STRATEGY PAPER 13

Development and Adoption of Novel Fertilizer Materials

NATIONAL ACADEMY OF AGRICULTURAL SCIENCES, NEW DELHI

February 2019

Development and Adoption of Novel Fertilizer Materials

NATIONAL ACADEMY OF AGRICULTURAL SCIENCES, NEW DELHI

February 2019

CONVENER : Dr Chandrika Varadachari

EDITORS : Dr V.K. Bhatia
Dr Kusumakar Sharma

CITATION : NAAS 2019. Development and Adoption of Novel Fertilizer Materials. Strategy Paper No. 13, National Academy of Agricultural Sciences, New Delhi: 16 p.

Published by Dr Anil K. Bawa, Executive Director on behalf of
NATIONAL ACADEMY OF AGRICULTURAL SCIENCES
NASC, Dev Prakash Shastry Marg, New Delhi - 110 012
Tel: (011) 25846051-52; Fax: (011) 25846054
Email: naas@vsnl.com; Web site: http://www.naasindia.org

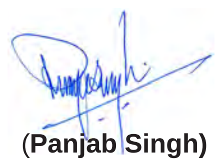
Preface

India is the second largest consumer and importer of fertilizers and their raw materials in the world. Although India is striving towards self-sufficiency in urea by 2021, imports of phosphates and potash raw materials will continue. One way of reducing import dependence would be to improve the efficiency of fertilizers and check the losses by leaching, volatilization and soil fixation and thereby increase utilization efficiency which is now around 30-50%. It is imperative to ensure availability of improved materials to farmers so that better yields are achieved using smaller amounts of fertilizers. Although the country has taken huge strides in other areas of agriculture, the fertilizer materials have basically remained unchanged for several decades. In this scenario, new products with higher efficiency, lower losses and better performance are required to tide over the issues that farmers are now facing. The other major problem associated with fertilizer usage is the farmers' reluctance to apply balanced fertilizers which has skewed fertilizer usage with the current NPK use ratio being 6.2:2.5:1 which is far removed from the ideal ratio of 4: 2: 1.

The roots of the problems associated with the use of fertilizer materials are many fold and changes are required to be brought about at many levels. Broadly, we need to look for new generations of fertilizers that will overcome the drawbacks of the existing products including reduced leaching losses, lower volatilization losses and minimized fixation so that farmers will not be losing a sizeable investment in fertilizers and less can produce more. With this objective, it will be prudent to look at how India can access such advanced fertilizer materials and which factors are the bottlenecks to prevent improved fertilizers being made available to farmers. The ultimate vision would be to develop fertilizers suited to India's unique soil-crop-environmental conditions and make India into a fertilizer technology export base to service the rest of the world.

This strategy paper looks broadly into six major areas of improvement as they exist today – the regulatory process (FCO), fertilizer quality control measures, role of State Governments, IPR matters, fertilizer subsidy as well as education and research. The issues faced by administrators, industry, researchers and farmers have all been considered based on the inputs provided from different stakeholders in this field including scientists, researchers and professionals in the field of fertilizers from ICAR research institutes, DST, State Governments, quality control laboratories, fertilizer industry and patent departments.

This strategy paper is based on the presentations and discussions in a strategy workshop on "Development and Adoption of Novel Fertilizer Materials" organized by NAAS on October 5, 2018. Nearly 13 eminent scientists and experts participated. The Academy thanks all of them. I especially compliment Dr Chandrika Varadachari, Convener for her initiative to organize this consultation. The editorial support extended by Dr V.K. Bhatia and Dr Kusumakar Sharma is thankfully acknowledged.



(Panjab Singh)
President

Development and Adoption of Novel Fertilizer Materials

1. BACKGROUND

There is increasing global thrust on new fertilizer materials with the key drivers of innovation being the need to improve fertilizer efficiencies, conserve mineral resources, reduce water and air pollution, improve economics of utilization, improve adaptability to local conditions and health benefits. Apart from these, India has its own set of agro-climatic and socio-economic problems including low levels of soil organic matter, poor micronutrient status, high temperatures, water logged conditions, soil acidification and alkalization, low economic status of farmers, etc. Improvement in fertilizer materials is, therefore, a basic requirement. The fundamental issues are discussed here in greater detail.

1.1 Shortcomings of fertilizers in use today

a. NPK Fertilizers

Agriculture contributes 18% to GDP and provides employment to 50% of the workforce. In turn, agriculture is shaped by fertilizers which provide the essential backbone for agriculture, to sustain yields and ensure food security. Fertilizers currently in use include urea, DAP, potash salts, micronutrients, etc. Fertilizer consumption for the year 2016-17 was nearly 54 Mt of which the largest was urea at 30 Mt and DAP at 9 Mt. Of this, a significant fraction (about 30%) is imported. Even for fertilizers that are indigenously produced, most of the raw materials are required to be imported, e.g., natural gas, ammonia, phosphoric acid, etc.

