https://doi.org/10.29321/MAJ.10.A04319

Advances in Fertiliser Production and Use *

by

A. H. SUBRAMANIA SARMA
Lecturer in Agriculture

One of the outstanding achievements in the field of Agriculture during the last one hundred years is the progress made in fertiliser production and use. Since the time Justus Von Liebig stressed the importance on plant nutrients and placed his patent manure on the market 110 years ago, scientists and manufacturers, the world over have probed into the problems of plant nutrition and nutrient supplies. Most famous are the studies at Rothamstead and Woburn in England, those of Wagner and Maercker in Germany, and those in the various states of the U. S. A. and in Pusa and Coimbatore in India. They have contributed a wealth of information on many phases of fertiliser production and fertiliser use in relation to soils and plant growth. This has resulted in the development of an industry of world-wide significance as an important branch of the chemical industry.

Early History: Even though the fertiliser industry occupies an important place today, until as late as 1940, fertiliser production was largely a byproduct subsidiary of the chemical industry. The era of cheap food prices till then, necessitated the sale of fertilisers at very cheap prices. Necessarily therefore, the fertiliser industry had to a substantial extent continue to be broadbased upon the by-products of other industries. The question then was whether any new process exclusively designed to produce a fertiliser suited to specific soil needs will ever hope to compete with the established byproducts of certain industries.

But with the departure of the cheap food era, the peculiar agricultural cum chemical background of the fertiliser industry is fast disappearing. Fertiliser consumption has expanded rapidly as can be found in the figures furnished in the subsequent paragraphs. A period of active technical development has now begun. Fertilisers are not just byproducts now, but have become largely specialised, and are produced and shaped to suit the needs of farmers in relation to their soil and the equipment used to apply them. Special methods of processing to facilitate easy application, the evolution of more specialised forms for increasing efficiency in

* Paper read at the College Day and Conference, 1954.

use, the production of better and cheaper types; are some of the lines on which the industry is bestowing more attention today.

Trends in Fertiliser Consumption: A review of the fertiliser situation during the last one hundred years would show that the industry did not make much progress in its early years of the twentieth century, farmers in some advanced countries had started using fertilisers in a small way. The American picture is quite revealing in this matter. As the largest consumer of fertilisers in the world today the United States of America reflect in a real manner the trends of fertiliser consumption. At the beginning of the century, the annual consumption of fertilisers there was only two million tons, while it is over twenty million tons today; a ten-fold increase. The British picture is more or less, quite similar. The real situation in regard to fertiliser consumption of other countries is rather misleading as disturbances of the war cut off their normal production and supplies. For instance, the high fertiliser consumption of several European countries dropped sevearly during the war years.

Looking at the Indian picture, we find that fertiliser consumption on any Substantial scale began only during the period of World War I. But rapid strides have been made in the development of the industry during the last decade. The war years witnessed a quick expansion in the consumption of fertilisers as also in their production. From a low of 30,000 tons during the thirties largely as a byproduct of the coke industry and the Belagula synthetic nitrogen factory in Mysore, ammonium sulphate production expanded more than ten times and very soon it is expected that production will touch half a million tons. Two new factories were set up, one in Alwaye, Travancore and another in Sindri. The first five year plan envisages a production of 4,60,000 tons of ammonium sulphate and 1,76,000 tons of superphosphate in addition to the 50,000 tons of bone meal produced in the country. Alongside of the increased production and consumption, we witness a marked change in the pattern of consumption of fertilisers. During the earlier years, the consumption was largely limited to the plantations and the hill crops like potatoes. This pattern has now changed and the largest consumer now possibly is the rice farmer. The price situation of agricultural commodities has done more to change the pattern of fertiliser consumption than anything that has happened during the last four thousand years.

