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Micronutrients for Food, Nutrition and Health Security

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Abstract

Micronutrient deficiencies in soils and crops are increasing globally, with many countries facing multiple nutrient deficiencies, particularly of Zn and B. In India, widespread deficiencies of Zn, B, Fe, and other essential micronutrients have emerged as a major challenge, adversely affecting crop productivity, produce quality, and nutritional value. Beyond their impact on agricultural sustainability, deficiencies of micronutrients such as Zn and Fe pose serious public health concerns, contributing significantly to hidden hunger or micronutrient malnutrition among human populations. Addressing these deficiencies through balanced and integrated nutrient management is, therefore, critical for ensuring food, nutritional, and environmental security.

Globally, nearly half of all agricultural soils are deficient in Zn, followed by B and several other essential micronutrients, and India is no exception. A strong correlation exists between the prevalence of Zn deficiency in soils and the incidence of Zn deficiency in human populations. It is estimated that nearly one-third of the world's population suffers from inadequate Zn nutrition, making its deficiency one of the most widespread forms of micronutrient malnutrition worldwide. In addition to its critical role in plant growth and development, Zn is indispensable for human health, particularly for maintaining immune function, growth, and overall well-being. The importance of adequate Zn nutrition in supporting immune competence was further highlighted during recent global health emergencies, where Zn status was recognized as an important determinant of immune resilience and health outcomes.

The continuous cultivation of high-yielding crop varieties has accelerated the depletion of essential nutrients, including micronutrients, from agricultural soils. Consequently, the balanced and sustainable management of micronutrient fertilisers has become imperative for sustaining soil fertility, improving crop productivity and nutritional quality, enhancing resource-use efficiency, and ensuring long-term agricultural sustainability, food security, nutritional well-being, and human health.

Key words: Micronutrients, Zn fertilisers, balanced plant nutrition, soil health, food security, nutrition security, health security

Introduction

Micronutrients are essential mineral elements required by plants in very small quantities for normal growth, development, and metabolic functioning. Of the 18 essential plant nutrients, nine are classified as micronutrients: Zn, B, Fe, Cu, Mn, Mo, Cl, and Ni. Although needed in trace amounts, these elements perform vital physiological and biochemical functions, including enzyme activation, photosynthesis, respiration, nitrogen metabolism, and hormone regulation.

Micronutrient Deficiency in Soils

In India, extensive soil fertility surveys conducted under the All India Coordinated Research Project (AICRP) on Micro- and Secondary-Nutrients and Pollutant Elements in Soils and Plants have revealed widespread deficiencies of micronutrients across agricultural soils. Analysis of over 242,000 soil samples across 615 districts reveals that micronutrient deficiencies are widespread, with Zn and B emerging as the most critical limiting nutrients. Based on the cumulative assessment of acute deficiency, deficiency, and latent deficiency categories, approximately 51.2% of soils were deficient in available Zn, 44.7% in B, 19.2% in Fe, 17.4% in Mn, and 11.4% in Cu. These findings highlight the widespread occurrence of micronutrient imbalances in Indian soils and underscore the need for location-specific nutrient management strategies. The spatial distribution of Zn +B deficiency across different states of India is presented in **Figure 1**.

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Micronutrient Deficiency in Crops

Micronutrient deficiency in crops has become a widespread and critical constraint to agricultural productivity, nutritional quality, and sustainability, particularly in intensively cultivated regions. Although micronutrients are required in trace amounts, their deficiency adversely affects several physiological and biochemical processes, including photosynthesis, enzyme activation, nitrogen metabolism, carbohydrate translocation, and reproductive development. Zn deficiency is the most prevalent micronutrient disorder and is particularly severe in cereal-based production systems such as rice–wheat cropping systems. Micronutrient deficiencies in crops manifest through symptoms such as chlorosis, stunted growth, reduced tillering, impaired flowering and grain filling, and lower tolerance to biotic and abiotic stresses. The increasing incidence of micronutrient deficiencies is attributed to factors such as intensive