Losses due to leaching, volatilization and fixation : Fertilizer use efficiency (FUE) is rather low for all NPK fertilizers. Nitrogen fertilizers suffer losses due to volatilization as ammonia, transformation to nitrate which is lost by leaching, and denitrification to gaseous nitrogen oxides (NOx). Volatilization to ammonia occurs when urea is hydrolyzed by the enzyme urease (secreted by some microorganisms) and converted to the ammonium form; ammonium is readily volatilized as ammonia. Microorganisms also oxidize ammonia to nitrates, which are easily leached out and thereby lost from the soil. Denitrification (conversion to gaseous ammonia) is yet another factor that contributes to volatilization loss of nitrogen fertilizers. As a consequence of these processes, only 30-50% of added urea is actually used by the crop, translating to 50-70% wastage. (Fig. 1)

Phosphate fertilizers undergo surface runoff and fixation reactions. Phosphate runoff into water bodies is the prime cause for water body pollution by eutrophication, e.g. algal blooms in oceans. Fixation of phosphate by various soil components further reduces P availability.

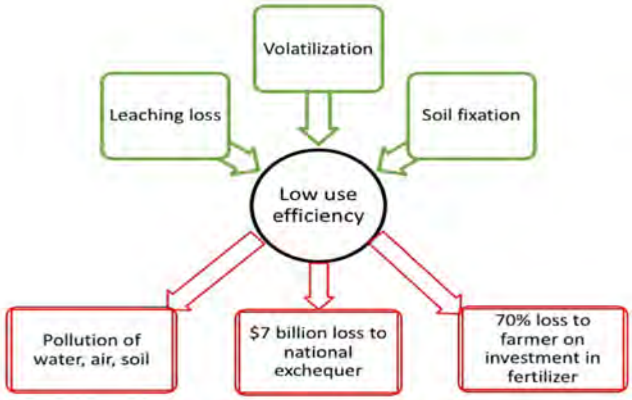


Fig. 1 : Fertilizer losses and its consequences

The fertilizer use efficiency of phosphates is, therefore, very poor (~15-30%). Potassic fertilizers are considerably more efficient with FUE of around 70-80%.

Economic impact of low use efficiency : Such low use-efficiencies amount to huge wastage of resources and a drain on foreign exchange. For urea alone, 50% loss amounts to $4.2 billion per annum whereas for DAP this loss amounts to about $2.7 billion. This amounts to a total annual loss of at least $7 billion.

Apart from an enormous loss of national resources, this low efficiency is also a loss to the farmer; in reality about 70% of his investment in fertilizers is literally going down the drain. Low efficiency is also a reason for farmer's disinclination to use balanced fertilizers and avoidance of micronutrient fertilizers. Productivity is thereby much lower than the optimal that can be achieved.

Environmental impact of such losses : Nitrate (NO_3) concentration of more than 45 mg L^{-1} in drinking water can lead to human and animal health problems. Nitrate pollution of waters has exceeded these levels and has become a matter of serious concern in most states of India, including 23 metropolitan cities. Emissions of NOx into the atmosphere leads to increased levels of greenhouse gases causing global warming. Phosphate leaching into waters results in algal growth in waterbodies. Such eutrophication causes death of fish and makes the water unfit for consumption.

Formulation and incompatibility issues : Existing fertilizers also present incompatibility issues in formulations of fertilizer blends and mixtures. Urea and superphosphates cannot be mixed because the urea will become soggy in contact with superphosphate. Therefore, in formulating NP mixtures, only DAP is used; SSP or TSP which contain calcium can never be used to make such complex fertilizers. Thus, soils get depleted in calcium and many soils are getting acidic. Micronutrient fertilizers cannot be mixed with phosphates because of precipitation of insoluble micronutrient phosphates. Thus, formulation of complete fertilizers is quite challenging.

Handling, storage and application issues : Several popular fertilizer blends are hygroscopic and cause problems in storage. Fertilizers stored in warehouses for many months under high humidity conditions and under high bag weight tend to form hard lumps which become powdery when broken. Fertilizer granules also need to be tailored to equipment for large scale application particularly with respect to their size and shapes and for avoidance of fine particles that choke nozzles. Liquid fertilizers also require specialized materials that will not produce insoluble materials that clog equipment.

b. Micronutrient Fertilizers

Actual requirement versus dosages– the huge gap : There is a huge difference between the amount of micronutrients that are actually consumed by crops and the amount that is required to be added. Whereas zinc uptake is around 100-250 g/ha, the amount of zinc fertilizer added is 5 kg/ha Zn. Thus, use efficiency of zinc sulphate fertilizer is only 2-5% and addition of zinc is more than 20 times its actual requirement. The dosage-uptake gap is similar, if not more for other micronutrients. Whereas the uptake of iron is around 0.2-2 kg/ha, the dosage requirements range from 10-30 kg/ha Fe. Micronutrient removal by different crops was estimated to be 188.3 thousand tonnes in 2013-14. A major part of this uptake was Fe (59%) followed by that of Mn (20%), Zn (13%), Cu (3.5%), B (5%) and Mo (0.5%). Therefore, all soils are gradually getting depleted in different micronutrients and require one or more micronutrient fertilizers. The poor efficiency of micronutrient fertilizers is a deterrent for their large scale use by farmers and is responsible for limiting yields.

