https://doi.org/10.29321/MAJ.10.A04829

MANUFACTURE OF SYNTHETIC NITROGENOUS FERTILIZERS IN INDIA

Part I. The demand for nitrogenous fertilizers in this country.

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The idea of applying inorganic fertilizers, especially nitrogenous, with a view to increase crop yields, may be said to have originated from India, where potassium nitrate obtained from the nitre-beds of Bihar, Bengal and the Punjab was for a long time used for the purpose. Before the nitre deposits of Chile were discovered and exploited from 1830, India was for centuries the sole source of nitrate both in times of peace for agricultural operations and in times of war, for the preparation of gunpowder. But after the discovery of the huge deposits in Chile, the export of nitrate from India rapidly decreased and the commercial exploitation of the nitre beds on a large scale has only recently been restarted by a subsidiary company of the Imperial Chemical Industries Ltd.

Though the usefulness of inorganic nitrogenous manures has been realised in India for a long time past, their application on the large scale for intensive cultivation has been undertaken mostly in the Europen countries, where the high density of population has necessitated the adoption of a highly scientific and intensive system of agriculture. Sir John (then Dr.) Russel,[1] writing in 1917, estimated the quantities of fertilizers used in the principal consuming countries to be as follows, and there is no doubt that the amounts have since that period greatly increased in the western countries.

TABLE I.

Country.	Fertilizers used per hectare (2·4711 acres) in cwts. (1917).	Density of population in 1931[2] per sq. K. meter. (0·3861 sq. mile).
Belgium	5·38	268
Luxemburg	4·05	...
Germany	3·31	139
Great Britain	1·78	194
Italy	1·19	134
Denmark	1·14	...
France	1·13	76
Cf. India (in 1937)	0·016	75

Such increased use of fertilizers in the more highly developed countries is reflected in the higher yields of crops obtained by them, as shown by the following figures for 1933-34[3]:—

TABLE II.

Rice.		Wheat.	
Country.	lb. per acre.	Country.	lb. per acre.
1. Spain	5,600	1. Netherlands	2,717
2. Italy	4,232	2. Denmark	2,652
3. Japan	3,720	3. Germany	2,154
4. Egypt	2,685	4. United Kingdom	2,144
5. India	825	5. India	632

Sugarcane.		Cotton.	
	Tons per acre.		Ginned cotton lb. per acre.
1. Hawaii	56·42	1. Egypt	452·8
2. Java	50·27	2. Brazil	306·5
3. Egypt	30·97	3. Argentine	220·0
4. Cuba	20·32	4. U. S. A	217·6
5. India	16·24	5. India	81·0

Even in India, the population is increasing at a rapid rate and the estimated acreage under food crops per head of population is steadily declining[4], as shown by the figures given below :—

TABLE III.

Year.	Population in millions.	Estimated acreage under food crops per head of population.
1871	230	1·01
1891	275	0·88
1901	294	0·81
1921	319	0·72
1931	353	0·60
1941 (estimated)	400	0·53

It is interesting to compare the above figures with the evidence of Burnet and Aykroyd[5], submitted to the League of Nations Health Bureau, on the amount of land required per capita for the production of different types of diet.

TABLE IV.

Diet.		Amount of land required per capita per annum.
1. Restricted diet for emergency use	...	1·2 acres.
2. An adequate diet at minimum cost	...	1·5 ,,
3. An adequate diet at moderate cost	...	1·8 ,,
4. A liberal diet	...	2·1 ,,

That there is not much more land available for cultivation purposes in the older provinces of India is shown by the following data :—

TABLE V.

% of cultivated land to total culturable area. (Wattal)[6].

Province.		% of cultivated to culturable area.
1. Madras	...	77·5
2. Bombay	...	86·4
3. Bengal	...	82·9
4. United Provinces	...	78·1
5. Bihar and Orissa	...	81·7
6. Punjab	...	67·4
7. Central Provinces and Berar	...	66·9

The above data clearly emphasize the urgent need for the State to take suitable measures for increasing the yield per acre of the present area under cultivation. This is possible only by a more extended use of inorganic fertilizers.

