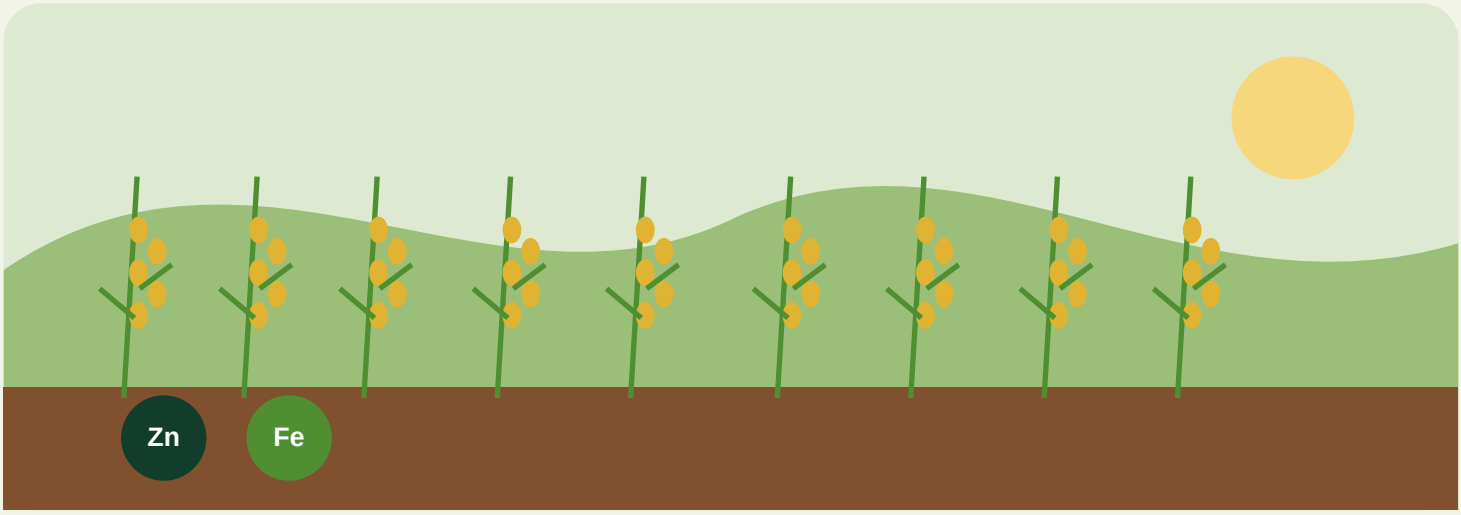
TheFarmScience
WHERE LAB MEETS LAND

VOLUME 1
ISSUE 1
2026

ARTICLE 2

Agronomic Biofortification of Zinc and Iron: An Efficient Approach for Increasing Nutrient Content in Crops and Addressing Hidden Hunger

Preeti Devatwal*, S. K. Yadav and Mahendra Junjariya



ARTICLE OVERVIEW

Explores agronomic methods for increasing zinc and iron levels in food crops, including soil and foliar application, seed priming, biofertilizers, and nanofertilizers. The article discusses how biofortification can improve crop nutritional quality and help address micronutrient deficiencies or hidden hunger.

CROP NUTRITION • MICRONUTRIENTS • FOOD SECURITY

Peer reviewed
monthly magazine

The Farm Science
visit us at www.thefarmscience.com

Article ID: 02/V01/02/0626

AGRONOMIC BIOFORTIFICATION OF ZINC AND IRON AN EFFICIENT APPROACH FOR INCREASING NUTRIENT CONTENT IN CROPS AND ADDRESSING HIDDEN HUNGER

Preeti Devatwal[1*], S.K. Yadav[2], Mahendra Junjariya[1]
[1]Research Scholar, Department of Agronomy, Agriculture University, Jodhpur, Rajasthan 342304
[2]Assistant Professor, College of Agriculture, Kota, Rajasthan, 324009
[*]Corresponding Email:-Preetiwal9@gmail.com

Abstract

Micronutrient deficiencies, particularly iron (Fe) and zinc (Zn), affect billions of people and lead to poor growth, weak immunity, and reduced mental development. Agronomic biofortification is an effective strategy to enhance the nutritional quality of crops and combat hidden hunger. Techniques such as soil and foliar application (0.5%), seed priming, and the use of biofertilizers and nano-fertilizers can significantly increase iron and zinc levels in cereals, pulses, and oilseed crops. Biofortified crops improve nutrition, health, crop yield, and food security. Continued research is needed to maximize the potential of agronomic biofortification in reducing global malnutrition.