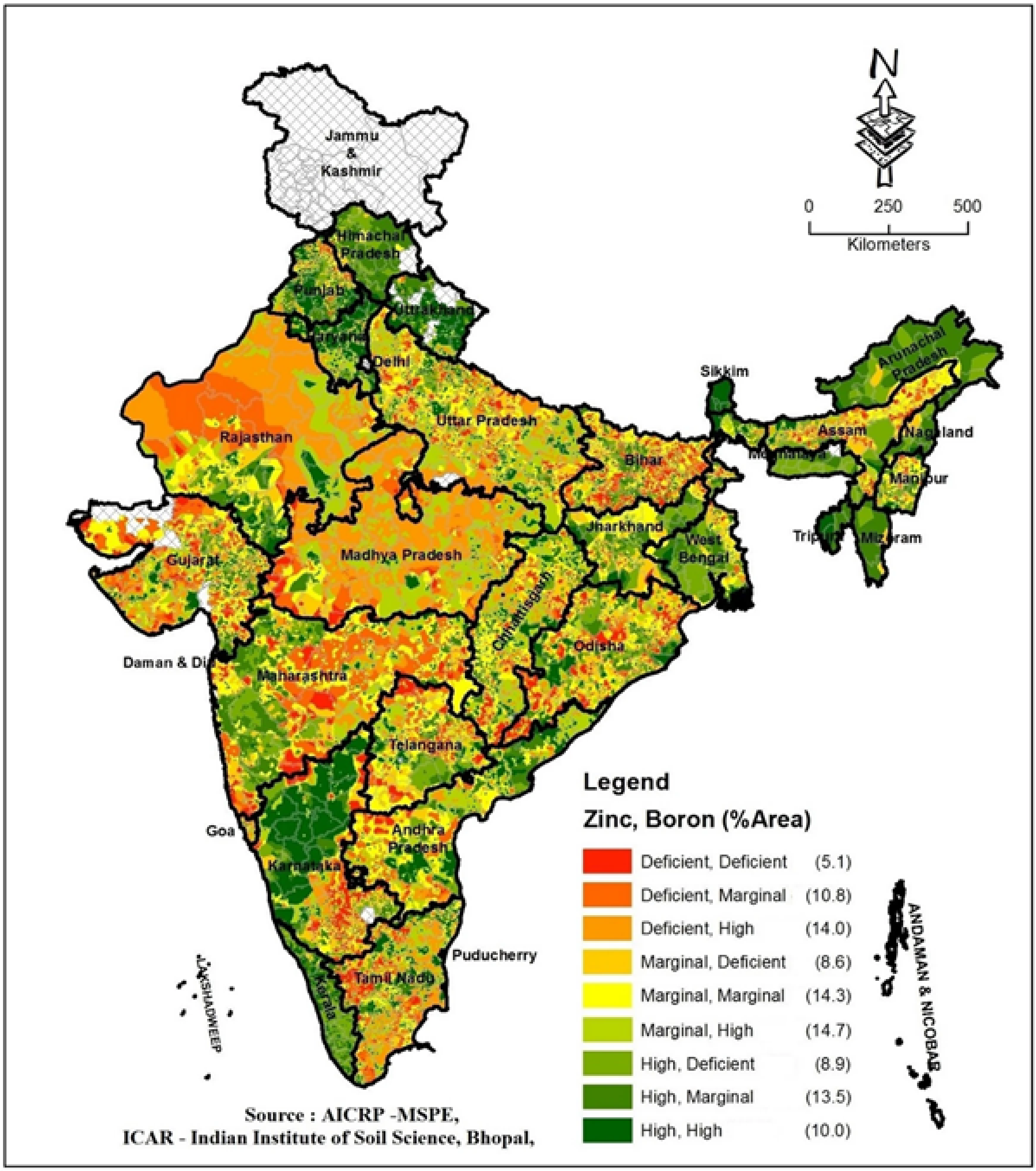

Figure 1. Spatial distribution of Zn+B deficiency in different states of India (The figure has been prepared using ArcGIS software (version 10.5.1), Environmental Systems Research Institute, Redlands, California) (Source: Shukla et al., 2021a)

cultivation, imbalanced fertiliser use with excessive emphasis on NPK fertilisers, depletion of native soil reserves, low organic matter content, high soil pH, calcareous conditions, and reduced recycling of crop residues.

Micronutrient deficiencies in agricultural soils have far-reaching consequences, reducing crop yields by 10–70%, depending on the crop and severity of deficiency, while simultaneously diminishing the concentration and bioavailability of essential micronutrients in edible plant products. This soil–plant nutritional imbalance ultimately contributes to widespread hidden hunger and micronutrient malnutrition in human populations.