India has so far been using mainly organic manures, e. g. farmyard manure, green manures, cakes etc. The supplies of such manures are limited and show a tendency to decrease, due to the extended use of cow-dung cakes as fuel and the heavy exports out of the country of bones, bone-meal, horn-meal, fish manure and guano, amounting to about 88,000 tons per year exclusive of oil cakes.

TABLE VI.

Exports of Manures from India[7].

	1935-36 Tons.	1936-37 Tons.	1937-38 Tons.
1. Bones and bone meal	42,894	57,247	68,830
2. Fish manures	6,165	6,583	6,396
3. Horn-meal	645	2,436	2,563
4. Sulphate of ammonia	7,072	2,626	1,919
5. Other manures	4,561	8,320	8,986
Total Exports	61,337	77,212	88,696

Further, under tropical conditions, the organic matter in the soil is easily oxidized and even heavy additions of organic manures, e.g. farmyard manure, barely serxe to maintain the organic matter content of the soil at the minimum level necessary for successful cultivation. As such, the beneficial effects of such bulky organic manures are more physical in improving the quality of the soil, rather than nutritional in the supply of plant food requirements. It has been the general experience of agriculturists both in this country and elsewhere that the highest yields are obtained by a suitable mixture of bulky organic manures with concentrated inorganic fertilizers.

Of the three important food constituents required by plants, viz., nitrogen, phosphoric acid and potash, Indian soils generally contain enough of potash and do not show any significant response to further additions. Phosphoric acid is no doubt deficient in several areas, but considering the fact that about 70,000 tons of bones and bone-meal are exported from the country, there should be no difficulty in meeting the country's requirements in this regard, by discouraging such export through suitable tariff barriers.

But the case is, however different with nitrogenous fertilizers, which are not manufactured in sufficient amounts within the country, and are moreover required in much larger amounts than either phosphatic or potassic manures. The reason for this greater demand for nitrogenous manures is due to the fact that, for most ordinary crops, the saturation point of the soil is more easily reached in respect of potash and phosphoric acid than for nitrogen In other words, it pays the cultivator to apply larger amounts of nitrogenous manures than phosphatic or potassic fertilizers.

Bueb[8] reports German experience which gives the following crop increases per ton of nitrogen applied as fertilizer :—

18 tons of wheat grain and 40 tons of wheat straw ;
24 tons of barley grain and 30 tons of barley straw ;
24 tons of oat grain and 34 tons of oat straw ;
129 tons of potatoes and 40 tons of potato foliage ;
150 tons of sugar-beet and 199 tons of sugar-beet foliage ;
240 tons of fodder turnip and 79 tons of fodder turnip foliage.

N. Caro[8] came to a similar conclusion that each ton of nitrogen increases the yield of grain by at least 20 tons and that of potatoes by at least 100 tons.

Sir John Russell in his recent Report[9] on the progress of Agricultural Research in this country, also observes :— "Nitrogenous fertilizers usually

give the largest returns" and gives data which show that a maund of nitrogen applied in the form of ammonium sulphate, gives the following increases of crop yield :—

275	maunds of	sugarcane ;	5	maunds of	tea ;
25	,,	sugar ;	22·5	,,	paddy ;
75	,,	potatoes ;	15	,,	wheat ;
6	,,	leaf tobacco ;	8	,,	seed cotton

The striking benefit to be derived from the use of nitrogenous fertilizers is reflected in the figures for the imports of manures into India during the last three years.

TABLE VII

Imports of Manures into India.

