposits in the Negev were found to contain millions of tons of potash, phosphate rock and other essential minerals (magnesium, bromine, and sodium chloride) warranting their exploitation not alone for local consumption but for export purposes as well.

The majority of the working staff employed in Israel's developing fertilizer industry have been trained in local and foreign institutions, and the rest are immigrants also trained in the field.

The development projects of Israel's fertilizer industry required millions of pounds which could not be raised from private sources in view of the special conditions prevailing immediately after the establishment of the State. The erection of these development projects therefore depended on adequate government financing.

The State's development policy in this respect was directed towards the maximum development of the country's potash and phosphate deposits. It was contemplated that in addition to supplying the needs of the local market these industries would carry out extensive exports of potash, phosphate rock and other essential minerals.

The following table gives the data showing the share of mining and quarrying in the total industrial production.

TABLE I.

The share of mining and quarrying industry in total Israel industrial production as percentage of:

| | 1966 | 1967 | 1968 | 1969 |
|---|---|---|---|---|
| Total industry | 100.0 | 100.0 | 100.0 | 100.0 |
| Mining and quarrying | 3.0 | 2.4 | 2.2 | 2.0 |

I. The Existing Fertilizer Industry

The development of this industry in Israel in fact goes back as far as 1929 when Mr. Novomeisky, a mining engineer, obtained a concession for the utilisation of the natural resources of the Dead Sea and the Palestine Potash Company Ltd. was set up. The main object of this company was to extract potash and other minerals from the Dead Sea.

After the establishment of the first potash works at the Northern end of the Dead Sea, in Kalia, the Palestine Potash Company Ltd. was able as early as 1931 to produce the first batches of potassium chloride at a concentration of 60-62 per cent $K_2O$ which were fully exported to the United States.

During the Second World War the Palestine Potash Company Ltd. covered half of the total potash consumption of Great Britain and its various Dominions. Five years after the erection of Northern Dead Sea Works a second plant was erected in Sedom, at the Southern end of the Dead Sea.

Fertilizers & Chemicals Ltd. was founded in 1946 in order to establish a potassium sulphate plant based on the reaction of potassium chloride with sulphuric acid. This plant was to be located in the industrial zone of Haifa, near the refineries and the port. Potassium sulphate was greatly in demand at that time as the most highly rated fertilizer. Thanks to Haifa's convenient location at that time the projected output could be entirely exported to countries growing crops which are sensitive to chlorine, such as tobacco, citrus fruit and the like. Together with this potassium sulphate plant Fertiliser and Chemicals Ltd. set up the first sulphuric acid plant in Haifa.

After the establishment of the State of Israel in 1948 the population was multiplied threefold Means had to be found to provide this expanded population with food and other basic necessities. It thus became the main duty of the fertiliser industry to provide the basic materials for the development of Israel's agriculture to grow the necessary amount of food and

livestock, and Fertilizers and Chemicals Ltd. adjusted their programme accordingly.

In 1950 the Government of Israel approved the expansion programme of the Company's Haifa plant, providing for the erection of new plants for the production of other essential basic fertilizers for farm development and mineral additives for animal feed. For the realization of these projects the Government joined with a group of private investors to supply the necessary capital by the acquisition of shares and the grant of loans.

By that time geological research had established the presence of ample high quality phosphate rock deposits in Israel and sufficient data were available to justify the establishment of a plant for their commercial exploitation and industrial processing. These deposits were found in various sites in the Negev. In the vicinity of Hamakhtesh Haggadol (the Large Center) they were found sufficiently close to the surface to be exploited by open mining. At the present the phosphate reserves of the Negev are estimated at hundreds of millions of tons.

At the end of 1951 Fertilizers and Chemicals carried out successful exploitation tests in the Oron region. Consequently under the joint ownership of the State of Israel and Fertilizers & Chemicals Ltd., Negev Phosphates Ltd. was established for the mining and industrial processing of these deposits. At this stage it became clear that like most phosphate rock all over the world the Oron deposits had to be suitably enriched before they could be placed on the market. With the aid of local scientists appropriate enrichment methods were worked out and means were found to increase the $P_2O_5$ content of the phosphate deposits.