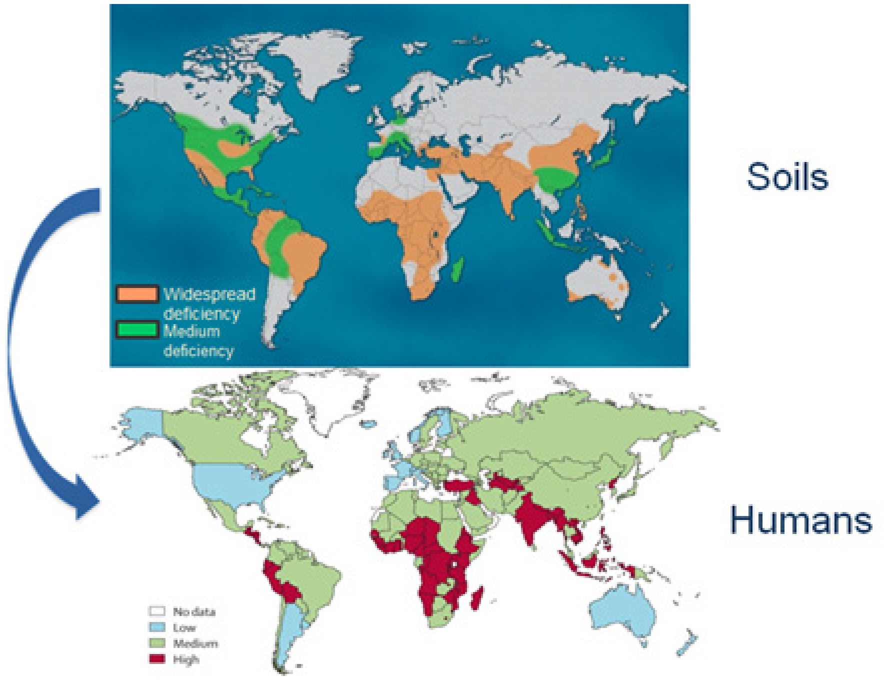

Figure 2. Worldwide Zn deficiency in soils and humans (Source: Alloway, 2008; Black et al., 2008)

Micronutrients in Human Health

Micronutrients such as Zn and Fe are indispensable for human health, growth, and development. Zn, in particular, is an essential trace element involved in numerous biological processes, including immune function, cellular metabolism, growth, and reproduction. Its deficiency, especially among infants and children under five years of age, has emerged as a major global public health concern. According to the World Health Organization (WHO), Zn deficiency is among the leading causes of morbidity and mortality in developing countries and is estimated to contribute to approximately 800,000 deaths annually, including about 450,000 deaths among children under five years of age. Inadequate dietary Zn intake has been strongly associated with increased susceptibility to infectious diseases such as diarrhoea, pneumonia, and malaria, which substantially contribute to child mortality. Globally, burden of Zn deficiency is estimated to account for nearly 16 million disability-adjusted life years (DALYs) lost annually, underscoring its profound impact on human health and socioeconomic development (Black et al., 2008; Brown et al., 2001; Caulfield and Black, 2004).

Zn deficiency remains a major public health concern in India and many developing regions of the world due to its adverse effects on growth, immunity, and child survival. Despite substantial progress in reducing undernutrition, India continues to bear a high burden of childhood malnutrition. According to the National Family Health Survey (NFHS-5, 2019–21), 36% of children under five years of age are stunted, 19.3% are wasted (thin for their height) and 32% are underweight, reflecting persistent nutritional challenges. Recent nationally representative data from the Comprehensive National Nutrition Survey (CNNS, 2016–18) revealed a substantial prevalence of Zn deficiency among Indian children and adolescents, with low serum Zn concentrations observed in 17.4% of preschool children (1–4 years), 15.8% of school-age children (5–9 years), and 31.1% of adolescents (10–19 years). Prevalence of Zn deficiency varied considerably across states and population groups, with a disproportionately higher burden among socio-economically disadvantaged populations.