Demand-supply and shortfall : Micronutrient deficiencies are widespread in Indian soils. Of the net sown area of 141.4 million hectares, about 49% is estimated to be deficient in Zn. Thus, around 70 miilion hectares would require zinc fertilization; this translates to 1,750,000 tonnes of zinc sulphate (around 350,000 tonnes of zinc) requirement. Present production figures are around 150,000 tonnes of zinc sulphate, or less than one-tenth of the actual requirement. Boron deficiencies are also widespread, with one-third of the cultivated area being deficient in boron; this would require 470,000 tonnes of borax. Therefore, there is a huge scope for micronutrient fertilizers. However, it must be kept in mind that micronutrients are expensive materials and to cover all deficient lands would require a sharp focus on improving efficiency and reducing wastage.

Environmental problems in production : Zinc sulphate is produced from zinc ash which is a byproduct of the galvanizing industry. Therefore, zinc ash invariably contains lead as contaminant. Production of zinc sulphate generates sizeable quantities of lead sulphate which is classified as a hazardous waste. Handling and disposal of lead sulphate requires strict compliance with environmental norms including special disposal pits, transportation, workers safety, etc. However, most manufacturing units are in the MSME sector and strict compliance adds sizably to the cost of relatively low price of zinc sulphate. Therefore, compliance to such norms by manufacturers is often questionable.

1.2 The global scenario in new fertilizers

a. Nitrogen Fertilizers

Several slow-release and controlled release N fertilizers are available globally, particularly in US, China, Japan, etc. The most popular are the condensation polymers – urea formaldehydes, urea isobutyraldehydes, urea crotonaldehydes. These are water insoluble and act by slow hydrolysis of N from the polymer chain. The other group are the coated fertilizers such as sulphur coated, polymer coated and latex coated urea products. Here the release is by slow diffusion through the coatings. Gel based materials are based on absorption of urea within acrylic gels; urea supergranules and compacted materials reduce water solubility by increasing size and compaction. Stabilized nitrogen products include urease inhibitors (e.g., NBTPT) that reduce the conversion of urea to ammonia and nitrification inhibitors that prevent the oxidation of ammonia to nitrates (e.g., N-serve, DCD).

b. Phosphate Fertilizers

New phosphatic fertilizers are limited. Technologies include liquids like polyphosphoric acid for fertigation uses, high purity MAP for liquid applications, granular superphosphates, efficiency enhancer products (e.g., Avail, Carbond P). The last type enhance efficiency by reducing fixation of phosphate. However, all products are water soluble.

c. Potash fertilizers

New technologies for potash fertilizers are also limited. Muriate of potash (MOP) is available as granules. Potash is also available as potassium sulphate and Langbeinite (potassium magnesium sulfate). All are water soluble.

d. Micronutrient fertilizers

Various formulations of the oxides (such as zinc oxide suspensions) are used to a limited extent. Partially sulphated products, including zinc oxysulphate, manganese oxysulphate are also marketed. Oxides with sucrate treatments are sold for iron and manganese; this includes sucrate compounds with magnetite, manganous oxide, etc.; however, these have minor markets. Chelated forms of micronutrients with EDDHA or HEDTA are also available.

1.3 Indigenously developed new fertilizer materials

a. Nitrogen Fertilizers

Neem coated urea is an indigenous technology that has already been adopted in the country. The oil obtained from *Azadirachta indica* (neem tree), has nitrification inhibition properties as well as insect repellent and bacteriostatic properties. The oil is used for the production of neem coated urea or NCU. Technology for indigenous production of ammonium polyphosphate was also attempted.

b. Phosphate Fertilizers

Smart phosphate fertilizers have been developed that are insoluble but release phosphate on-demand by the plant. Smart phosphates have no run-off problems and will not react with other soil inorganic components; consequently, dosages are reduced by 50%. Smart phosphate provides a highly efficient phosphate source that provides higher yields at much reduced dosages. Smart phosphates can result in significant import savings on phosphatic fertilizers. Nano phosphate fertilizers have also been developed using microbial spores as a base.

c. Potash fertilizers

India has no viable reserves of soluble potash salts. Therefore, attempts have been made to utilize alternative sources. Technologies for recovery of potassium sulphate and potassium phosphates from mica (which has ~10% K_2O) have been successfully developed on a pilot scale. Processes have also been developed to recover potash from sea water salt bitterns and from glauconite. The major issues here are the very low concentrations of K_2O in both salt bitterns and glauconite.

e. Micronutrient fertilizers

Smart micronutrient fertilizers have been developed. These are based on crystalline water insoluble polyphosphates. One product, zinc polyphosphate is already included in FCO. Similar products are available for boron, iron, manganese, etc. Nano fertilizers of zinc and silica have also been developed but there are global concerns with nano materials in the environment that need to be addressed.