Negev Phosphates Ltd. then began to erect a new plant in Oron for the mining, processing and enrichment of phosphate rock. During the first year of its existence, in 1952/53, it was able to produce the first 16,500 tons of ground phaophate rock containing 21-22 per cent $P_2O_5$ which could all be taken up and processed by Fertilizers & Chemicals Ltd. in Haifa.

Upon the discovery of these phosphate deposits in the Negev, Fertilizers & Chemicals Ltd. in Haifa started to erect a new superphosphate plant fed by granulated Oron phosphates, and within three years it made Israel totally independent of imported phosphorus fertilizers.

At this stage the Haifa Works also started supplying poultry farmers with defluorinated enriched superphosphate as a mineral feed additive providing

phosphorus and calcium.

Before the outbreak of Israel's War of Liberation the country's potash output stood at about 100,000 tons produced in both potash works - in Sedom and in Kalia. During the War the Kalia Works was destroyed and became occupied Jordanian territory. The Southern Works, however, remained in Israeli hands, but could not be operated until 1953 for lack of suitable access roads. In 1952 the Government of Israel set up the Dead Sea Works, replacing and succeeding the Palestine Potash Co., Ltd., with a view to developing the resources of the Dead Sea. This required the building of new access roads, the restoration of the evaporation pans and the reconstruction of the production plants.

The first stage of development was completed in 1956. A new production plant with an output capacity of 200,000 tons per year was put into operation. In order to expand production beyond these limits fundamental changes in the layout of the evaporation pans were required. The solution arrived at was cut off the southern part of the Dead Sea by a dyke and turn it into one large evaporation pan.

1964 saw the completion of a modern potassium chloride plant with an output capacity of 400,000 tons per year. With the completion of a third unit, total capacity reached 800,000 m.t. in 1969.

When all the development projects are completed the Dead Sea Works Ltd. will be able to produce 1,200,000 tons of potassium chloride, some 10-15,000 tons of bromine and bromides, and considerable quantities of magnesium and sodium chloride. The bulk of these products is destined for export.

TABLE II.

Production of Potassium Chloride in Israel (in '000 tons $K_2O$)

| | |
|---|---|
| 1954/55 | 15 |
| 1959/60 | 114 |
| 1964/65 | 320 |
| 1968/69 | 344 |
| 1969/70 | 437 |

In the extraction of potash from the Dead Sea a method specifically adapted to local conditions is used. The Dead Sea is a closed inland lake with a salt concentration of up to 27-30 per cent. It lies at the lowest point

of altitude in the entire world, at 390 meters below sea level, in an arid zone where annual precipitations do not exceed 50 mm. The yearly temperatures are very high, and evaporation is considerable.

The mineral content of the Dead Sea is estimated at 43 million tons, as follows:

| | |
|---|---|
| Magnesium chloride | 22 million tons |
| Sodium chloride | 12 |
| Calcium chloride | 6 |
| Potassium chloride | 2 |
| Bromides (mainly magnesium bromides) | 1 |

Potash production is thus based on the solar evaporation of sea water. The potassium chloride concentration is thus raised from 1.2 per cent in the brine to 21 per cent in the karnellite, which is the raw material used by the potash plants.

The potash is then extracted from the karnellite by two alternative methods, a cold and hot leach process.

The only difference between the hot and cold process is that instead of by floatation the potash is extracted from the sylvinite by means of a hot saturated sodium chloride solution not saturated with potassium chloride. The resultant saturated potassium chloride solution is cooled gradually when the potassium chloride forms chrystals of any desired size up to 2 mm.