Nature of manure.	1935—36 Tons	1936—37 Tons	1937—38 Tons
Nitrogenous Manures.			
Ammonium Sulphate	46,385	61,238	53,216
Ammonium phosphate	5,529	4,122	2,167
Sodium Nitrate	2,714	2,470	3,208
Others	488	550	589
Total.	55,116	68,380	59,180
Potassic manures	4,475	2,754	4,532
Phosphatic manures (other than ammonium phosphate)	10,434	9,191	11,184
Other manures	2,185	3,328	3,529
Total imports	72,210	83,653	78,425

The above Table shows that about 75% of our total imports of fertilizers are nitrogenous and about 70% is accounted for by one item, viz. ammonium sulphate. The 50 to 60 thousand tons of ammonium sulphate imported per year are in addition to about 16,000 to 18,000 tons which are produced in India as a by-product in the "coking" industry. The total consumption of ammonium sulphate, therefore, comes to about 75,000 tons per year ; and almost the whole of it is used as fertilizer.

The main sources for the world supply of nitrogenous fertilizers are : (a) Chilean nitrate, (b) by-product ammonia, obtained from coal and (c) synthetic nitrogen obtained by atmospheric nitrogen fixation. Before the War, Chilean nitrate held the predominant position, being almost the only major source for nitrogenous fertilizers. But during the War, Germany which was cut off from the Chilean supplies, perfected the synthetic method for the manufacture of ammonia and also greatly developed her production of by-product ammonia. After the War, the production of synthetic nitrogen compounds has been greatly developed in most of the European and American countries, so much so that, at present this source is supplying about 75—80% of the world demand for nitrogen (vide Table VIII).

TABLE VIII.

Sources of nitrogen supply for the World. (Metric tons of N).

Source.	1912.	1925.	1935.
1. Chilean Nitrate	411,329	421,000	192,000
2. By-product ammonia	272,007	302,000	365,000
3. Synthetic nitrogen from the atmosphere	32,435	495,000	1,776,000

In the case of India, the distance from Chile is a decisive factor working against the import of sodium nitrate into this country. It can be seen from Table VII that only 3,208 tons of sodium nitrate were imported into this country in 1937–38, as against 53,216 tons of ammonium sulphate.

A local source for nitrate, no doubt, exists in the surface accumulations of saltpeter (potassium nitrate) found in some of the saline areas of Bihar, Bengal and the Punjab. But this source is at present of a limited and uncertain nature; and moreover on account of the tedious processes of dissolving out the nitrate from the soil and recrystallising it, the cost of the nitrate produced in India is higher than that of the imported material. Thus crude 10% saltpeter (local) is selling on the Calcutta market at Rs. 4 to 5 per maund, which works out to about Rs. 120 to Rs. 140 per ton, as against the price of Rs. 100 for sodium nitrate (15·65% N).

As regards the manufacture of ammonium sulphate as a by-product of the coal and coking industry, India is, no doubt, raising about 20 to 25 million tons of coal per year, which at a conservative estimate of a recovery of 0·05 % as ammonia, contains a potential content of 50,000 tons of ammonium sulphate. Further, large amounts of hydrogen are obtained as a by-product during the manufacture of coke, which could be easily converted into ammonia by synthetic methods. The annual production of pig iron in this country during 1937—38 was over 1,620,000 tons, and making a fair allowance for the portion produced with the help of charcoal, the amount of coke used in the iron industry may be estimated at a minimum of 1,000,000 tons. The manufacture of this amount of coke would yield, under conditions of effective recovery of by-products, enough hydrogen to yield 30,000 tons of ammonia or about 150,000 tons of ammonium sulphate.

In the coal industry, therefore, India may be said to possess a potential source for over 200,000 tons of ammonium sulphate per year, which will be more than sufficient to meet her requirements for some years to come at least. But, unfortunately, the coking industry in India is so ill organized that the production of by-product ammonia has been quite unable to cope with the rapidly increasing demands, as will be seen from the following Table.

TABLE IX

Year.	The amount of ammonium sulphate	
	Produced in India. Tons.	Imported from outside. Tons.
1932—33	8,116	37,612
1933—34	9,702	29,800
1934—35	14,034	40,875
1935—36	17,619	46,385
1936—37	16,041	61,238
1937—38	18,100	53,216

There are no indications of any immediate rapid improvement of supply from this source. An annual production of about 20,000 tons of by-product ammonium sulphate is probably what could be expected for some years to come, till the coking industry is better organized.