Keywords: Agronomic biofortification, Zinc, Iron, Biofertilizer.

Introduction

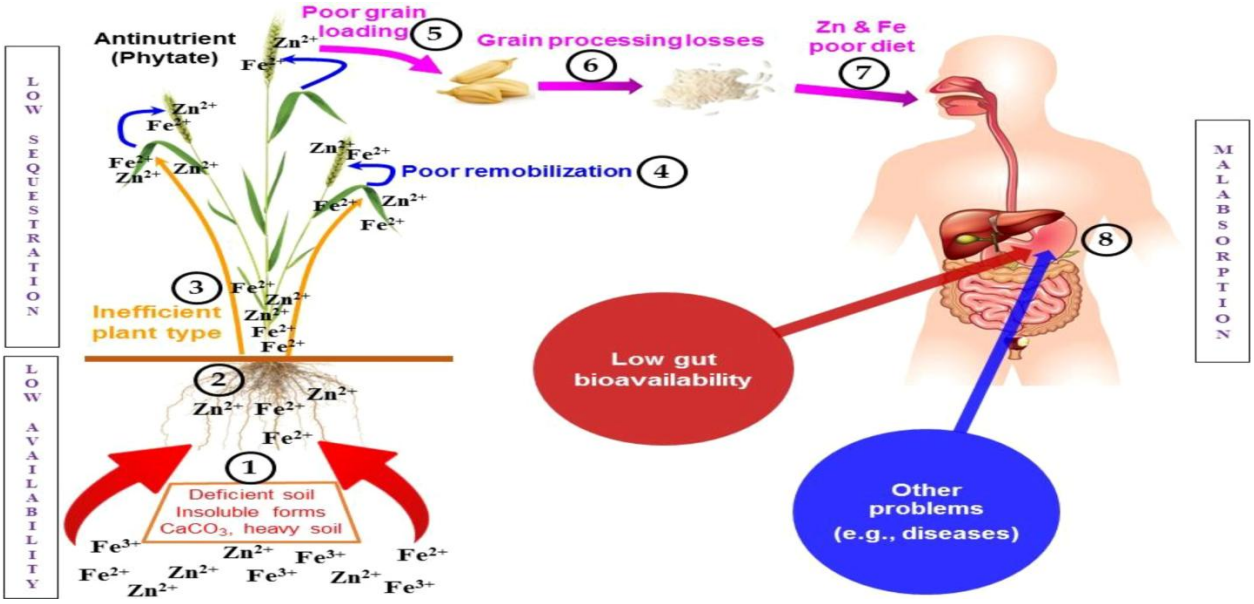
Cereals and pulses are staple food crops for many developing countries and are consumed to meet daily nutritional needs and micro nutrient requirements. However, they lack certain necessary substances, such as micronutrients such as zinc and iron, high-quality proteins, and some important amino acids. According to the World Health Organization (WHO), micronutrient deficiency is generally observed in more than 2 billion people worldwide, with iron and zinc being the most common micronutrients. Zinc (Zn) and iron (Fe) are crucial elements for human health. As the human body cannot produce Zn and Fe, external consumption is important for appropriate Zn and Fe levels in the body. Both micro nutrients catalyze several enzymes. Zn-containing enzymes such as superoxide dismutase (SOD) and RNA polymerase increase the effectiveness of cellular proteins. Biofortification guarantees optimal mineral absorption, micro nutrient transfer to consumable components, and bioavailability. Therefore, adding microelements to crop species through bio fortification can guarantee long-term food security. Biofortification helps in producing micronutrient-rich food crops with increased micronutrient bioavailability. The dual goals of biofortification are to increase the bioavailability and micronutrient content in grains, thereby mitigating the effects of micronutrient deficiencies in humans and animals

Zinc and iron are involved in numerous physiological processes in humans

Zinc (Zn)

Zinc is vital for healthy cell functions, such as DNA replication; RNA and DNA synthesis; transcription; endocrine and immune system functions; differentiation; cell division; growth; cellular transport; physical development; healthy reproduction; and neurobehavioral activity. Zinc is present in relatively high amounts in the muscles, bones, liver, brain and other tissues.

