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Enhancing Fertilizer Use Efficiency for Sustainable Soil Health

POLICY BRIEF

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Preamble

Fertilizers have a crucial role in sustainability of global agriculture as they provide the necessary nutrients to crops for optimum growth and yield. The ultimate food security for this ever-increasing global population necessitates a rising demand of fertilizers. India became the world's most populous country in 2023, with increase in population by 4.33 times (from 330 m to 1,432 m) since independence (1947), though simultaneously there is rise in food grain production (6.61 times–from 50 mt to 330.5 mt) and fertilizer use (464 times – from 0.07 to almost 32.51 mt). The technology-based high yielding varieties (HYVs) and fertilizer use, and investment-led irrigation infrastructure played an important role in transforming Indian agriculture from net importer to self-sufficiency. The country became the second largest consumer and importer of fertilizers with more than 6 per cent average annual increase from 1970s and currently accounts for 16.1 per cent of the global fertilizer use. Over the years, Government of India (GoI) has been ensuring fertilizer availability to the farmers at subsidized price resulting in huge burden of subsidy, which increased almost 1.5 times from US$ 20 billion in 2021-22 to US$ 28 billion in 2022-23. The GoI has allocated a subsidy of Rs 1.08 lakh crore for 2023-24 *kharif* including Rs 70,000 crore subsidy for urea and Rs 38,000 crore for diammonium phosphate (DAP) and other fertilizers. Existing subsidy provisions do favour nitrogen (N) fertilizer use, causing overuse of N at the cost of requisite dose of phosphorus (P), potash (K), and micronutrients. Observing the recent trends in international prices of DAP, MOP and S, the GoI approved the nutrient base subsidy (NBS) rates for *rabi* 2023-24 effective from 1 October 2023 to ensure the availability of P and K fertilizers to farmers at affordable prices. Among the essential plant nutrients, use of N fertilizer has increased significantly (around 67 per cent of the total fertilizer nutrient consumption) in the country. The N partial factor productivity declined from 32 kg

foodgrain per kg of N applied in 1970s to 12 kg in 2020, reducing the nitrogen use efficiency (NUE) as low as 30 per cent and phosphorus 20 per cent. Low NUE and energy intensive urea production emits around 119 mt CO_2 equivalent emissions annually in the country. The technology-led growth increased food production, but also enhanced the agro-eco-environmental challenges by over-exploitation of natural resources such as soil, water, and biodiversity, decreased NUE and factor productivity, depleted soil health and increased climate aberrations. Hence, low efficiency results in considerable waste of resources and a drain on foreign exchange as the country imports almost 25, 90 and 100 per cent of N, P and K as finished product or as raw material. These problems are of utmost concern for industry, farmers, researchers, and policy makers.

The projections do suggest that India may have to double its fertilizer use by 2050 to feed its ever- increasing population. Since India depends extensively on fertilizer imports, the sky-high fertilizer prices during Russia–Ukraine war have adversely impacted the fertilizer subsidy and agriculture sector. Now the prices have largely receded to pre-war levels, but as was the case with previous disruptions (1978, 2008), the fertilizer prices on an average will probably remain somewhat higher than that in the decade before the war. The Indian fertilizer industry achieved a high energy efficiency comparable to the best in the world, which has been possible through continuous modernization of old plants and addition of state-of-the-art plants. Now fertilizer industry needs to be given realistic time schedule and obligations to switch from grey ammonia to green ammonia. These multi-faceted challenges of inter-connections between energy, fertilizer prices and availability, food insecurity, nutrition, and its environmental implications as well as the health impacts of the increasing environmental losses due to fertilizers have become a subject of growing scientific concern – both biophysical and socioeconomic. It is also evident that exclusive dependence on inorganic fertilizers, particularly if misused, can have serious environmental consequences. Therefore, GoI is promoting alternative sources of plant nutrition, organic and biofertilizers on a large scale through several sponsored schemes. But currently, the total area under organic farming is only about 2.7 per cent and production of biofertilizers (soil and liquid) is less than 0.15 mt in 2020-21, despite a growth of around 500 per cent in the past one decade. There are several barriers in widespread use of biofertilizers and organic fertilizers, relating to subsidies, and support for promotion of biofertilizers and organic fertilizers, quality control, data collection and reporting. Therefore, combining

fertilizers with natural and organic sources (organo-minerals) is a kind of assurance to minimize adverse economic and environmental impacts. Global scientific innovations on improving NUE by 20 per cent reveal to reduce carbon footprints by 21 mt of CO_2 equivalent annually in India. The annual reduction in carbon footprints may provide an additional carbon trading/green credits income to farmers and industry to the tune of around US$ 213 m annually, save around US$ 4 billion subsidy, and achieve the targeted Nationally Determined Contributions (NDCs) under Paris Agreement by 2030 at the country level.