Zn deficiency is associated with impaired growth, weakened immune function, and increased susceptibility to infectious diseases such as diarrhoea and pneumonia, which continue to contribute significantly to childhood morbidity and mortality. Globally, inadequate intake remains widespread, with an estimated 60–70% of the population in Asia and sub-Saharan Africa at risk of insufficient Zn intake, representing nearly 2 billion people in Asia and approximately 400 million people in sub-Saharan Africa. These observations highlight the urgent need for integrated interventions, including dietary diversification, food fortification, supplementation programs, and agronomic biofortification strategies to address Zn deficiency and improve nutritional security (Prasad, 2006; Pullakhandam et al., 2021). A strong correlation exists between Zn deficiency in soils and the prevalence of Zn deficiency in human populations (**Figure 2**). Globally, approximately one-third of the population is estimated to be affected by Zn deficiency, underscoring its significance as a major public health and nutritional challenge.

Zn is an essential micronutrient involved in numerous biological functions and a wide range of cellular processes in the human body. It serves as a structural, catalytic, and regulatory component of more than 300 enzymes and is indispensable for protein synthesis, DNA synthesis, cell division, wound healing, and the maintenance of normal taste and smell perception. Zn also plays a critical role in immune function by supporting the development and activity of white blood cells involved in combating infections. Its deficiency, particularly among infants and young children, is associated with a range of adverse health outcomes, including diarrhoea, pneumonia, stunted growth, impaired immune function, delayed mental development, dwarfism, cognitive impairment, behavioural disorders, memory deficits, impaired spatial learning, and neuronal atrophy. The widespread prevalence of Zn deficiency has contributed significantly to Zn malnutrition, especially in developing countries such as India, where it remains a major public health concern.

Iron is an essential micronutrient that plays a critical role in oxygen transport, DNA synthesis, energy production, and muscle metabolism. Fe deficiency is the leading cause of anaemia worldwide and affects approximately 33% of non-pregnant women, 40% of pregnant women, and 42% of children globally (WHO, 2020). In adults, iron deficiency can result in fatigue, reduced physical capacity, impaired cognitive performance, decreased work productivity, and diminished quality of life and social functioning. Its deficiency occurs primarily when physiological requirements increase during periods of rapid growth and development, such as infancy, childhood, adolescence, and pregnancy, although it can occur at any stage of life. In pregnant women, Fe deficiency increases the risk of maternal anaemia and is associated with adverse pregnancy outcomes, including low birth weight, preterm delivery, and impaired fetal development.

Micronutrient Malnutrition – Way forward

Micronutrient malnutrition in humans can be addressed through three major strategies: dietary supplementation, food fortification, and biofortification. While supplementation and food fortification programs have proven effective, their successful implementation depends on adequate infrastructure, purchasing power, access to markets and healthcare systems, and sustained financial support, all of which pose significant challenges, particularly in developing countries. Moreover, these interventions often have limited reach among rural and remote populations and are generally more accessible to urban communities. In this context, biofortification—the enhancement of micronutrient concentrations in food crops—offers a sustainable, cost-effective, and long-term strategy for alleviating micronutrient deficiencies. Unlike conventional interventions, biofortification has the potential to benefit both rural and urban populations by delivering nutrient-rich foods through regular diets. Biofortification can be achieved through two complementary approaches: genetic biofortification, which involves breeding or biotechnological enhancement of crop varieties, and agronomic biofortification, which involves the application of micronutrient fertilisers and improved crop management practices.

Research on the biofortification of food crops with essential micronutrients is being actively pursued worldwide to address micronutrient malnutrition. Biofortification strategies include both the development of crop varieties with an enhanced genetic capacity to accumulate higher concentrations of micronutrients, such as Zn and Fe, in edible plant parts (genetic biofortification), and application of micronutrient fertilisers to increase the micronutrient content of crops (agronomic biofortification). Although genetic biofortification is considered the most sustainable and cost-effective long-term strategy, agronomic biofortification offers the fastest and most practical approach for rapidly enhancing micronutrient concentrations in crops and improving human nutrition. Furthermore, cultivation of biofortified crop varieties with greater micronutrient uptake efficiency necessitates the replenishment of nutrients removed from the soil through harvest. Therefore, judicious and sustained use of micronutrient fertilisers is essential for maintaining soil fertility and ensuring the long-term success of biofortification programs (Das and Green, 2016).