In 1956 Fertilizers & Chemicals Ltd. started operating an anhydrous ammonia plant followed by ammonium sulphate and nitric acid plants. The raw materials for anhydrous ammonia production were the affluents of the Haifa petroleum refineries and later on also heavy fuel oil. These plants helped to provide local agriculture with its full requirements of the three chief nutrient elements - nitrogen, phosphorus and potassium. This domestic production thus also relieved the need for nitrogen fertilizer imports from abroad. A new 80,000 m.t./year ammonia plant and 30,000 m.t. urea plant have started to operate in 1971.

Ramified research carried out by the company's own team helped to introduce liquid ammonia as a nitrogen fertilizer for most field crops in Israel, replacing solid ammonium sulphate.

Thus some of the cost of the unit nitrogen supplied to the farmer was

considerably reduced, and the foreign currency formerly spent on buying sulphur from abroad could be saved.

The Company's research team also succeeded in developing new processes for the utilization of the by-products of its basic production plants. As a result a plant for the production of feed grade dicalcium phosphate was set up, mainly using the hydrochloric acid obtained in the production of potassium sulphate. This made Israel's farmers independent of the supply of non-standard bonemeal as a source of phosphorus and calcium for their entire livestock.

Bearing in mind the needs of Israel's agriculture, the next development stage consisted of the erection of liquid fertilizer plants at the Haifa Works, which were thus in a position to supply locally manufactured hydrous ammonia, liquid ammonium nitrate and three types of composite liquid fertilizers. In addition a granulation plant was set up for the granulation of both single and enriched superphosphates and the production of granulated ammonium calcium nitrate and other granulated composite fertilizers.

At present the Haifa Works produces most of the fertilizers required by local farmers, and is able to export surpluses.

Negev phosphates

It was necessary to find means and ways for enriching the Oron phosphate deposits in order to improve their quality by raising their $P_2O_5$ contents. By mechanical enrichment alone, the phosphate rock could be brought up to 29-30 per cent $P_2O_5$, but with the establishment of a floatation and drying plant in 1960 the $P_2O_5$ contents could be increased to 30-31 per cent. In the same year the company's team succeeded in developing a new economical enrichment process based on calcination, whereby the $P_2O_5$ contents could be raised to 34-36 per cent. The calcinated phosphate rock now produced at Oron is of superior quality, particularly suited for the production of triple superphosphate. Since it contains but few waste materials and no organic matter the sulphuric acid consumption in the production of phosphoric acid is particularly low.

The output of the Oron Works has soared from the experimental production of 16,500 tons non-enriched phosphate rock in 1952/53 to about 400,000 tons of enriched material by 1965 and 1,000,000 m.t. in 1970.

For the implementation of future development plans Fertilizers & Chemicals Ltd. and Negev Phosphate Ltd. were in 1963 merged into one company now operating under name of Chemicals and Phosphates Ltd.

TABLE III.

Phosphate Rock Production in Israel (in '000 metric tons)

| | |
|---|---|
| 1955 | 72 |
| 1956 | 116 |
| 1957 | 152 |
| 1958 | 210 |
| 1959 | 205 |
| 1960 | 224 |
| 1965 | 400 |
| 1966 | 750 |
| 1967 | 1,000 |
| 1970 | 1,000 |

The seond development stage of Israel's fertilizer industry aimed mainly towards the upgrading of its basic raw materials and replace the export of raw materials by more sophisticated products. Israel is not at the final stages of two of the first production units in this development scheme. Both projects employ new processes which were invented and developed by IMI Laboratories Ltd., Israel.

Arad Chemical Industries

A chemical complex for the production of phosphoric acid. The phosphate rock is reacted with hydrochloric acid produced from Dead Sea magnesium chloride. The product is 69 per cent $P_2O_5$ phosphoric acid, which can be upgraded easily and be used for various application other than fertilizer, such as feed, phosphates and detergents etc.

Present installed production capacity is 166,000 m.t. $P_2O_5$. The company is one of the pioneers in international trade in phosphoric acid. The greater part of the produce will be exported as phosphoric acid to be further processed to fertilisers in the importing countries. The acid will be used specially in the production of high nutrient containing fertilizer, liquid fertilizer and P containing minerals for animal feed. The company has built an intensive storage, handling and transportation system to carry out the export programme.