Pragmatic reforms are urgently required for the soil health and plant nutrient sources and technologies in India since the inaction cost would be far greater than that of action. To address these issues, the GoI has to focus more on incentivizing efficient use of fertilizers. The fertilizer industry must change the way it produces and do marketing of fertilizers. Competitiveness and innovation are vital for its survival and growth. Innovation to develop, test and manufacture high-quality improved fertilizer blends, coatings, compounds, organo-minerals at different production scales are needed to replace/modify the traditional fertilizer formulations, especially urea. Moreover, the sustainable agriculture production systems demand innovations in new organic, inorganic, and mixed products and integrated nutrient management (INM) technologies including mechanization of fertilizer deep placement (FDP) and use of artificial intelligence and machine learning tools.

The Stakeholders Dialogue

In view of above, the Trust for Advancement of Agricultural Sciences (TAAS), New Delhi, a neutral 'Think Tank', and the Indian Council of Agricultural Research (ICAR) in collaboration with International Fertilizer Development Center (IFDC), Alabama, USA organized a Stakeholders Dialogue on ***Enhancing Fertilizer Use Efficiency for Sustainable Soil Health*** at New Delhi on 28-29 September 2023. A total of over 100 diverse stakeholders representing researchers, policy planners, development officials, representatives of private sector and progressive farmers had participated. The objectives of the Dialogue were to: (i) understand the interdependence between energy, fertilizers, soil, and environmental health for developing innovative pathways to achieve food and nutritional security, (ii) suggest innovative options for enhancing holistic nutrient use efficiency (factory-to-field) through novel products, management practices, and science of scaling, and iii) suggest the 'Way Forward' for promoting science-led incentive-based policies and strategies

for improving nutrient use efficiency and restoring soil health.

Major Recommendations

The participants attending the Stakeholders Dialogue expressed the need for urgent steps towards addressing the existing challenges and constraints and enhance the fertilizer/nutrient use efficiency by restoring and sustaining soil health. It was emphasized that the Indian fertilizer sector requires multi-pronged research, development and policy interventions of all stakeholders including ministries, R&D institutions, and the private sector such as industry. Hence, to ensure prompt action by all the key stakeholders, it was decided to bring out a Policy Brief on *Enhancing Fertilizer Use Efficiency for Sustainable Soil Health* outlining the policy, development, and research related recommendations. The major recommendations are as follows:

I. Policy

1. The fertilizer/nutrient use efficiency needs to be doubled by 2030 in a mission mode in fertilizer technology, innovation, research, and extension through factory-to-fork (F2F) approach by investing at least 1 per cent of existing subsidy amount (around US$ 250 m) in novel research and state-of-the-art infrastructure. This investment is necessary for developing efficient fertilizer products (organo-minerals, multi-nutrient granules, slow-release fertilizers, etc.) and technologies, which will curtail the subsidy budget by 50 per cent and reduce carbon footprint by 30 per cent mediated *via* development of carbon farming/ green credit markets.
2. A Centre of Excellence on Fertilizers (CoEF) needs to be established in public-private-producer partnership (4P) along with a pilot plant with innovative laboratory facilities to promote innovations in fertilizer technologies including efficient production, and improved NUE efficiency with support of international organizations like IFDC which will cater skill and knowledge development needs of different stakeholders, especially the youth of India. The CoEF may be established through strategic involvement of the Ministry of Chemicals and Fertilizers (MoC&F) with technical backstopping of the Indian Council of Agricultural Research (ICAR), and the State Agricultural Universities (SAUs).
3. To inspire higher investment for research from the private sector, the GoI needs to consider incentivizing the companies for developing and scaling-up new innovations (efficient products and INM solutions and technologies).

4. There is an urgent need to reorient the current fertilizer subsidy policy into incentive-oriented policy under the PM Program for Restoration, Awareness, Nourishment, and Amelioration of Mother Earth (PM-PRANAM) Scheme linked with soil health cards (SHCs) for balanced nutrient application. Also, there needs to be a provision of rewarding and incentivizing researchers, industry, and farmer producer organizations (FPOs) centering on development, promotion, and adoption of climate smart and scientifically proven fertilizer products with INM supported by direct benefit transfer (DBT).