Soil-Plant-Animal-Human Continuum Study

To elucidate the significance of Zn within the soil–plant–animal–human continuum, a comprehensive feeding study was conducted using Zn-biofortified wheat grains produced on Zn-deficient soils amended with soil and foliar Zn fertilization (Shukla et al., 2014). In this experiment, wheat grains differing in Zn concentration were fed to laboratory rats to assess Zn bioavailability and assimilation. The results demonstrated that rats consuming wheat grains with low Zn concentrations exhibited significantly lower serum Zn levels compared with those fed Zn-enriched grains produced through agronomic biofortification. Conversely, rats fed Zn-biofortified wheat maintained substantially higher serum Zn concentrations, indicating enhanced Zn absorption efficiency and greater bioavailability of grain Zn. These findings provide direct experimental evidence that Zn nutrition in animals is strongly influenced by the Zn status of agricultural soils, which governs Zn uptake by plants, its translocation and accumulation in edible grains, and ultimately its bio-assimilation in animal and human systems. The study thus established a clear functional linkage across the soil–plant–animal–human continuum, highlighting that Zn deficiency originating in soils can propagate through the food chain and adversely affect animal and human health.

This evidence underscores the importance of agronomic Zn biofortification, particularly through combined soil and foliar Zn fertilization strategies, as an effective intervention for improving dietary Zn intake and alleviating Zn malnutrition in populations dependent on cereal-based diets. The findings also reinforce the concept that enhancing soil Zn fertility not only increases crop productivity and grain nutritional quality but also contributes significantly to improving nutritional security and public health outcomes (Shukla et al., 2014).

Micronutrients in Abiotic and Biotic Stress Management

Micronutrients play a pivotal role in enhancing plant tolerance to both abiotic and biotic stresses by regulating a wide range of physiological, biochemical, and molecular processes. These essential elements contribute to stress adaptation through multiple mechanisms, including the activation of antioxidant defence systems for scavenging reactive oxygen species (ROS), stabilization and reinforcement of cell wall structures, modulation of stress-responsive gene expression, and interaction with key signaling and metabolic pathways. By maintaining cellular homeostasis and metabolic integrity under adverse environmental conditions, micronutrients significantly improve plant resilience and productivity. Emerging approaches such as agronomic biofortification, seed priming, and nanotechnology-based micronutrient delivery systems are increasingly recognized as promising strategies for enhancing micronutrient use efficiency and strengthening plant adaptation to stress conditions. Adequate and balanced micronutrient nutrition has therefore become a cornerstone of climate-resilient and sustainable agricultural systems. Furthermore, advances in breeding for nutrient-use efficiency, functional genomics, transcriptomics, and the development of nano-fertilisers are expected to further expand the potential of micronutrient-based interventions for improving crop productivity, nutritional quality, and resilience under changing climatic scenarios (Das, 2025).

Micronutrients and Climate Change

Researchers at Harvard University, USA, reported that climate change has the potential to substantially reduce the nutritional quality of food crops (Myers et al., 2014). The study demonstrated that elevated atmospheric CO_2 concentrations of approximately 550 ppm—a level projected to occur by the mid-21st century under current emission scenarios—significantly decreased the concentrations of essential nutrients, particularly Zn, Fe, and protein, in several major staple crops. The investigation, conducted over a decade across experimental sites on three continents, revealed consistent reductions in the nutritional quality of key food crops, including wheat, rice, maize, and soybean. These findings suggest that rising atmospheric CO_2 levels may exacerbate the already widespread problem of micronutrient malnutrition, thereby posing a serious threat to global food and nutritional security, especially for the billions of people who depend heavily on staple crops as their primary source of dietary minerals and protein (Myers et al., 2014).

Dietary deficiencies of Zn and Fe remain major global public health concerns, affecting an estimated two billion people worldwide and contributing to the loss of approximately 63 million disability-adjusted life years annually. A large proportion of the affected population relies heavily on C_3 cereal grains and legumes as their principal dietary sources of Zn and Fe. However, studies have demonstrated that these crops exhibit significantly lower concentrations of Zn and Fe when grown under elevated atmospheric CO_2 conditions projected for the middle of the 21st century. Experimental evidence from field-based Free-Air CO_2 Enrichment (FACE) studies indicates that atmospheric CO_2 concentrations expected by 2050 (approximately 550 ppm) can substantially reduce the concentrations of essential micronutrients, particularly Zn and Fe, as well as protein content, in major food crops such as wheat, rice, maize, and soybean (**Figure 3**). These declines in nutritional quality are expected to exacerbate the global burden of micronutrient malnutrition and pose a serious challenge to future food and nutritional security.