The Supply Position: *Nitrogen:* Until World War I, the source of supply of this plant nutrient was partly ammonia, a byproduct from coke ovens, and partly nitrate from the South American nitrate deposits. These supplies were soon found inadequate, but by this time the fixation methods of atmospheric nitrogen had been perfected and between 1918 and 1930, the process was firmly established. Indeed by 1930, three quarters of the world's needs of fertiliser nitrogen were produced from the air. By 1939, Europe, where the fixation industry established itself first, was not only self supporting but was exporting large quantities to the outside world, with Germany as the largest producer. The United States of America was then largely an importer, but rapid strides were made during the forties in that country to make up the deficit. Many nitrogen fixing units were established during World War II mainly for the production of explosives but after the war was over, these were switched over to fertiliser production. The world production in 1950 of fixed nitrogen was to the tune of 2½ million tons.

Phosphorus: The main source of the world's fertiliser phosphorus is the various deposits of rock phosphate which are largely found in North America, United States of America, U. S. S. R., Dutch West Indies and Oceania. Some of these latter deposits were damaged during the war but are being rapidly rehabilitated. Annually about twenty million tons of rock phosphate are mined and utilised in the manufacture of various products, chief being the fertiliser superphosphate. Most of these flour-apatites are made available with sulphuric acid and until the time of World War II, the acid superphosphate process was a means of utilising the surplus sulphuric acid production which existed then in many countries of the world. There was therefore, considerable international competition in the disposal of this surplus acid which led to enormous price cuts in the superphosphate fertiliser scales. But this picture has now changed. What with the shortage of world sulphur supplies and the use of sulphuric acid in other more profitable directions, superphosphate today is selling at three to four times the prewar price.

The posititition in this country in regard to phosphate supply s extremely difficult. Supplies of sulphur have to be largely mported. In regard to rock phosphate also the mineral has to be ntirely imported. In India unfortunately, no supply of phosphate ocks has been within her terrain so far, barring the Tiruchirappalli nodules found in that district. These nodules have not been xploited to any extent and therefore an urgent need exists for exploitation of this phosphate deposit. The application of finely powdered rock phosphate as such, in some of the acid soils is worthy of further experimentation as it is reported that this method is finding favour in the coconut and tea areas of the west coast, and also in Ceylon. It is for consideration, whether the nodules could not be processed into a fine form and made available for such direct application.

Other sources of phosphatic fertilisers in India are bone meal and a little of basic slag. The latter is confined to the very small and insignificant output from the iron industry. Bonemeal on the other hand is an important source and it has been estimated that the annual available supplies would amount to about 60,000 tons. A large portion of the bonemeal is however exported as the unit value of the phosphorus from bonemeal is relatively high compared to that from the mineral superphosphate and therefore the latter is a cheaper source of phosphorus.

Potassium: Potassium is another major plant nutrient essential to plant growth. Under the tropical climatic conditions obtaining in India however, the soils are subject to intense weathering, thus liberating adequate quantities of potassium which forms a substantial portion of the soil mineral matter. The soils in India are therefore generally well supplied with potash reserves, excepting possibly the laterites. Consequently, manurial experiments with nitrogen and phosphorous have not given significant results in crop production except possibly in the case of some special crops like tobacco, chillies, potatoes and groundnut. Potassium shortage may possibly arise only under intensive cropping conditions where the natural speed of weathering may not keep pace with the removal of potassium by the growing crops.

But elsewhere in the world, potassium plays an active part as an essential plant nutrient. Potassic fertiliser consumption trends indicate that its use has considerably expanded in recent times. From a low of 68,000 tons in 1880 the consumption touched a high of 28,80,000 tons by 1940 and to about for million tons by 1950. Upto the period of World War I, potash supplies were a German monopoly but the war experiences forced other countries to develop alternate sources. Today, potash deposits are extensively worked, not only in Germany but the United States, the U. S. S. R., France, Spain and Palestine. Large potash deposits are reported to have been located in Canada recently.

Analysis of consumption trends: Analysis of the figures of consumption of the three important plant nutrients give some interesting information in regard to the emphasis laid on one or the other nutrient in different countries.