Haifa Chemicals Ltd.

Haifa Chemicals came recently into full production producing potassium nitrate and phosphoric acid. Annual capacity is 100,000 m.t. of potassium nitrate (13-44-0) and 16,000 m.t. $P_2O_5$ of very high grade phosphoric acid. Production is via processes developed by IMI. It is the first generation of highly sophisticated products to be produced in Israel.

The two production lines described above represent the trend of development of the Israeli fertilizer industry. Possessing raw materials, technological know-how and trained manpower on one hand, and a very small market on the other hand forced the fertilizer authorities to adjust the production and products to meet the standard of international trade, so that the industry will be able to sell profitably in the international market and also will benefit from the inflow of hard currency.

Israel Mining Industries Ltd.

Side by side with the research units, operated by these commercial firms, a special research unit was set up in 1951 to develop suitable methods for the efficient utilization of Israel's mineral resources. This research unit now goes under the name of Israel Mining Industries Ltd. Its work is financed by government funds and royalties collected for processes successfully developed by its staff.

This company engages in the following fields of research:

1. Processes for the production of concentrated fertilizers
2. Hydro-metallurgical processes
3. Mineral enrichment
4. Petrochemicals and fine chemicals.

The company at present holds 30 basic patents, the most outstanding of which are:

a) The production of concentrated (60-70 per cent) $P_2O_5$ phosphoric acid, with the aid of hydrochloric acid,

b) The production of potassium nitrate

c) The purification of phosphoric acid produced by the wet process

d) The production of monopotassium phosphate from potassium chloride and phosphoric acid.

Fertilizer & Chemical Development Council

In Israel the Fertilizer & Chemical Development Council was set up as a joint institution of government and industry to collect and propagate data and information on all matters relating to production, utilisation and marketing of fertilizers in Israel and abroad. The fertilizer & Chemical Development Council is in charge of Israel's contribution to the Freedom from Hunger Campaign of FAO and collaborates with other international organisations active in this field. It organises international courses in soil fertility

and fertilizer use and supplies material information and publications to all interested parties.

Israel Chemicals Ltd. (I.C.L.)

With the growth of the fertilizer industry and scale of activities of each of the local companies in the home market as well as in the export trade of fertilizer, companies which are owned mainly by the government were organized under a central holding company which coordinates the activities, decides the development policy and encourages research and development.

TABLE IV.

ISRAEL: FERTILIZERS - STATISTICAL DATA

| | | 1969/70 (tons/year) |
|---|---|---|
| **Installed capacity nitrogen under production:** | | |
| Ammonia (N) | | 80,000 |
| Urea (material) | | 80,000 |
| **Installed capacity of phosphates ($P_2O_5$)** | | |
| a) | Phosphoric acid | 35,000 |
| | there of (Hcl rout) | 16,000 |
| b) | running in stages (Hcl rout) | 166,000 |
| **Installed capacity potash ($K_2O$)** | | |
| a) | Under production | 600,000 |
| b) | Planned | 240,000 |
| **Special fertilizers, potassium nitrate (material)** | | 100,000 (13-0-44) |
| **Consumption** | | |
| **Endproducts (materials)** | | |
| a) | Ammonium sulphate | 66,100 |
| b) | Calcium ammonium nitrate | 12,000 |
| c) | Urea | 6,500 |
| d) | Aqueous ammonia | 19,500 |
| e) | Other liquid fertilizers | 3,200 |
| f) | Superphosphate (single) 14.5-17% $P_2O_5$ (powdered) | 5,500 |
| g) | Enriched superphosphate 21-22% $P_2O_5$ | 53,800 |
| h) | Potassium sulphate 48-50% $K_2O$ | 1,200 |
| i) | Muriate of potassium 60-62% $K_2O$ | 14,000 |
| j) | Mixed fertilizers: | |
| | Granulated: 15-15-0 | 4,500 |
| | 12-12-0 | 1,600 |
| | 0-9-27 | 500 |
| | Liquid: 12.5-12.5-0 | 3,400 |
| | 8-24-0 | 2,000 |
| | Potassium nitrate | 500 |

