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BALANCED USE OF FERTILIZERS: KEY TO SOIL HEALTH, PRODUCTIVITY, AND SUSTAINABILITY

Email

¹Raghavendra Nargund* and ²Raghuandan K.

raghavendra4449@gmail.com

¹Division of Crop Production, ICAR-Indian Institute of Soybean Research, Khandwa Road, Indore-452001 (MP), India

²Crop Science Section, ICAR-Central Coastal Agricultural Research Institute, Ella, Old Goa, Goa-403402, India

Agriculture is the backbone of the Indian economy, and fertilizers have played a pivotal role in enhancing food grain production over the past several decades. The Green Revolution revolutionized Indian agriculture through the widespread adoption of high-yielding crop varieties supported by irrigation and increased use of fertilizers. However, continuous and indiscriminate application of high-analysis fertilizers, particularly nitrogenous fertilizers such as urea, has led to serious concerns, including deterioration of soil health, nutrient imbalance, declining factor productivity, and environmental pollution. In the present context of climate change, escalating input costs arising from global conflicts and energy crises, and rapid degradation of natural resources, the balanced use of fertilizers has become crucial for ensuring sustainable agricultural production and long-term soil fertility (Eliazer et al. 2019, Singh et al. 2021).

Concept and Importance of Balanced Fertilisation

Balanced fertilisation refers to the judicious application of essential plant nutrients in optimum proportions based on crop requirements, soil nutrient status, and targeted productivity levels. Crop plants require adequate supplies of primary macronutrients, namely nitrogen (N), phosphorus (P), and potassium (K), in addition to secondary nutrients such as sulphur (S), calcium (Ca), and magnesium (Mg), along with micronutrients including zinc (Zn), boron (B), iron (Fe), manganese (Mn), copper (Cu), and molybdenum (Mo) for normal growth, metabolic activities, and reproductive development. An imbalance in nutrient supply, whether through deficiency, excess, or disproportionate application, adversely affects nutrient uptake, physiological processes, crop productivity, and produce quality. Consequently, balanced nutrient management is recognized as a critical component for sustaining soil health, enhancing

nutrient use efficiency, improving crop productivity, and ensuring the long-term sustainability of agricultural production systems (Khambalkar et al. 2025).

Balanced Fertilization for Soil Health

Healthy soil is the basis of sustainable crop production. Balanced fertilization helps maintain soil fertility by replenishing nutrients removed by crops. It improves soil physical, chemical, and biological properties. Application of organic manures such as farmyard manure (FYM), compost, vermicompost, crop residues, and green manures, along with chemical fertilizers enhances soil structure, water-holding capacity, and microbial activity. Integrated Nutrient Management (INM), which combines inorganic fertilizers with organic and biological sources, is considered an effective approach for maintaining long-term soil productivity (Kumar et al. 2025).

Nutrient Use Efficiency and 4R Nutrient Stewardship

Balanced fertilizer use is fundamental to enhancing nutrient use efficiency and minimizing nutrient losses from agricultural systems. A substantial proportion of applied nutrients is often lost through processes such as leaching, surface runoff, volatilization, denitrification, and soil fixation, thereby reducing fertilizer efficiency and increasing environmental risks. Adoption of scientifically sound nutrient management practices, including soil test-based fertilizer recommendations, site-specific nutrient management, split application of nitrogenous fertilizers, deep placement techniques, fertigation, and the use of coated, stabilized, or slow-release fertilizers, can substantially improve nutrient recovery and crop uptake efficiency. In this context, the “4R Nutrient Stewardship” framework—application of the right nutrient source, at the right rate, at the right time, and in the right place—has emerged as a globally accepted strategy for optimizing fertilizer use efficiency, sustaining crop productivity, and reducing the environmental footprint of intensive agricultural systems (Mikkelsen, 2011).

Micronutrient Management and Nutritional Quality

Micronutrient deficiencies are emerging as a major challenge in Indian agriculture. Deficiencies of zinc, sulphur, boron, and iron are increasingly reported in intensively cultivated soils. Though required in small quantities, micronutrients play critical roles in plant growth, enzyme activity, flowering, seed formation, and crop quality. Balanced fertilization involving

both macro and micronutrients is therefore essential for sustaining productivity and improving nutritional quality of agricultural produce (Verma et al. 2025).

Economic Benefits and Policy Support

Economic benefits to farmers are another important advantage of balanced fertilization. Fertilizers constitute a major component of cultivation cost. Unscientific and excessive use not only increases production costs but also reduces profitability. Soil test-based nutrient management helps farmers apply only the required amount of fertilizers, thereby reducing unnecessary expenditure and improving returns. Balanced fertilization also improves crop quality, market value, and overall farm income. Government initiatives such as the Soil Health Card Scheme, promotion of nano fertilizers, customized fertilizers, and awareness programmes on Integrated Nutrient Management are encouraging farmers to adopt balanced fertilizer practices. Advances in precision agriculture, remote sensing, drones, and digital advisory services are also creating new opportunities for efficient nutrient management (Goyal et al. 2023, Kumar et al. 2025).

Challenges and Way Forward

Despite these efforts, several challenges remain. Lack of awareness among farmers, inadequate soil testing facilities, rising prices of phosphatic and potassic fertilizers, and limited availability of organic inputs are major constraints in balanced fertilizer use. Strengthening extension services, farmer training programmes, and easy access to soil testing and nutrient advisory services are essential for wider adoption of balanced nutrient management practices.

Need for Integrated and Balanced Nutrient Management

Therefore, balanced use of fertilizers is the key to maintaining soil health, enhancing crop productivity, improving nutrient use efficiency, and ensuring environmental sustainability. Sustainable agriculture cannot be achieved through excessive dependence on chemical fertilizers alone. Integrated and balanced nutrient management involving chemical fertilizers, organic manures, crop residues, and biofertilizers is the need of the hour. Farmers, scientists, policymakers, and extension agencies must work together to promote balanced fertilization practices for ensuring long-term food security, profitability, and conservation of natural resources.

Conclusion

Balanced fertilization is a central requirement for sustaining soil fertility, nutrient-use efficiency, crop productivity, and environmental quality in intensive agricultural systems. The integration of soil test-based fertilizer application, organic nutrient sources, biofertilizers, micronutrient management, and 4R nutrient stewardship can correct nutrient imbalances, reduce nutrient losses, improve soil biological functioning, and enhance farm profitability. Therefore, balanced and integrated nutrient management should be promoted as a key strategy for achieving sustainable intensification, climate-resilient production, and long-term food and nutritional security.

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