2. ADAPTATION OF NEW TECHNOLOGIES – SMOOTHENING THE WAY FORWARD

2.1 Procedural matters in introducing new fertilizers

The Fertilizer Control Order (1985) is an Order under the Essential Commodities Act, 1955 (10 of 1955). The FCO regulates every aspect of trade, price, quality and distribution of fertilizers in the country. Any new product is required to be registered with the FCO. The procedure for registration of a new fertilizer is illustrated in Fig. 2.

The first step is an application containing details of the product including field trial data, composition, analysis methods and specification with impurities and tolerance limits. This

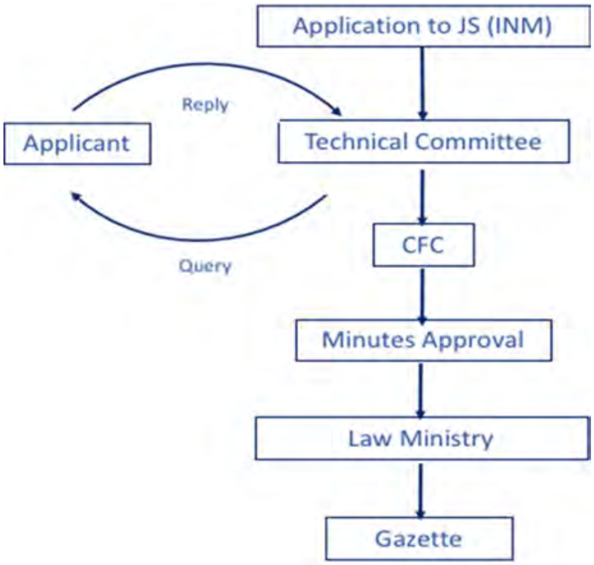


Fig. 2 : The process for registration of a new fertilizer under FCO (courtesy Dr A Rastogi, Coromandel International)

is submitted to the Joint Secretary (INM) and then placed before a Technical Committee. The TC could revert with queries to the applicant. This process may be repeated several times. The TC then places the application to the Central Fertilizer Committee (CFC). After approval the application is forwarded to the Law Ministry and ultimately notified in the Gazette of India. Products requiring registration under FCO include complex, customized, fortified and water soluble fertilizers, micronutrients and organic fertilizers. Liquids, fertilizer mixtures, growth promoters, biostimulants, etc. are outside the scope of FCO.

a. FCO

i. Drawbacks of the FCO process

The existing system is archaic and has limitations in several areas.

- There are no clear-cut protocols for testing of fertilizers that are to be considered for approval under FCO. In general, a minimum of two season multi-location trials are required preferably at Agricultural University/ICAR/KVKs to seek approval for registration of new fertilizers in FCO for its sale. The requirements are, however, not clearly specified. It is also preferred that the testing be conducted by IISS, Bhopal. This is practically impossible in view of the very large number of samples that would be required to be tested every year. Briefly, therefore, there is not enough clarity on the number of trials, the agencies for testing, number of test locations, seasons, crops, test protocols, etc.

- The Central Fertilizer Committee under Ministry of Agriculture is empowered to approve or reject any proposal. Rejection could also be due to a lack of understanding of a novel technology. There is little transparency in the process. There is also no provision for appeal against the decision of the committee. The main issue is that there are no clear-cut criteria for acceptance or rejection of a sample.
- The future of new technologies is controlled just by a committee. This is an outdated mechanism and has no parallels in any sector in India.
- Specifications and testing standards are much too rigid in many instances.
- Quality control labs are highly inadequate to deal with the huge number of samples. Neither are they equipped to deal with new products that would require advanced testing methodologies.
- Many of the provisions of FCO are a continuation of the ECA 1955 license raj. This has been an approach adopted since 1985 when FCO guidelines were implemented. This approach which was adopted for the purpose of keeping a tab on subsidized products, has outlived its relevance and has proved to be a formidable red-tape barrier to introduction of new fertilizers. The FCO was never meant to be a regulatory authority for new products and is definitely not tailored for such functions. There is clearly a need for drastic reform in the regulatory processes.

ii. Proposals for simplification of new product registration

- The Order should be replaced by an Act – a Fertilizer Act. This Act would be similar to that for seeds (Seeds Act) or insecticides (Insecticides Act). All items related to food and health such as food, drugs, insecticides, etc., are covered by Acts and there is no reason for excluding fertilizers from the purview of an Act and to continue keeping it within the narrow confines of an Order. The Act would specifically provide for rules and regulations concerning fertilizer materials, their quality and registration of new products.
- There would be defined formats for registration of new products and minimum requirements that must be met. Thus, the conditions for approval of a new product would be clear-cut.
- There would be scope for appeal of rejected applications.
- Time frame for registration approval would be provided.
- Field trial requirements would be specified - including number of trials, seasons, locations and acceptable results.
- Agencies conducting such trials could include all recognized scientific institutions, government organisations and research units of public limited companies. Results from public limited companies conducting their own trials should be acceptable. The rationale being, that such companies are investing sizeable resources in manufacturing and marketing a new product and would not do so if the efficacy data of the new product was not satisfactory and farmer acceptable.