Raw materials used

a) Gas from oil refineries fro N production

b) Phosphate rock from Oron for phosphatic fertilizers

c) Dead Sea brine for potassium fertilizers

Processes adopted and designed by:

a) Phosphates - mainly Hcl process, and at a lesser extent Kuhlmann process

b) Potassium

| Production 1969/70 | in tons |
|---|---|
| a) Nitrogen (N) | 28,000 |
| b) Phosphatic fertilizers ($P_2O_5$) | 17,000 |
| c) Phosphate rock ($P_2O_5$) | 1,000,000 |
| d) Potassic fertilizers ($K_2O$) | 437,000 |

Consumption, 1969/70

| | |
|---|---|
| a) Nitrogen (N) | 28,000 |
| b) Phosphatic fertilizers ($P_2O_5$) | 14,000 |
| c) Potassic fertilisers $K_2O$ | 9,500 |

Imports/Exports in 1969/70

| | |
|---|---|
| a) Nitrogen (N) - imports | 3,000 |
| b) Phosphate rock ($P_2O_5$) exports | 700,000 |
| c) Potassic fertilisers ($K_2O$) - exports | 435,000 |

## II. The Local Fertiliser Market

Consumption of plant nutrients in Israel totalled 51,500 m.t. in 1969/70. This quantity is more than double the consumption figure of 1953/54. It represents an average consumption growth rate of 9.5 per cent.

Total consumption during this period had a general upward trend, although annual changes fluctuated substantially. This pattern of consumption is the outcome of the different consumption trends of the three major nutrients. One can also see that over the last fifteen years the annual rate of increase has declined.

### Nitrogen

Consumption of nitrogen increased continuously at an average annual rate of

7 per cent. The growth was faster in the early sixties. It was exceptionally high in 1967/68 probably sales to the West Bank were included.

Phosphosus

Consumption of $P_2O_5$ decreased during the sixties. In recent years it fluctuated around 12,000 m.t. per annum.

Pottasium

Consumption of potash was stable and low duri[illegible] 1953/54 - 1[illegible]. Since 1964/65 consumption of potash has been growing at a very fast rate. Potash is still used to a much lesser extent as compared with nitrogen and phosphorus.

TABLE V.

Consumption of plant nutrient '000 m.t.

| | 1953/4 | 1959/60 | 1963/4 | 1964/5 | 1966/7 | 1967/8 | 1968/9 | 1969/70 |
|---|---|---|---|---|---|---|---|---|
| N | 10.7 | 16.3 | 21.1 | 22.8 | 24.8 | 28.5 | 27 | 28 |
| $P_2O_5$ | 7.5 | 14.6 | 10.2 | 11.3 | 11.2 | 11.8 | 12.3 | 14 |
| $K_2O$ | 2.3 | 2.2 | 2.5 | 3.0 | 4.8 | 6.4 | 6.6 | 9.5 |
| Total: | 20.5 | 33.7 | 33.8 | 37.1 | 40.8 | 46.7 | 45.9 | 51.5 |

TABLE VI.

Annual change in consumption %

| | 1953/4 | 1959/60 | 1962/3 | 1963/4 | 1964/5 | 1965/6 | 1966/7 | 1967/8 | 1968/9 | 1969/70 |
|---|---|---|---|---|---|---|---|---|---|---|
| N | - | 5 | 11 | 12 | 8 | 5 | 3 | 15 | -5 | 4 |
| $P_2O_5$ | - | 95 | -20 | -13 | 11 | 6 | -7 | 5 | 4 | 14 |
| $K_2O$ | - | -4 | 9 | 4 | 20 | 47 | 3 | 33 | 3 | 46 |
| Total | - | 64 | -2 | 3 | 10 | 9 | 1 | 16 | -2 | 11 |

Consumption of fertilizers by kind of fertilizers

Straight fertilisers dominate fertilizer application in Israel. Use of compound was introduced at the beginning of this decade. Annual consumption is small, and fluctuates around 8 per cent of the total nutrient consumption. Almost all compounds are NP compounds.

