Frank Notes

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Integrated Nutrient Management: Key to Sustainable Soil Health and Crop Productivity

India achieved spectacular growth in agricultural production during the last 50 years with its march from 'ship to mouth situation' of mid-1960s to 'current net export surplus' on food production front. Country's dependence on agriculture is more than 10,000 years old. Organic manures were the sole source of nutrients as well as organic matter in the Indian soils up to the beginning of 20th century. Soils supported precarious low yield levels. In 1928, diagnosing poor fertility of soils as the cause of lower yields, Royal Commission on Agriculture observed, "Indian soils have been depleted to the extent that no further depletion is possible". Inadequacy of organic manures in meeting the crop nutrient requirements led to a search for other/ alternative nutrient sources.

Historically, production of single superphosphate by Liebig and chemical fixation of atmospheric nitrogen as ammonia by Haber-Bosch process heralded the era of chemical fertilizers. In India, fertilizer started with the EID-Parry company setting up a single superphosphate (SSP) factory at Ranipet, Tamil Nadu in 1906. Chemical fertilizers introduced in first half of 20th century started supplementing the nutritional requirements of the crops. With heralding of the Green Revolution era, chemical fertilizers emerged as the dominant sources of plant nutrient supply to high yielding varieties of crops. With increase in crop intensity, more land area put under cultivation, and more reliance on farm machinery replacing draught animals, availability of organic manures as nutrient source declined gradually. In this scenario, fertilizers assumed a key role in strengthening the national food security. Currently, 50% of the food production both globally as well as in India is attributed to fertilizer use.

While agricultural intensification model helped in achieving self-sufficiency in the food grain production by the close of 20th century, issues related to soil health degradation (particularly, soil fertility depletion) became more critical. Indian soils are plagued by abysmally low soil organic carbon of less than 0.5%. More than 90% of the Indian soils are deficient in available nitrogen (N). Deficiencies of phosphorus (P), potassium (K), sulphur (S), zinc (Zn), boron (B), iron (Fe) and manganese are 80%, 50%, 41%, 36%, 23%, 13% and 7%, respectively. Consequences have been the low nutrient use efficiencies: 30-50% for N, 15-25% for P, 50-60% for K, 8-12% for S, and 2-5% for micronutrients. Decline in fertilizer response ratio from 12.1 kg grain per kg NPK in 1960-69 to 5.1 kg grain per kg NPK in 2010-17 reflects on the deterioration of soil fertility. Imbalanced fertilizer use, unabated burning of crop residues and climate change pose further challenge to the sustenance of soil health.

The increased nutrient uptake under high yielding crop varieties and intensive agriculture has exerted pressure on soil fertility. Although, annual fertilizer (NPK) consumption increased from 0.78 million tonnes (Mt) in 1965-66 to a record level of 28.12 Mt in 2010-11, the problem of soil nutrient mining has continued unabated. As per the FAI estimates, the annual uptake of primary nutrients (NPK) by crops during 2015-16 was 36.6 Mt against application of 26.8 Mt, leaving a gross nutrient gap of 9.8 Mt. By taking into consideration the nutrient use efficiencies, the net gap between nutrient uptake by the crops and addition through fertilizers widened to 13.0 Mt. Nutrient-wise analyses revealed that the whopping gap between nutrient uptake and application of fertilizer nutrients was largely on account of K, leading to its over-mining from the soil.

The nutrient needs of Indian agriculture are so huge that no single source by itself, be it fertilizer or organic manure or bio-fertilizer, can meet the entire nutrient demand. Integrated nutrient management (INM) *i.e.* combined use of fertilizers, organic manures and bio-fertilizers is the only practicable, efficient, economically feasible and environmentally benign way of managing nutrients. Concept of INM first originated in late 1980s or beginning of 1990s due to widespread emergence of multi-nutrient deficiencies and deterioration of physical and biological health of the soil. Its basic objective was the maintenance of soil fertility, sustenance of crop productivity and improvement of the farmers' profitability.