- Required information on product composition, its method of application, analysis methods to determine quality, etc., would be submitted to Ministry of Agriculture in advance. Provisional registration could be provided on this basis. This would allow marketing of the fertilizer in a small scale to provide the necessary feedback on whether the product is worthwhile for the company. It would also provide useful information for registration purposes.
- Quality control should be on the basis of label claim on product packs declared by marketers. The quality control process would be similar to that for drugs. Thus, a few high-tech Fertilizer Control Laboratories (similar to Drug Control Laboratories) would monitor fertilizers sold in the market.

Such an approach will encourage investment in R & D by corporations and entrepreneurs to develop innovative and efficient fertilizers. Farmers would thus benefit by way of simple and cost-effective solutions. Market forces, farmers' right to choose new products and companies risking large investments in new technologies must also be taken into consideration. Farmers will reject fertilizers that do not perform, and companies would not risk financial losses in backing technologies in which they are not fully confident. A comprehensive but simple mechanism that will address the needs and concerns of farmers and deliver improved products can be worked out.

b. Quality control analysis

i. Bottlenecks in analytical requirements

- Insufficiency in laboratory capacity - The major constraint even in the present system, is an insufficient number of laboratories to handle the huge volume of samples. Reports are to be completed within 15 days of receipt of a sample. At present, there are 82 Quality Control Laboratories with an annual capacity of only 1.2 lakh samples. For analysis to cover all fertilizers and all dealers at each kharif and rabi season, would mean about 17 lakh samples (2.83 lakh dealers x 3 fertilizers x 2 seasons) to be analyzed annually. When micronutrients are included, total samples per annum will exceed 20 lakhs.
- Deficiency of sophisticated instruments - Laboratory facilities with sophisticated instruments are scanty. Even for existing materials, such as analysis of boron and molybdenum, lack of ICP makes it very difficult to analyze fertilizers having low levels of these nutrients. Gravimetric and titrimetric methods presently being followed, have to be completely replaced. With the introduction of new materials requiring more sophisticated analytical techniques, the situation becomes even more difficult.
- Shortage of trained manpower – Analysis requires specialized skills. Trained manpower is highly insufficient. Additionally, trained personnel are frequently shifted to other departments thereby compounding the shortage of analysts.

- Implementation of sophisticated analysis equipment across all states, which would be ready to handle huge volumes of new samples, appears to be nearly impossible in the current situation.

ii. Dealing with analysis of new materials

- As mentioned earlier, the first step should be to control quality on basis of label claim on product packs declared by manufacturers/marketers. This procedure is similar to that for drugs. As with drugs, Government laboratories will then analyze randomly picked samples to check with the label claims of the manufacturer. Thus, the onus will be on the manufacturer to analyze each production batch and have it conform to the standards.
- This would require a few sophisticated laboratories to be established in the country (similar to the Drug Control Laboratory). These Central Laboratories would be equipped with highly sophisticated instruments like ICP, HPLC, FTIR, XRD and also designed for automated analysis to reduce errors and to speed up timeline. These facilities would have to be continuously upgraded to cope with materials requiring specific quality control procedures. Manpower training will also have to be continuously updated.
- Personnel would be recruited and trained specifically for the tasks of monitoring fertilizer quality. Such personnel would not be general recruits and would remain attached to the Central Laboratories.

c. State government approval

i. Current requirements

Every fertilizer mixture requires approval from the State Government where it is to be marketed. This approval is granted only for 6 months and is extended to a maximum of 12 months under certain conditions. Such limited period approval is a huge deterrent for manufacturer to set up a production unit and market a new product. The approval process itself is time consuming

ii. Streamlining the process

The process of granting approval by each State Government, for registration of new fertilizers should be discontinued. Any new fertilizer which has been already approved by FCO should be allowed to be marketed in the states without further registrations.

Only products that are effective will sell and fertilizers that are not effective or not economical will be rejected by farmers. This has been the case even with FCO approved fertilizers where many are no longer in the market. Such an approach based on product performance and economics will also enhance general awareness and education of farmers and solve most of the anomalies of extension education program.

2.2 Fertilizer subsidies

a. Are subsidies standing in the way of new fertilizers?

Subsidy policy is a huge hurdle in way of new, innovative and efficient fertilizers. Subsidy is allowed only on select fertilizers. All fertilizers containing NPKS are not entitled for subsidy. Therefore, even if a new fertilizer is far more efficient, it cannot compete in the market against a subsidized fertilizer. Such a policy kills innovation completely. One prime example is sulphur coated urea which could not compete in the market with subsidized urea although it was more efficient. Another example is with customized fertilizers that were introduced with great efforts, but the subsidy policy stands in the way of such a promising and scientific product to reach to farmers.