Consumption of plant nutrients, 1950:

Continent	in 1000 tons N	P_2O_5	K_2O	Ratio of plant nutrients N	P_2O_5	K_2O
Europe	1,641	2,367	2,380	1	1·44	1·45
North America	996	1,999	1,094	1	2·01	1·10
South America	65	75	21	1	1·15	0·32
Asia	567	320	139	1	0·56	0·25
Africa	117	149	34	1	1·27	0·29
Oceania	11	475	12	1	26·29	0·67
Total	3,405	5,386	3,681	1	1·58	1·08

The above figures of consumption are revealing in regard to the emphasis placed in the use of phosphatic fertilisers the world over excepting in the continent of Asia. In North America, the P_2O_5 application is more than double that of N and K. In Europe also, the extent of P_2O_5 use is greater than N. It is only in Asia that we find that the P_2O_5 application is less than that of N. In our country, we lay equal or sometimes more emphasis on Nitrogen than on P_2O_5. How far this tendency has to be modified the future alone could prove, but if world experience is a guide, the rate of application of P_2O_5 may have to be soon stepped up.

In the earlier sections, the trends of fertiliser consumption in various countries were given. But a proper comparison of fertiliser consumption can be made only by relating the consumption to the respective cultivated acreages. The following data from the Food and Agricultural Organisation relating to some countries of the world are interesting.

Consumption of fertilisers – (1946):

	Lb. per acre of arable land N	P_2O_5	K_2O	Total nutrients
World average	2·9	4·5	2·4	9·8
Holland	56·0	92·0	90·0	238·0
Belgium	40·0	62·0	48·0	150·0

	Lb. per acre of arable land			
	N	P_2O_5	K_2O	Total nutrients
Germany	26·5	26·0	44·0	96·5
United Kingdom	9·0	31·0	13·5	53·5
Denmark	13·5	22·0	11·0	46·5
France	7·0	15·5	11·5	34·0
U. S. A.	2·5	5·0	2·6	10·1
Canada	0·6	1·4	1·0	3·0
U. S. S. R.	0·6	1·7	0·7	3·0
India (author's estimate)	1·0	0 3	0·1	1·4

It is seen that there is a high level of fertiliser consumption in some of the densely populated regions of Europe. Where the pressure of population on land is great, an intensive system of farming with high doses of fertiliser application have come to be evolved. This is possibly a lesson to India. Our agricultural output can be increased only by larger and larger applications of fertilisers.

Advance in fertiliser manufacture: It was mentioned earlier from a technological point of view, fertiliser production did not keep pace with the other segments of the chemical industry. Compared with the other processing industries such as synthetic rubber, rayon and plastics, fertiliser production was till recently woefully behind in the adoption of modern processes. Revolutionising developments are however now taking place in the industry.

Recent advances in fertiliser technology are directed towards (1) improving the availability of the various plant nutrients in relation to the soil conditions and plant growth, (2) in reducing costs of production, (3) in increasing nutrient concentrations to reduce handling costs, and (4) in evolving newer forms for better and efficient application. Some of these developments are considered below.

In the nitrogen field, developments have taken place largely in the use of new fertiliser materials like ammonia gas. ammoniacal liquids, urea and ammonium nitrate. Each has its own advantages and is suitable to certain favoured conditions. Recent interest has turned to the production of nitrogen materials of low water solubility. Outstanding development is the 'Urea-form' type of material which is now being extensively tested agronomically in America. Under controlled conditions, the reaction of urea with formaldehyde gives a product which is quite slow in solubility and therefore would furnish nitrogen for plant growth at rate satisfactorily required during the growth of crop plants. It is well-known that the superiority of groundnut cake over ammonium sulphate is largely due to its slow availability, so that the nitrogen in the cake becomes available as and when the plants require the nitrogen. The 'urea-form' type functions in similar manner.