[illegible]

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Straight fertilizers | [illegible] | | | | | | |
| Compounds | | | | | | | |
| Total | | | | | | | |
| Straight fertilizers | | | | | | | |
| Compounds | | | | | | | |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Consumption of fertiliser was 5.75 kg/dunam in 1953/54 and 11.42 kg/dunam in 1968/69. This level of consumption is much lower than that prevailing in agriculture of similar degree of advancement in other countries.

The most significant single factor in the intensification of local agriculture was the expansion of area under irrigation. All other factors undoubtedly contributed to increased fertiliser consumption, but to a smaller extent as compared with irrigation.

Following are the estimated fertiliser consumption data in irrigated and non-irrigated crops:

TABLE VIII.

Consumption of fertilizers by type of farming 1967/8

| | Irrigated area NPK | | | Non-irrigated area NPK | | |
|---|---|---|---|---|---|---|
| | Total | Kg/D | Ratio | Total | Kg/D | Ratio |
| N | 20,000 | 12,00 | 1.00 | 8,400 | 3.30 | 1.00 |
| $P_2O_5$ | 7,000 | 4.25 | 0.35 | 4,800 | 1.88 | 0.59 |
| $K_2O$ | 6,400 | 3,20 | 0,32 | 0 | 0 | 0,00 |
| Total | 33,400 | 20.15 | | 13,200 | 5.18 | |
| | | % of total Kg/D | | | % of total Kg/D | |
| N | | 70 | | | 30 | |
| $P_2O_5$ | | 59 | | | 41 | |
| $K_2O$ | | 100 | | | 0 | |
| Total: | | 72% | | | 28% | |

From the above figures it is obvious that main consumption of fertilizers is by irrigated crops which in 1967/68 took in 72 per cent of the total consumed. Consumption of fertilizer per dunam of irrigated crops in 3.8 times higher than non-irrigated crops.

NPK ratio

Nitrogen is the dominant nutrient in fertilizer consumption. Its share of total consumption grew from 52.1 per cent in 1953/4 to 54.3 per cent in 1969/70. During this period its annual average increase was 6 per cent. It was higher in the earlier years of this period.

Consumption of P reached its peak in 1959/60 and since then has been on a downward trend. Actual consumption in recent years was more or less stable, but consumption per dunam continued to decrease. In 1953/4 P contributed 37 per cent of total fertilizer consumption, while in 1969/70 its contribution was only 27 per cent.

Annual consumption of potash was almost the same until 1963/4. In 1964/5 its consumption started to rise and since then has been increasing at a high rate. In 1969/70 potash constituted 18.4 per cent of total nutrient consumption.

In dry farming, fertilization based on N and P fertilizers only, plus minor quantities of potash in unirrigated cotton. Only 30 per cent of the nitrogen is used on non-irrigated crops.