Therefore, we are left with the situation that Indian farmers use the same fertilizers today which they had used 40 years ago. Innovative and efficient fertilizers have not found entry in India due to the subsidy policy. India is probably the most backward in terms of new, innovative fertilizers in the market. This has also led to formation of lobby of manufacturers of subsidized fertilizers both at the domestic and international levels. Also, whereas major investments by fertilizer companies have been made in the manufacturing sector, investment in R&D is very minimal.

b. Rationalization of subsidies to encourage improved fertilizers

- Fertilizer subsidy should be in the form of direct benefit transfer (DBT).
- Subsidy should be completely nutrient based. If any nutrient (such as nitrogen) is subsidized, then all fertilizers for that nutrient (all nitrogen fertilizers) should be subsidized. Innovative products will also come within the scope of such subsidies and thereby it will be a level playing field; the farmer will buy a product that is most efficient and economical for him.
- There should be appropriate subsidy on NPK mixtures, multinutrient complex fertilizers and customized fertilizers. This will encourage farmers to use balanced fertilizers rather than imbalanced fertilization with excess urea, such as being practiced today.
- Individual State Governments should be allowed to determine the nutrients to be subsidized, depending upon its relevance to the soil and crops grown there. The concept of national subsidy on select fertilizers should be discontinued as it is biased to certain States with low fertilizer loving crops. Freedom should be provided to States to decide the nutrients critical for crop production and subsidy should be announced accordingly. For example, the NE states would benefit greatly by subsidy on calcium fertilizers (lime), since their soils suffer from high acidity problems. This subsidy would not be required in the Northern states. States that are poor in potassium would subsidize K nutrients while those deficient in phosphorus would subsidize P.

- Extent of subsidy should be graded depending on the land holding of the farmer. At present, it is difficult for small and marginal farmers to invest in fertilizers and thereby his returns are reduced. Small and marginal farmers should receive fertilizers at heavily subsidized rates to encourage them to use fertilizers and in a balanced way. This would be similar to the PDS scheme. Farmers in the higher income (larger land holding) bracket should receive reduced or even no subsidy. In this way, subsidy will help to improve productivity of small farms and the agricultural output of the nation on the whole.

This approach will minimize the discrimination done to farmers by way of national subsidy of select fertilizers which goes in favour of resource rich states and its relatively rich farmers. Agriculture growth and sustenance should be left to State Governments on a market driven approach. Geographic advantages should benefit the farmers and not otherwise. Such an approach will encourage investment in R&D to develop and design customized fertilizers specific to region and crop grown. Such a DBT subsidy regime will encourage use of innovative and efficient fertilizers.

2.3 Patents & IPR issues

a. Existing status of fertilizer patents in India

The number of patent applications (110) and granted patents (176) including those submitted by foreign companies for fertilizers invented abroad in the field of fertilizers in India in the last 20 years are woefully small. Out of these, patents on fertilizer compositions or granules are very few in number compared to other fields of emerging technologies. Almost no fertilizer in India is a patented product (with the only exception of zinc polyphosphate). There is a lot of misunderstanding with fertilizer companies that grant of FCO gives a free right to production and sale regardless of patent status. This is a worrisome situation for innovators. In reality, however, FCO approval is only a right to sale; patent rights and IPR are completely separate matters and have to be addressed as per the Patents Act. The FCO or an alternative Act if made, should also clarify that inclusion of a new fertilizer in any schedule, cannot remove the requirement for obtaining a license from the patent holder. At present, FCO has no scope to clarify patent protected fertilizers. Most emerging fertilizer technologies have product patents and the owners of these patents are hesitant because of lack of clarity on such materials by FCO. Patents on nutrients that can be combined with organic materials or coated on seeds face major hurdles by getting entangled with the Biodiversity Act.

b. Steps for ensuring patent protection & ownership

All Government agencies that are involved in granting licenses for manufacture or sale (including MOEF) must give due cognizance to the secrecy of know-how and process details involved in manufacture of patented fertilizers. The FCO or an alternative Act if made, should also clarify that inclusion of a new fertilizer in any schedule does not remove the requirement for obtaining a license from the patent holder. Any organization conducting any testing of new materials like field trials should not demand a share of patent right ownership.

2.4 R&D in Indigenous fertilizer materials

a. Status of fertilizer R&D

There is no research institute, or other organisation in India devoted to fertilizer technologies and new fertilizer development. Fertilizer research in India focuses almost exclusively on fertilizer trials. Neither are there research centres in Universities, IITs or other academic institutions that are involved in fertilizer development. Not even a handful of scientists are involved in fertilizer technology development. The status of fertilizer R&D in the country is, therefore, very inadequate. This is in contrast to the situation in the fifties and sixties when PDIL (then P&D under FCI) functioned with the entirety of fertilizer technology from product development to fertilizer catalysts and engineering R&D.

b. Development of indigenous fertilizer materials R&D

India needs to innovate new fertilizer materials and develop into a fertilizer research hub. India has its unique requirements in terms of its soils, crops, agro-climatic, socio-economic, technological and other issues and we need to develop technologies tailored to suit our own requirements. India is also deficient in most raw materials required to produce fertilizers. We do not have sufficiency in natural gas to produce urea or high quality rock phosphate to produce phosphate fertilizers. We also import our entire requirement of potash fertilizers. This situation is quite different from other nations which have one or more of these resources. Therefore, we need to develop materials for more efficient fertilization with significantly reduced losses of nutrients.