Micronutrient Requirements

The micronutrient requirements for agricultural and horticultural crops in India are presented in **Table 1**. The current requirement of different micronutrients has been estimated based on the existing extent of soil micronutrient deficiencies, nutrient mining from soils,

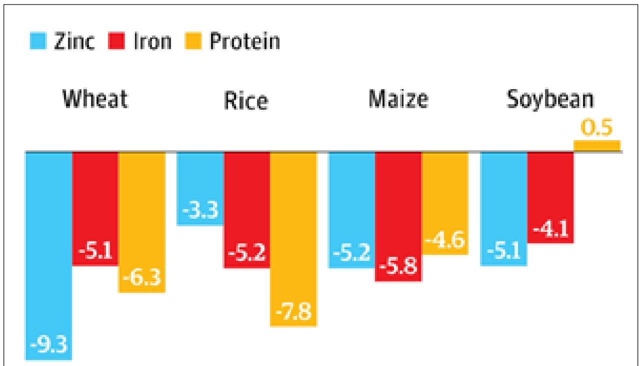

Figure 3. Per cent reduction of nutrients from the staple food crops in an expected level of CO_2 by 2050 (Source: Myers et al., 2014)

Table 1. Micronutrient requirement for agricultural and horticultural crops in India (Source: Shukla et al., 2021)

Micronutrients	Micronutrient requirements ('000 MT)		
	2020	2035	2050
Zn	285	347	402
B	129	147	167
Fe	177	193	216
Mn	118	127	138
Cu	29	31	34

and the recommended micronutrient application rates for various crops. Future micronutrient requirements have been projected by considering the anticipated expansion of micronutrient-deficient areas and the increased nutrient demand associated with agricultural intensification and higher productivity targets by 2035 and 2050 (Shukla et al., 2021b). These estimates underscore the growing importance of micronutrient management for sustaining crop productivity, nutritional quality, and food security in India.

Of the total Zn fertiliser consumption, approximately 70% is utilized in field crops, while the remaining 30% is applied to horticultural crops, including vegetables and fruits. In contrast, the pattern of use for Mn, Fe, and Cu is largely reversed, with nearly 70% of their total consumption occurring in vegetable and fruit crops and only 30% being used in field crops. For B, about 60% of the total application is directed towards vegetable and fruit crops, reflecting their relatively higher demand for B, whereas the remaining 40% is applied to foodgrain and oilseed crops.

Micronutrients in FCO

The Fertiliser (Inorganic, Organic or Mixed) (Control) Order, 1985 (FCO) of India regulates micronutrient fertilisers under the categories '1(g) Micronutrients', '1(h) Fortified Fertilisers', and '1(k) Liquid Fertilisers' listed in Schedule I, Part A: Specifications of Fertilisers. As per the amendments notified by the Government of India up to December 2025, the FCO includes specifications for 25 micronutrient fertilisers, 32 fortified fertilisers, and 5 liquid fertilisers containing micronutrients (**Table 2, 3 and 4**). Among Zn fertilisers, Zn sulphate heptahydrate (ZnSO ·7HO) containing 21% Zn has traditionally been the most widely used source in India.

However, Zn sulphate monohydrate (ZnSO·HO) containing 33% Zn has gained increasing popularity in recent years owing to its higher Zn concentration, better physical characteristics, and improved handling and storage properties. Chelated Zn sources, particularly Zn-EDTA (12% Zn), exhibit 2–3 times greater agronomic efficiency than zinc sulphate fertilisers due to their higher availability and mobility in soils; however, they are 15–20 times more expensive per unit of Zn nutrient. To ensure the quality and safety of micronutrient fertilisers, the FCO prescribes maximum permissible limits for heavy metal contaminants in Zn fertilisers, with concentrations of lead (Pb), cadmium (Cd), and arsenic (As) not exceeding 0.003%, 0.0025%, and 0.01% by weight, respectively.