In the phosphate field, developments in the method of converting the phosphate rock into a form more available to plants than superphosphate by retarding or preventing the fixation of the phosphate in the soil are in progress. This is quite an important approach. It is well known that so far as phosphates are concerned the 'water soluble form' may not always be the easily available form when applied to the soil as the easy solubility may lead to the rapid fixation of the phosphate in the soil which may only be difficultly available later. This has led to a search for techniques by which acidification could be entirely eliminated and this has resulted in the evolutinn of the fusion processes. One such process is the high temperature fusion of the rock phosphate with silica resulting in the production of complex silica-phosphates. This type of phosphate is citrate soluble but not water soluble and field tests with this material in Great Britain have been found to be satisfactory. A factory was working there for a few months during the war in 1945 on this principle but was closed after the war. Work on these lines is in progress in Coimbatore. One handicap of the fusion product however, is reported to be its high alkaline reaction and therefore it is not mixable with ammonium sulphate in the manufacture of fertiliser mixtures. This is supposed to be of disadvantage in the fusion method in countries where fertilisers are largely applied in the form of mixtures. But in India, our farmers do not appear to have any such exclusive preferences in the matter and therefore as a fertiliser. This disadvantage may not be a great impediment in the use of silico-phosphate.

Another line of development in recent times is the improvement in the physical properties of fertiliser materials and also in their nutrient concentration with a view to reducing the bulk. This makes fertilser products more suitable for easy handling, storage and application. Secondly, such processing improvements like 'granulation' offer a chance of reducing the extent of phosphate fixation. This is possibly because, the application in a granular form exposes a lesser surface area per unit weight of fertiliser for soil contact than the conventional powder form and therefore the chances of fixation are reduced. The efficiency of the phosphate application is increased thereby.

Developments in the production technique have arisen recently consequent on the shortage of essential raw materials employed in the manufacture of fertilisers. A classical example is the shortage of sulphur. This has resulted in new techniques in the manufacture of ammonium sulphate by the use of gypsum as is done in Sindri. Another consequential development arising out of this shortage is in the use of nitric acid in the treatment of phosphate rocks. The basic principle is in the acidulation of phosphate rock with nitric acid or nitric-phosphoric acid and the production of 'nitraphosphates' and this method is being widely advocated in the United States.

Advances in Fertiliser Application: Many advances have come about in recent times in the methods of application of fertilisers to increase their efficiency and also to economise in the quantities applied. This is due to the recognition of the fact that best method of fertiliser application is the one that would allow the crop to secure the nutrients in optimum quantities at the time required by the crop plants and at the places where they would be most effective. The placement of fertilisers near the root zone leads to greater utilisation of fertilisers. Further, smaller applications by placement have been found to produce the same results leading thereby to a greater efficiency and economy in the use of the fertiliser. For example, the application of ammonium sulphate by pelleting and placing the pellets in the reduction zone for paddy crop is reported to halve the requirement of the fertiliser to produce similar results within a certain range. The placement of phosphates is now an accepted practice in phosphate fertiliser application. Apart from reducing the chances of fixation, phosphate placement facilitates better uptake of this nutrient as phosphorous is largely immobile in the soil.

Other advances in application methods relate to the form in which various fertilisers are applied. For example, an important advance in nitrogen application has been the use of anhydrous and liquid ammonia in the direct form. This form carries 82 per cent N and therefore is becoming very popular in some countries for Horticultural crops. In the United States, it is reported that 15 per cent of the total nitrogen application in that country is in this direct form and its use is expanding. Considerable economy attends this form of application and therefore has a great future in India. Another recent development is in the use of water solutions of ammonium nitrate. Spraying the leaves of fruit trees, specifically apple and citrus with a urea solution resulted in a much more rapid absorption of nitrogen than the conventional soil application. This method of spray application on the foliage is receiving much attention. Pre-treatment of seeds prior to sowing with phosphate solutions has been reported to result in larger crop yields.

Further knowledge in fertiliser behaviour under various conditions of soils and crops by the use of radioisotopes has been gained in recent times, and this bids fair to revolutionise fertiliser application methods or fertiliser use.

Conclusion: This is a changing world. Technogical changes in all fields both agriculture and industry have been breathtaking. When Malthus predicted that world population would out grow its food supply, the scientific aspects of agriculture were unknown. With our present knowledge of plant nutrient behaviour and use, we can falsify the dire Malthusian predicition. New and better bred varieties together with richer fertilisers now enable some farmers in our country to produce a 10,000 lb. paddy crop and a 100 tons sugarcane crop.

Acknowledgment: My thanks are due to Sri. P. A. Venkateswaran, Agronomist and Professor of Agriculture for his critical reading of the text and its revision.