To develop this research base, the following steps are required to be taken :

- Establish Fertilizer Materials Development R&D Centres at Universities and Research Institutes. These Centres will focus on developing new fertilizer materials. It will not focus on field trials for fertilizer dose optimization, which is within the activities of SAU, ICAR institutes and both Central and State Governments.
- Introduce curricula at degree level and through special courses to teach various aspects of fertilizer chemistry and technology.
- Introduce Master's degree courses in Fertilizer Chemistry (similar to Biochemistry) as a chemistry specialization.
- Introduce one year course to Chemical Engineering graduates specific to the requirements of the fertilizer manufacturing companies.

c. Development of fertilizer engineering R&D

Import of new fertilizer technologies will require engineering R&D support for adaptation of new technologies. Without *in situ* engineering R&D support, all new technologies will have to go in for turnkey plants and total dependence on outsourcing for equipment, installation and maintenance. Indigenously developed products will also require engineering R&D support to scale up to a commercial level. Without such engineering support, no indigenous technology can reach the commercial stage. To develop a good engineering support base for fertilizer manufacturing industries, manpower training must start from the college level. Currently, graduates from Chemical Engineering or even other disciplines of engineering have to be trained for fertilizer industries. The steps to be taken include:

- Engineering institutions should introduce courses on fertilizer engineering so that India can produce trained manpower.
- Allied subject, but very important, is also to revive R&D in fertilizer catalysts. The earlier leadership of PDIL in this field can be revamped so that we can develop and produce our own catalysts and do not depend on foreign suppliers for our requirement of this critical component.

The costs of fertilizer plants in India would reduce significantly if indigenous technology is used. Plant and machinery maintenance costs would also be much lower.

d. Exporting fertilizer R&D

India must strive to develop into a fertilizer technology export base. This is a neglected field all over the world and India could take the lead in designing of new products as well as in engineering and design of fertilizer plants. This would also include fertilizer catalyst research, of which India had a remarkable success in the past. Being at the forefront of fertilizer R&D has multiple benefits. New fertilizers developed in India could be licensed to companies across the world and this could be a good revenue earner. India could take a lead in setting up of turnkey fertilizer plants in the developing countries; this would be at a substantially lower cost than being offered by the companies in US and Europe and would be highly competitive.

3. RECOMMENDATIONS

The outline of our recommendations has been shown schematically in Fig. 3. There are six broad areas that are required to be addressed. The first area is to replace the Fertilizer Control Order (FCO), 1985 with a Fertilizer Act as applicable to food, drug or insecticides. Without compromising protection to the interest of farmers and their environment, the Act would provide a robust transparent avenue for registration of new fertilizer materials with clearly defined registration format, minimum requirements for approval, protocol for field trial testing coupled with listing of registered organizations to perform such testing, time frame for the approval process, etc. Provisional registrations can be allowed on the basis

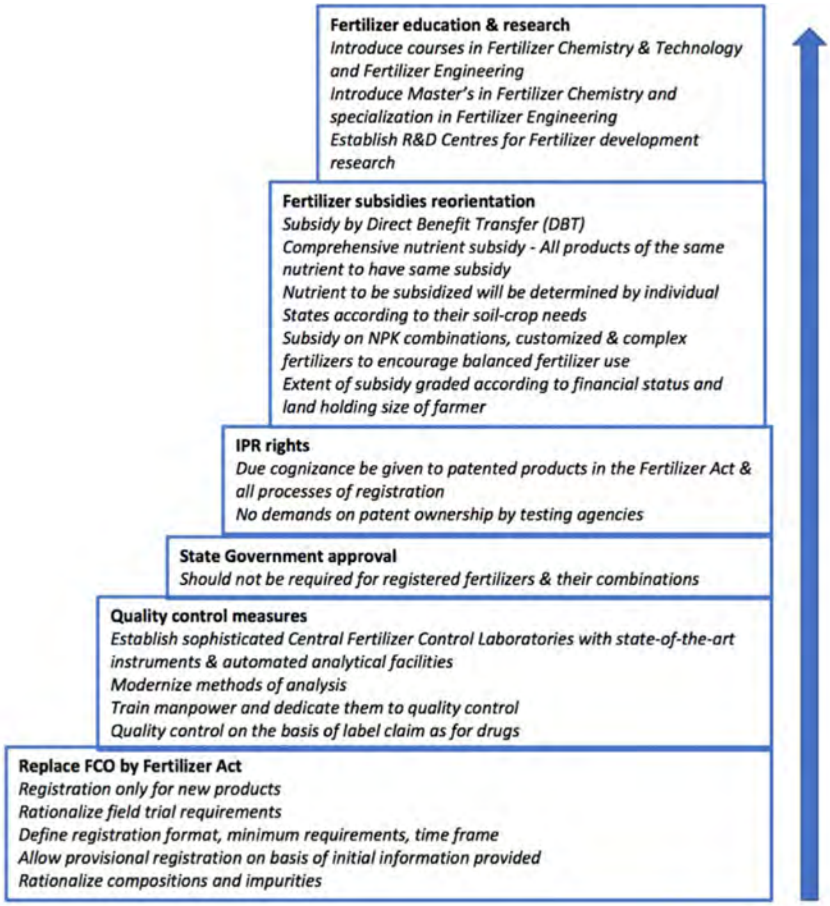


Fig. 3 : Steps to achieving a transformation in the fertilizer scenario towards adoption of fertilizer novel materials.

of some essential information to allow large scale trials and marketing trials. Registration would be required only for new products.