Micronutrient Fertiliser Policy

The declining response of crops to applied fertilisers and the stagnation of agricultural productivity in many regions of India have been attributed, to a large extent, to imbalanced fertiliser use. The prevailing $N:P_2O_5:K_2O$ consumption ratio remains highly skewed across states and cropping systems, resulting in suboptimal nutrient use efficiency and depletion of secondary and micronutrients from agricultural soils. Furthermore, application of micronutrients is often not aligned with crop-specific nutrient requirements, necessitating concerted efforts by policymakers, researchers, extension agencies, and farmers to promote balanced nutrient management. Recognising this challenge, the Government of India has undertaken several policy interventions to encourage the use of micronutrients. Under the Nutrient-Based Subsidy (NBS) Scheme, additional subsidies are provided for the fortification of phosphatic and potassic fertilisers with micronutrients, amounting to Rs.500 per metric tonne (MT) for Zn and Rs.300 per MT for B. In addition, micronutrient application is promoted under the National Food Security Mission (NFSM) through an assistance of Rs.500 per hectare. The Fertiliser (Inorganic, Organic or Mixed) (Control) Order, 1985 (FCO) also provides specifications for a wide range of need-based micronutrient fertilisers to facilitate their quality assurance and adoption.

It is pertinent to note that fertilisers are generally

Table 2. Micronutrients in Schedule 1 (g) notified in FCO (Source: FCO 1985)

S. No.	Micronutrient based fertilisers	Nutrient content, minimum (%)						
		Zn	B	Mn	Cu	Mo	Other Micro-nutrient	Other nutrients
1 (g) Micronutrients								
1	Zinc sulphate heptahydrate	21						10 S
2	Manganese sulphate			30.5				17 S
3	Borax (Sodium tetraborate)		10.5					
4	Copper sulphate				24			12 S
5	Ferrous sulphate						19 Fe	10.5 S
6	Ammonium molybdate					52		
7	Chelated Zn as Zn-EDTA	12						
8	Chelated iron as Fe-EDTA						12 Fe	
9	Zinc sulphate monohydrate	33						15 S
10	Boric acid		17					
11	Di-Sodium octa borate tetra hydrate		20					
12	Di-Sodium tetra borate penta hydrate		14.5					
13	Zinc sulphate monohydrate	33					1 Fe	15 S
14	Zinc oxide suspension concentrate	39.5						
15	Di-Sodium tetra borate penta hydrate		14.5					
16	Anhydrous borax		20.5					
17	Zinc polyphosphate	16						9 Mg
18	Chelated Zn as Zn-HEDP	17						
19	Chelated iron as Fe-HEDP						17 Fe	
20	Colemanite		11					0.5 Na
21	B ethanolamine		10					
22	Magnesium hydroxide & Zn phosphate	10						24 Mg
23	Manganese carbonate suspension conc.			26				
24	Chelated Manganese as Mn-EDTA			10				
25	Chelated Copper as Cu-EDTA				12			

classified under Chapter 31 of the First Schedule to the Customs Tariff Act, 1975. However, with effect from 6 April 2016, micronutrient fertilisers were reclassified from Chapter 31 (Fertilisers) to Chapter 28 (Inorganic Chemicals). This reclassification resulted in a substantially higher customs duty burden on imported micronutrient raw materials and finished products, leading to an increase in the market prices of micronutrient fertilisers. To promote balanced fertilization and enhance the affordability of micronutrients, it has been suggested that all fertilisers listed under the Fertiliser (Inorganic, Organic or Mixed) (Control) Order, 1985, including micronutrient fertilisers, should be retained under Chapter 31 and accorded customs duty treatment other fertilisers.

GST on micronutrients was 18%. However, the GST Reforms 2.0 announced by the Government of India in September 2025 marked a positive step by reducing the GST rate to 5% for micronutrients covered under Category 1(g). These benefits have not been extended to Category 1(h) (Fortified Fertilisers) and Category 1(k) (Liquid Fertilisers). This exclusion has perpetuated the inverted duty structure faced by micronutrient fertiliser manufacturers, adversely affecting the industry's competitiveness and growth. Extending the concessional GST rate uniformly across all categories of micronutrient fertilisers would not only address this anomaly but also reduce the cost burden on farmers, thereby encouraging the adoption of balanced and sustainable nutrient management practices essential for enhancing soil fertility, crop productivity, and nutritional security.