As such, the balance of our nitrogen requirements, which may be expected to go up to about 100,000 tons within the next few years, will have to be imported from abroad, unless arrangements are made for their manufacture within the country itself.

The most effective means at our disposal for this purpose and the one that has been tried with great success in Europe and America, is the fixation of nitrogen from the air by synthetic chemical processes.

It is not proposed to deal here with the question of fixation of nitrogen by bacterial agency, through leguminous crops, as this is already being followed in the systems of crop rotation adopted in this country. But such a system of rotation, by itself, has not been found sufficient to give the maximum yields of crops. Large quantities of nitrogenous fertilizers are being imported and applied directly to crops such as paddy, sugar-cane, cotton, coffee, tea, rubber etc. Our imports in this respect are nearly 80,000 tons, valued at Rs. 8 crores and promise to increase rapidly in the coming years. There is, therefore, every justification for taking necessary steps for the manufacture of synthetic nitrogenous fertilizers in this country, by starting plants for the fixation of atmospheric nitrogen.

Another reason which has induced European and American countries to greatly develop their atmospheric nitrogen industries has been the great importance of such concerns in times of War, in providing enough supplies of nitric acid for the preparation of munitions. Thus, Germany is at present equipped with plants capable of fixing nearly 1,500,000 tons of nitrogen per year, while America, France and England can fix about 750,000 tons each. Though the world production of fixed nitrogen in 1935-36 was about 2,378,000 tons, the potential capacity is believed to be nearly 10 million tons of fixed nitrogen per year. The ability of Germany to withstand the last War for over 4 years, was mainly due to her capacity to replenish her supplies of munitions by fixation of nitrogen from the air. In these days of modern aerial warfare, survival from annihilation is determined by the ability of a country to produce enough ammunition for its protection against aggression. As such, the importance of starting a number of nitrogen fixing plants in different parts of the country needs no stressing.

In the next Part, we shall briefly consider the relative merits of some of the important methods that have been tried so far in Europe and America, for the fixation of atmospheric nitrogen, with a view to choose one which combines cheapness with suitability to conditions in this country

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RURAL EXHIBITION *

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An Exhibition as a means of advertising new methods and wares is considered to be very useful. It really creates a sense of healthy rivalry and has served to produce very valuable results in improving the efficiency of production and the quality of the produce. It is accepted on all hands that Exhibitions are a necessary means to progress. Even the ignorant and illitrate can be educated very effectively through their sense of sight by presenting things in the most attractive manner in an exhibition. Thus an exhibition is fundamentally a means for the education of the masses.

Government Departments and business organisations have conducted or taken part in exhibitions with great success. Such exhibitions were mostly arranged in urban areas or in very important villages where alone they could secure the necessary co-operation from the local public. From them a few of the organisations have without much effort been able to achieve very good results to help them to make progress and expand their business while others have not had such good opportunities in spite of the great pains taken and care bestowed on putting up the show in a very telling manner. Business-men who were attempting to secure patronage from a wider circle or to popularise their produce and to find a market for them have succeeded best in them so much as to say that some of the exhibitions have become an array of show rooms or shops wherefrom sales are effected to new customers. Stalls containing curios, fancy goods, toys, carving and inlaid works, furniture, etc. are the most popular places in these exhibitions; Cotton, woollen or silk fabrics take the next place of importance while exhibits on subjects of rural importance such as agriculture, sanitation &c., attracted the least attention. The reason for this state of affairs is not far to seek; since it is due to the simple fact that the visitors to such exhibitions are mostly urban people who can have little taste or interest in rural subjects. Taking into consideration the fact that more than ¾ of the population of India live in rural parts it will be clear that these urban exhibitions can

* Paper read at the Twenty-seventh College Day and Conference, July 1938.