The second area to address is the quality control of fertilizers. The new system will follow the procedure used for quality control of drugs. Sophisticated laboratories with state-of-the-art equipment and automated analytical techniques should be established with dedicated and trained manpower. Quality control would be on the basis of label claim with random sampling of fertilizers in the market and matching with claimed compositions. Thirdly, State Government approval should not be required for fertilizers already registered. All new products are being registered under the Fertilizer Act and therefore, further registrations can be done away with. IPR for patented fertilizers must be recognized and no demands can be made for IP rights by testing agencies.

Next and more importantly, fertilizer subsidies need to be reoriented to allow level playing for all products of the same nutrient. Subsidy through Direct Benefit Transfer (DBT) to farmers is the way forward. Subsidy should be completely nutrient based and not product based – all products with same nutrient should have the benefit of the same subsidy. State Governments should be allowed to determine the particular nutrients to be subsidized according to their crop-soil needs. Further subsidy on fertilizer combinations, fortified and customized fertilizers should be given so that balanced fertilizer use is encouraged. Further, the extent of subsidy should be adjusted according to the financial and landholding status of the farmer. Finally, education and research on fertilizer needs to be given emphasis with courses and degree specializations in Fertilizer Chemistry, Technology and Engineering.

4. MAJOR ACTIONABLE POINTS

- Government of India may consider replacing Fertilizer Control Order (FCO), 1985 by a suitable Act.
- Subsidy on fertilizers should be nutrient based only, not product based and subsidy should be by transfer through DBT.
- Ministry of Chemicals & Fertilizers, Government of India may establish Central Fertilizer Quality Control laboratories with state-of-the-art analytical facilities.
- Degree courses in Fertilizer Chemistry and Technology; Fertilizer Engineering may be introduced as an optional specialization in Chemical Engineering degree courses.
- Department of Science & Technology, Government of India may set up state of art Fertilizer R&D Centres in the country at the zonal level.

REFERENCES

Annual Report (2017-2018). Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India

IFDC/FAI Report (2017). Fertilizer Subsidies – Which way forward? FAI & IFDC https://ifdcorg.files.wordpress.com/2017/02/fertilizer-subsidie swhich-way-forward-2-21-2017.pdf

Indian Fertilizer Scenario (2017). Economics & Statistics Wing, Department of Fertilizers, Ministry of Chemicals & Fertilizers, Government of India

The Drugs & Cosmetics Act & Rules (2005). Ministry of Health & Family Welfare, Government of India

FISME (2011). Fertilizer Quality Control in India: The need for a systemic change. Federation of Indian Micro and Small & Medium Enterprises

Varadachari, C. and Goertz, HM (2010). Slow-release and Controlled-releaseNitrogen Fertilizers. Ed YP AbrolING Bulletins on Regional Assessment of Reactive Nitrogen. Bulletin 11

The Fertiliser (Control) Order (1985). Ministry of Agriculture and Rural Development, Department of Agriculture and Cooperation

LIST OF PARTICIPANTS

1. Dr Chandrika Varadachari, *Convener & Director, RCAIS, Alipore, Kolkata*
2. Dr I.P. Abrol, *Director, Centre for Advancement of Sustainable Agriculture, New Delhi*
3. Dr Anil K. Singh, *Ex VC, RVSKVV, New Delhi*
4. Dr V.K. Bhatia, *Editor, NAAS & Former Director, IASRI, Delhi*
5. Dr Kusumakar Sharma, *Editor, NAAS & Former ADG, ICAR, Greater Noida*
6. Dr A.K. Biswas, *Head, ICAR-IISS, Bhopal*
7. Dr Gurudas Chakrabarti, *Ex-Director, Fertilizer Quality Control Laboratory, Ghaziabad*
8. Dr P. Dey, *Project Coordinator (STCR), ICAR-IISS, Bhopal*
9. Dr Kunal Ghosh, *Professor (Retd), University of Calcutta, Alipore, Kolkata*
10. Dr Gautam Goswami, *Director, TIFAC, New Delhi*
11. Dr Raj K. Gupta, *B4/205 First Floor, Safdarjung Enclave, New Delhi*
12. Dr S.K. Mitra, *Ex-Joint Controller of Patents, GoI, Kolkata*
13. Dr A.K. Patra, *Director, ICAR-IISS, Nabibagh, Bhopal*
14. Dr Amit Rastogi, *Senior Vice President (Technology), Coromandel Fertilizers, Secunderabad*
15. Shri. B.B. Singh, *Vice-President, SCM & Corporate Affairs, IRC Agrochemicals Pvt Ltd, Kolkata*
16. Dr Pradip Sen, *Ex-Addl Director of Research, Department of Agriculture WB, Kolkata*

Note: *The designations and affiliations of the participants are as on the date of Strategy Workshop.*