Challenges

Several technical, economic, and policy-related challenges continue to impede the effective integration of micronutrients into balanced plant nutrition systems, as enumerated below:

i. Micronutrient fertiliser use efficiency in crops remains very low (<5%), which underscores the

Table 3. Fortified fertilisers with Zn and B in Schedule 1 (h) in FCO (Source: FCO 1985)

1 (h) Fortified Fertilisers

1	Bated single superphosphate		16			0.2-0.3	11 S
2	Zincated Urea	43			2		
3	Zincated phosphate (suspension)		14		17.5		
4	Bated NPK complex (10:26:26)	10	26	26		0.2-0.3	
5	Bated NPK complex (12:32:16)	12	32	16		0.2-0.3	
6	Bated diammonium phosphate (18:46:0)	18	46			0.2-0.3	
7	Zincated NPK complex (10:26:26)	10	26	26	0.5		
8	Zincated NPK complex (12:32:16)	12	32	16	0.5		
9	Bated calcium nitrate	14.5				0.2-0.3	
10	Bated nitrophosphate with K (15:15:15)	15	15	15		0.2-0.3	
11	Zincated DAP (18:46:0)	18	46		0.5		
12	Zincated SSP		16		0.5		11 S
13	Bated NPK complex (24:24:0)	24	24			0.2-0.3	
14	Bated single super phosphate (granular)		16			0.2-0.3	11 S
15	Zincated bentonite sulphur				18		65 S
16	Zincated urea ammonium phosphate (28:28:0)	28	28		0.5		
17	Zincated NPK complex (14:35:14)	14	35	14	0.5		
18	Zincated ammonium phosphate sulphate	20	20		0.5		13 S
19	Bated ammonium phosphate sulphate	20	20			0.2-0.3	13 S
20	NPK 14:35:14 fortified with Zn & B	14	35	14	0.5	0.3	
21	SSP fortified with Zn & B (granular)		16		0.5	0.2	11 S
22	Bated sulphur (granular)					1.2	80 S
23	Zincated SSP (granular)		16		0.5		11 S
24	Elemental sulphur fortified with Zn oxide				14		67 S
25	NPK 8:21:21 fortified with Mg, S, Zn & B	8	21	21	1.0	0.2-0.3	2 S, 1.2 Mg
26	NPK 9:24:24 fortified with Mg, S, Zn & B	9	24	24	0.6	0.2-0.3	2.1S,0.3 Mg
27	Bated NP 28:28:0	28	28			0.2	
28	NPK 11:30:14 fortified with Mg, S, Zn & B	11	30	14	1.0	0.2-0.3	1.2 S,0.4Mg
29	SSP fortified with Mg, Zn & B (granular)		16		0.5	0.2	0.5 Mg, 11S
30	SSP fortified with Zn, Fe, B		16		0.5	0.2	0.25 Fe,11S
31	Sulphur with Zn (granule)				8		70 S
32	NPK 14:34:14 fortified with Zn, B, Mo	14	34	14	0.5	0.2	0.01 Mo

Table 4. Liquid fertilisers in Schedule 1 (k) of FCO (Source: FCO 1985)

	1 (k) Liquid Fertilisers						
1	Chelated Zn as Zn-glycine (liquid)				6.8		
2	Chelated B as B-glycine (liquid)					5.0	
3	NK 6:0:18 fortified with Ca, Mg & B (susp.)	6		18		0.5-0.8	5 Ca, 2 Mg
4	NPK 11:11:8 fortified with Zn & B (susp.)	11	11	8	0.7	0.5-0.7	
5	Zinc gluconate				12		

urgent need for innovative and efficient micronutrient fertilisers.

ii. The shortage of quality raw materials poses a significant challenge to the production of micronutrient fertilisers.

iii. The higher GST rate (18%) on micronutrients (other than those listed under clause 1(g) of FCO) and their raw materials has adversely affected manufacturers through an inverted duty structure.

iv. The subsidy rates for fortified fertilisers under the Nutrient-Based Subsidy (NBS) scheme are outdated and require urgent revision.

v. The existing registration process for new micronutrient and specialty fertiliser products require simplification to support ease of doing business and encourage innovation.

vi. A supportive and enabling policy environment is needed to promote the adoption of innovative fertilisers by farmers.

Way Forward

Micronutrient deficiency in both crops and humans constitutes a major global challenge with significant implications for agricultural productivity, food and nutritional security, and public health. A sustainable and long-term solution lies in promoting the balanced use of micronutrients through integrated nutrient management practices that combine organic, inorganic, and biological sources of plant nutrients. Such an approach not only enhances nutrient use efficiency and crop productivity but also contributes to the maintenance of soil health, improvement of crop nutritional quality, and ultimately the sustenance of human health. A favourable and enabling policy framework is needed to promote balanced plant nutrition and sustainable agricultural development.

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