India Needs Relook at Nutrient Use Efficiency

Frank Notes

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Fertiliser is a vital component of agricultural development world over. It contributes 50% to the growth of global foodgrain production. In Indian context, use of fertilisers in terms of nutrients has shown tremendous increase from mere 65,600 metric tonnes (MT) in 1951-52 to 32.9 million MT in 2024-25. Same is case with foodgrain production. The corresponding increase for the same has been 52 million MT to 357.7 million MT. In 2025-26, nutrient consumption may be around 33.54 million MT, whereas foodgrain production may touch a figure of about 365 million MT. It is not out of place to make a mention that fertiliser has played an important role and will continue to do so in future also. However, such gains in food production have come at a cost in terms of exploitation of natural resources and environment. In addition, there are issues of sustainability both for fertiliser and agriculture sectors. The imbalance ($N:P_2O_5:K_2O$ use ratio as 9.7:3.7:1 in 2025-26 also) and inefficient use of fertilisers result in lowering nutrient use efficiency (NUE); declining crop response to fertiliser application; reducing farm productivity; deterioration of soil health; and accentuating environmental footprints. There is a challenge for sustainable growth in agriculture to sustain food security on long-term basis.

The country has entered an era of multi-nutrient deficiencies. The deficiency particularly of 6 nutrients namely N, P, K, S, Zn, B has become widespread. The increasing deficiency of secondary and micro-nutrients has become a limiting factor in improving farm productivity. Use efficiency of applied fertiliser nutrients is abysmally low. Therefore, NUE has moved from being a 'technical detail' to becoming 'central' to the future Indian agriculture. Use efficiency of N, P, K, S and micronutrients, applied through fertilisers, has been documented as <50%, <20%, <60%, <12% and <5%, respectively. Such low efficiency is a matter of great concern and the country has to seriously relook into and find out the ways and means for improvement, cohesively.

Nitrogen is a mobile nutrient in the soil and more than 80% N requirement is met by urea. Urea when applied in the soil leaks to the environment through ammonia volatilisation, and N_2O emissions in addition to surface run off and leaching of NO_3^- ion in the soil. In case of P, fixation takes place in the soil. In acidic soils, formation of insoluble aluminium and ferric phosphate takes place. Through different kind of reaction products in the form of di-calcium phosphate, tri-calcium phosphate, carbonate or hydroxyl apatite, P gets fixed in alkaline soils. Available K ions are trapped or bound within the inter-layers and lattice spacings of clay minerals present in the soil. Micronutrients also get fixed in the soil through various processes of reaction products. Due to such factors, use efficiency of applied nutrients remains low.

Under such situation, what is the way out? Fertiliser nutrients are used in imbalanced proportion and that is a major cause of low NUE. The assertion that imbalanced fertiliser use is a primary driver of low NUE is supported by extensive scientific literature. Continued reliance on disproportionate nutrient ratios, specifically high N application relative to P, K, and micronutrients, result in soil fertility deterioration and reduced crop response. Scientific evidence very well demonstrates that balanced fertilisation considerably improves NUE by enabling crops to reach their full potential, decreasing nutrient losses, and enhancing overall soil fertility. Further, integrated nutrient management comprising balanced fertilisation based on soil test based fertiliser recommendations; organic-, bio-, and nano - fertilisers, bio-stimulants, fermented organic manure (FOM) and liquid fermented organic manure (LFOM), organo-minerals, etc. further increases NUE and soil health.

The other foremost way is popularization of 4R farming and nutrient stewardship among the farmers. They are right source to match crop needs; right rate to meet crop needs fully; right time to make nutrients available when crops need them; and right place to apply nutrients where crops can use them. For N, split application is advisable. For P, precision placement (band placement) is to be adopted at the time of sowing/transplanting. Potassic fertilisers need application at the time of sowing/transplanting. Micronutrients should be applied at sowing/ transplanting and also in standing crops through foliar application.

Concerted and collaborative efforts of the industry, Governments, and all concerned stakeholders will go a long way to improve NUE for betterment of soil health, farm productivity and the farmers.