5. There is a need to develop district-wise soil health maps, every 5 years, under 'One Health' initiative by establishing a soil conservation fund of Rs 10,000 crore to monitor and implement appropriate solutions including incentivizing the farmers adopting appropriate fertilizer inputs and maintaining the soil organic carbon (SOC) above 0.5 per cent.

6. The Fertilizer Control Order (FCO) needs to be revisited to expedite the registration process of new fertilizer carriers/molecules through scientific data backed system, while having compliance of norms to ensure quality and adequate quantity of product in the market to ensure easy availability, accessibility, and affordability.

7. In view of high dependence on import of P and K fertilizers, it would be desirable if Government decides to build contracts, and collaborations for setting-up joint ventures abroad and also create a sovereign fund of US$ five billion for sourcing raw materials or investment in foreign rock phosphate mines by Indian fertilizer companies in resource rich countries, especially from Africa and Central Asia.

8. An enabling policy decision is needed to include glauconite-K mineral as part of minor/associated minerals. This will help in harnessing the potential of indigenously available K resources, as glauconite can complement potash imports equal to 1 mt annually, worth approximately US$ 590 m in foreign exchange and Rs 1,518 million in fertilizer.

9. The use of organic fertilizers needs to be promoted through enabling policies along with proposed incentives of Rs 1,500 per ton to manufacturers to produce quality organic manures using scientific methods of composting.

10. It will be desirable to incentivize nutrient recycling (organo-minerals)

through industrial processing of wastes such as sewage sludge, poultry manure and distillery spent wash with a target for generation of 1.0 mt per year of recyclable nutrients through indigenous or industrial processing of wastes linked with enabling policy on INM targeting 75 per cent mineral and 25 per cent organic nutrients.

11. Since acid soils suffer more from sulphur (S), Boron (B) and Molybdenum (Mo) deficiencies, there is a need to strengthen strategy on integrated nutrient supply and management and enhance availability of custom-made fertilizers to assure balanced management of these nutrient deficiencies; use of glauconite-K mineral will reduce dose of lime and strengthen integrated nutrient supply and management. Application of lime to acid soils once in 3 years costs Rs 4,800 per ha. Hence, there is a need to make provision of investment of Rs 1,200 crore for ameliorating entire 25 mha acid soils. Also, provision needs to be kept for cost of freight on sharing basis, 50 per cent each by the beneficiary farmer and the State Governments. SAUs and ICAR Institutes also need to disseminate technical advice on lime treatment.

12. Department of Fertilizers, MoC&F, GoI and the ICAR may consider bringing out a 'White Paper' on Fertilizers in India involving Think Tanks like the Trust for Advancement of Agricultural Sciences (TAAS), National Academy of Agricultural Sciences (NAAS) and other International Organizations.

13. There is need to: (i) convert fertilizer, and other agricultural subsidies (Centre and State) – around Rs five lakh crore (majority of which is on fertilizer) and (ii) fertilizer use on soil test basis – up to Rs 10,000 per ha to smallholder (80%) farmers, into incentives for adopting GAP-using regenerative agriculture (RA) and conservation agriculture based sustainable intensification (CASI), which will make all the difference with direct benefit transfer (DBT) to farmers and not to industry, as at present.

II. Development

14. For promoting application of the best fertilizer management practices for maximizing efficient fertilizer use, a comprehensive awareness and educational program for extension/ field workers is needed. This would help popularizing art and science of 4R (right source, right rate, right time

and right place) nutrient stewardship with a goal to promote site-specific nutrient management (SSNM) using available decision support system (DSS) and artificial intelligence (AI), etc.

15. Concerted efforts are needed to promote the use of alternative sources such as NPK, single super phosphate (SSP), triple super phosphate (TSP), nano-urea/DAP to bring down demand for imported fertilizers. To promote crop-specific grades in place of generic grades, there is a need for tailor- made compounds from existing carriers by adopting wet or dry granulation process in a decentralized system.

16. For science-driven efficient fertilizer management, *Krishi Vigyan Kendras* (KVKs) need to enhance knowledge sharing and promote resilient nutrient management practices and nutrient decision support systems (DSS) among communities, extension workers and farmers.