Integrated nutrient management, combining the age-old and modern methods of nutrient management, is designed to derive benefits from usage of all possible organic and inorganic sources in a judicious, efficient and integrated manner. The combined use of inorganic, organic and biological sources of plant nutrients is not only important for nutrition of crops but also in improving physical and biological health of soils. Several researchers have

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reported that the combined application of chemical fertilizers and organic manures increased soil organic matter (SOM) more effectively than did the application of fertilizers or organic manures alone. The INM-induced SOM build up brings about improvement in soil physical properties such as soil structure and water holding capacity.

Chemically, SOM enrichment enhances the capacity of soil to resist changes in the pH, increases cation exchange capacity, reduces phosphorus fixation and serves as reservoir of nutrients, including micronutrients. Soil health- related microbial indicators such as soil microbial biomass, soil bacterial community diversity and soil enzyme activities also improve significantly under the INM practice. Biologically, SOM favours growth of fauna and micro-organisms which disrupt the nutrient cycles operating in the soil and facilitate the release of minerals in the ecosystems. Conjoint use of organic and inorganic sources helps improve the nutrient use efficiency by increasing synchrony between soil nutrient availability and crop demand.

Farmers are aware of benefits of organic manures; however, the real challenge is the scant availability or non-availability of organic manures. Shifting of animal-based farming to mechanized agriculture, and burning of crop residues and their diversion for other purposes are some of the reasons for low availability of biomass for compost preparation. All these practices singly or together are major hindrances to the adoption of INM technology by the farming community.

Crop residues constitute a good nutrient source; however, the quality of residues is often low and the amounts are generally insufficient. In India, an estimated 500-550 Mt of crop residues are produced annually. After accounting for multiple competitive uses, about 140 Mt are surplus most of which are burnt *in situ*. Burning of straw poses phenomenal pollution problems in the atmosphere and is a reason for huge nutritional and physical health deterioration to the soil.

Biogas plant integrated with low cost cattle sheds and rural toilets may be a viable option for proper recycling of crop residues, cow dung and urine, human excreta, weed biomass, and kitchen wastes. It will help in supplementing rural fuel and fodder needs besides generating valuable biogas manure for agricultural use.

Promotion of city compost can serve twin objectives of supporting Swachh Bharat Abhiyan of the Government of India and providing valuable manures to the farmers. To encourage the use of city compost, the Department of Fertilizers, Ministry of Chemicals and Fertilizers, GOI has started providing a market development assistance of Rs.1500 per tonne of city compost. However, it seems to be inadequate and therefore has not yielded desired results. Ministry of Agriculture and Farmers Welfare is promoting the concept of INM through various programmes and schemes. However, the adoption of INM technology at the farmers' fields is still abysmally low.

The existing nutrient based subsidy (NBS) policy of the Government keeping urea out of this policy and maintaining artificially very low retail price works against the promotion of balanced and integrated use of nutrients. With heavy subsidy on urea, farmers are encouraged to overuse urea, leading to the excessive-N use related risks of ground water pollution with nitrates, eutrophication of surface water bodies, nitrous oxide emissions-induced climate change, etc. Lower or scant use of other nutrients like P, K, secondary and micronutrients reduce the use efficiency of applied N resulting in low crop response and degradation of environment. Accelerated appearances of multi-nutrient deficiencies arising out of this imbalance are threatening the sustainability of soil and crop productivity. Therefore, there is a need for immediate correction in retail prices of fertilizers. This can early be done by brining urea under NBS policy. Fertilizer manufacturing companies should be encouraged to produce and promote organic fertilizers and bio-fertilizers so that these fertilizers contribute 15% of fertilizer basket of the farmers. Awareness among farmers should be created to adopt the improved agricultural management practices like crop diversification including legumes, crop residue retention, mulching, cover crop, use of organics in conjunction with chemical fertilizers as a wholesome package.

Although location-specific relevant INM packages to address soil health related issues are available, the outcome is far below the expectations mainly because the INM activities are being implemented in isolation through different developmental schemes/programmes by different Ministries/Agencies. There is a need for convergence of all the related programmes/schemes to address nutrient management issues. Needless to say that all policies related to the fertilizer and agriculture sectors should promote integrated nutrient management. These steps are necessary to maintain soil health, sustain water quality, protect the environment, and make the country food and nutrition secure. ■