Controlled & slow release fertilisers, urease & nitrification inhibitors, sulphur coated urea, and stabilized N fertilisers have been developed to bring about improvement in N use efficiency. These products have proven their superiority in enhancing the recovery efficiencies of applied N and cutting down on the N_2O emissions. However, the cost of such products is high. They are used in developed countries and possibility needs to be explored for use of such products in India.

Water soluble fertilisers (WSFs) have witnessed rapid growth in India. Consumption of WSFs in India witnessed 8-fold increase, from 50,000 MT in 2010-11 to 4,00,000 MT in 2024-25. There is an enormous potential to increase consumption of WSFs. Area under micro-irrigation was estimated as 16.74 million ha as on 31 March 2024. Use of such fertilisers with micro-irrigation system, generally known as fertigation, improves fertiliser as well as water use efficiency to a great extent. Liquid fertilisers are another category of innovative fertilisers with good potential due to better monetary returns and minimum environmental footprints. Commercial success of these products remains to be evaluated in our country as fertilisers in the liquid form require distinctive handling and storage facilities. The demand for micronutrient-fortified staple diets is on rise. Consumption of micronutrients in 2024-25 was about 3,33,486 MT, out of which share of zinc sulphate was 64%. Use of other micronutrients was found in the order of ferrous sulphate>borax/boric acid> manganese sulphate>copper sulphate. Use of such fertilisers enhances NUE of traditional fertilisers also. Therefore, they should be given more recognition in fertiliser management schedule.

Nano fertilisers have a potential of enhancing use efficiency of nutrients and reducing the environmental footprints. A number of nano products (nano urea, nano DAP, nano phosphorus, nano NP/NPK, nano zinc and nano copper) have been developed and included in FCO in India and needs to be given more emphasis and popularise among the farmers.

Lot of work has been done on identification and evaluation of beneficial microorganisms that help in the fixation of atmospheric N in soil and solublization/ mobilization of nutrients fixed in soil. Based on nature and role of such microorganisms, different types of bio-fertilisers have been developed and are being used to supplement the bulk fertilisers. They have the potential to supplement 15-20% nutrient demand of the crop, and improve the biological soil health. Soil organic carbon content in India is very low (<0.5%) and it is also one of the major reasons of poor NUE. Organic carbon of soil can be increased by use of organic manures and soil carbon enhancers like FOM and LFOM. Farmers should be educated to use crop residues / farm wastes and animal wastes in fields. Further, conversion of rural, urban and periurban wastes into manurial wealth for its use in soil should be encouraged under Swachh Bharat Abhiyan of Government of India. Higher organic carbon content in soil results in higher use efficiency of fertilisers.

Adoption of best management practices of precision agriculture focusing on optimizing resource inputs (water, fertiliser, seeds) using GPS, sensors, drones, and AI, improves crop yields while reducing waste and environmental impact. Key practices include site-specific nutrient management, variable rate technology for inputs, precision irrigation, and real-time, data-driven monitoring of soil and crop.

Indian fertiliser industry with its limited resources is making efforts to develop value added / efficient fertiliser products, but registration process for inclusion in FCO should be simple and less time consuming. Large scale adoption of innovative products requires reforms in the present fertiliser policy and regulatory environment to provide level playing field to all those engaged in development of sustainable plant nutrition systems to improve NUE. Development and introduction of new fertiliser products or the customization/ modification of the existing ones are required for meeting challenges of food, conservation of natural resources, protection of environment and mitigation of adverse impacts of climate change.

Government of India has also been implementing schemes/programs such as PM PRANAM, RKVY, MOVCDNER, National Mission on Natural Farming, etc. towards improving soil health and NUE. The extension agencies need to be energized to educate the farmers across the country on adoption of the practices of sustaining soil health, thereby a way for improving NUE.

Correction in fertiliser pricing policy is the most important step for promotion of NUE in India. It is high time to bring urea under the ambit of nutrient based subsidy (NBS). The subsidy levels under NBS may be so calibrated to promote balanced fertilisation including application of micronutrients. Products and practices, which give higher NUE need encouragement. Concerted and collaborative efforts of the industry, Governments, and all concerned stakeholders will go a long way to improve NUE for betterment of soil health, farm productivity and the farmers. ■