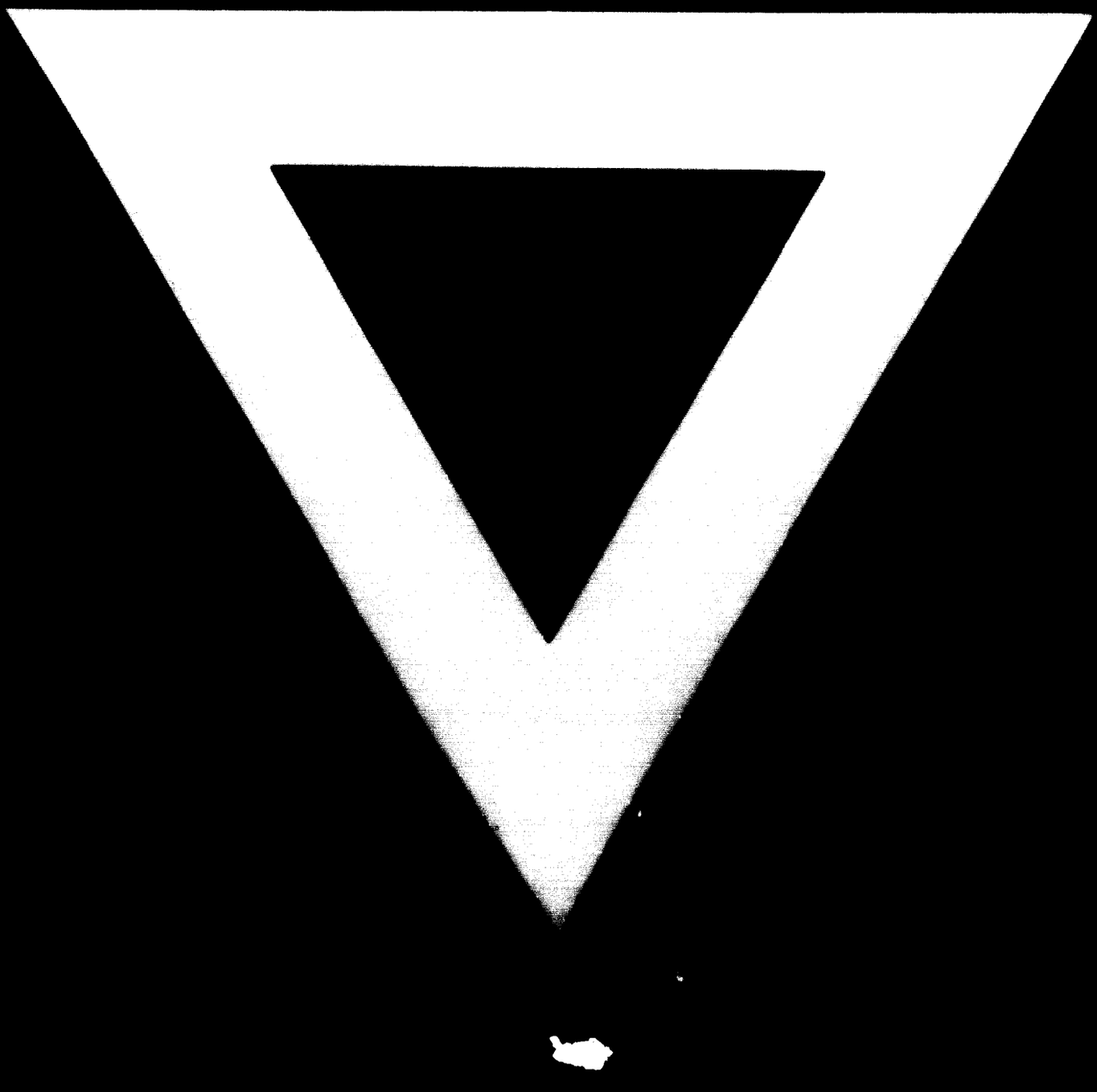
The actual NPK application depends primarily on the crops, intensification of its cultivation and type of soil. Total consumption as well as NPK ratio differs greatly from one crop to the other.

Fertilization is practised in many crops. Consumption of N is distributed more evenly and on a greater number of crops as compared with the application of phosphorus and potassium.

Conclusion

The foreseen development of the fertiliser industry will increase the number of fertilizers produced in Israel. This will undoubtedly increase the pressure on the local market and change the present types of fertilizers being used. The expansion of covered crops will create a market for special compound fertilizers. When the expansion of the local fertilizer production materializes, the share of the local market as part of the total output and sales will decrease, and its effect on fertilizer companies will become of less importance.

Considering land being farmed, crops cultivated, availability of irrigation water and level of Arab agriculture, we find that doubling of the present level of fertilizer consumption is the upper limit of development which can be expected during the next few years. As unknown factors outweigh the known ones, these areas were not included in our calculations and forecasts.



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