17. Tagging of nano-urea with fertilizer sale, as at present, is counter-productive. Hence, its purchase need not be made mandatory but left to farmers' choice. For such technologies, perfection for use of drones with sensor-based technology for precise foliar spray in N-deficient areas using artificial intelligence (AI) be given greater attention.

18. There is a need to promote the use of NP/NPK fertilizers with organic matter by making necessary changes in the Fertilizer Control Order (FCO). A minimum of 10 per cent use of biofertilizers be made mandatory in organo-mineral fertilizers.

19. There is an urgent need for new research to understand the impact of increased mineral fertilizers use on soil acidity in and align with their contemporary need for alternative fertilizer sources and application technology. There is a necessity to disseminate technical advice on lime treatment by SAUs and ICAR Institutes. This will help in sustaining acid soils and increase productivity by 0.5 t/ha in around 25 mha, and an additional food production of 12.5 mt worth Rs 2,500 crore.

20. For efficient soil testing facilities, creation of accredited private laboratories by well-trained young entrepreneurs under the Government Scheme of soil health cards (SHCs), is urgently required.

21. An urgent attention is needed to rationalize import duty structure of raw materials/ intermediates for

stepping up capacity utilization of phosphates and capping P_2O_5 at 10 mt per year with 50 per cent security through investments in mines and joint ventures.

22. There is a need to establish Neutral Fertilizer Platform- A Think Tank involving public-private sector and technical experts for better exchange of information and knowledge among stakeholders, and suggesting country's future needs and possible pathways including research, innovations, and policy advocacy, etc.

III. Research

23. Intensive research on agro-economic evaluation of specialty fertilizers must be taken-up by strengthening cooperation between public sector institutions and fertilizer industry to move forward the innovations from lab-to-land for commercialization.

24. There is need for updating and revising the package of practices recommended for use in the state and intensified efforts for their wider adoption by SAUs besides including climate smart fertilizers – specialty fertilizers (slow release, water soluble fertilizers, controlled release fertilizers, organics, etc.).

25. Understanding and documenting the translocation mechanism of nano-particles relating to their effectivity and efficiency, are a must. *Modus operandi* of nanoparticles in soil-plant (xylem and phloem) system is complex, hence in-depth research following a consortium approach at the national level by the ICAR-Indian Institute of Soil Science (IISS) be taken up on priority.

26. The existing mandate of the ICAR-AICRP on long-term fertilizers need to be revisited to align with contemporary needs and futuristic relevance to improved NUE. There is a need for focused research in the context of natural farming (NF), conservation agriculture (CA) and regenerative agriculture (RA) to make fertilizer research more holistic, and also ensuring economic and environmental sustainability.

27. Concerted efforts must be made for mechanization of fertilizer deep placement (FDP) by redesigning and innovating multi-crop, multi-utility machinery for deep placement of fertilizers to reduce losses and carbon footprint with simultaneous improvement in FUE. Intensive research needs to be undertaken to promote one-time deep placement *vis- a- vis* repeated top dressings. The FDP has the potential to double the NUE (30 to 60%) which will save more than 10 mt of fertilizer,

hence, there is need to provide incentives on fertilizer-cum-seed drill/planters, and promote the use of recommended 40 to 50 per cent N and 100 per cent P and K fertilizer as mechanized deep placement while seeding/planting and rest as foliar – split application using sensors, AI and DSS, etc.

28. The Ministry of Environment, Forest and Climate Change (MoEF&CC) in collaboration with the ICAR may consider developing protocols for the measurement, reporting and verification (MRVs) of carbon farming/green credit practices, including enhanced fertilizer use and efficient technologies for smallholder farmers.

29. Specific research is needed on inventing slow/controlled release sulphur-coated urea variable dissolution rates i.e., 1DDR (1 Day Dissolution Rate) or 7 DDR. While such developments must pass the test of use efficiency, these also have to be economically favorable and ecologically benign.

30. A new agri-business model-oriented approach needs to be adopted to understand the fertilizer-based innovations from a business perspective with scalable adoption and markets. Also, to become self-sufficient in urea production, enhancing the recovery efficiency by upgrading the existing plants, is a must.


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For Copies Contact:

Trust for Advancement of Agricultural Sciences (TAAS)

Avenue-II, Indian Agricultural Research Institute, Pusa Campus
New Delhi - 110 012, India
Phone: +91-11-25843243; 8130111237
Email : taasiari@gmail.com; Website: www.taas.in

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