Organ system	Role of Zn
Skin health	Anti-inflammatory and antibacterial qualities, helps to avoid or lessen the incidence of dermatitis, acne, and other skin-related disorders.
Cardiovascular system	Critical part in maintaining the health of blood vessels by enhancing circulation and lowering artery inflammation.
Eye Health	Contributes to clear eyesight and maintains the retina. Prevented eye disorders, like age-related muscular degeneration (AMD) and cataracts
Reproductive system Central nervous system	Responsible for sperm production, maturation, and motility in males and ovulation in females Stimulates antioxidant enzymes such as superoxide dismutase (SOD), which combat oxidative stress and minimize cellular damage.
Immune system	Regulate the intracellular signalling pathways of both innate and adaptive immune cells. Effect on generation of antibodies, activation of inflammation, and differentiation of lymphocytes.
Endocrine system	Necessary for synthesis and structural integrity of insulin.



Iron (Fe)

In addition to Zn, Fe plays a vital role in many processes in the body. It is advantageous for important biological activities, such as the transport of oxygen, the synthesis and repair of DNA, heme synthesis, immunological functions, and cellular respiration, because of its special capacity to provide and receive electrons. It is the major component of haemoglobin (70 %) for the transport of oxygen in blood and of myoglobin, which stores oxygen in muscle tissue, as well as the cytochrome system, and is important for releasing energy in cells through cellular respiration.

Role of iron in human physiology

Organ system	Role of iron (Fe)

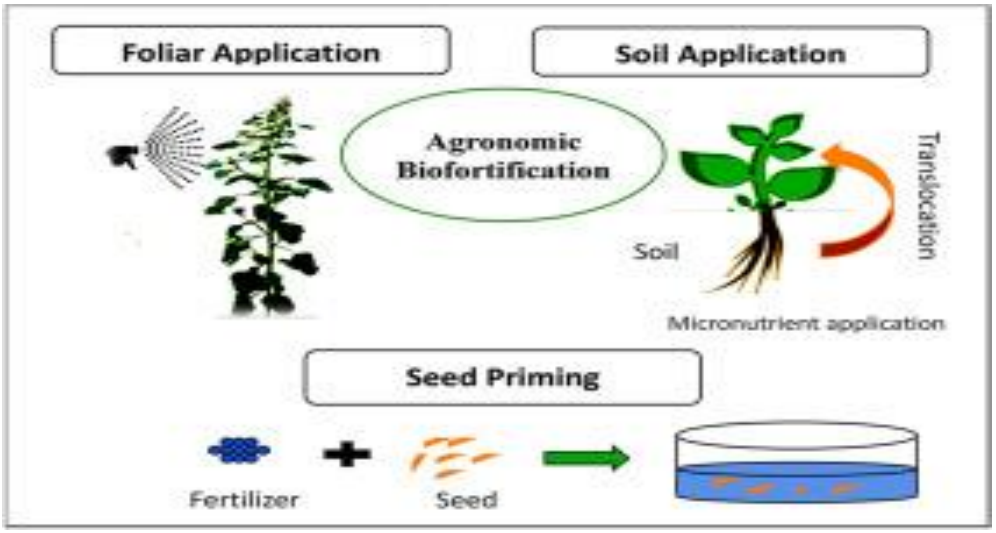
Central nervous system	Essential for healthy brain development and function, particularly in young children, adolescents, and infants. Synthesis and metabolism of neurotransmitters like dopamine and serotonin.
Skin health	Necessary for healthy skin, hairs, mucous membranes and nails. Significant role in regulation of epidermal exfoliation along with determining skin and hair colour. It also aids in cutaneous wound healing.
Reproductive system	Vital for the menstrual cycle due to its role in hormone synthesis and regulation, such as estrogen and progesterone. Affects the health of connective tissues and the proper implantation of embryos in the uterus.
Immune system	Required for the proper functioning of the immune system via the development and proliferation of immune system cells.
Cardiovascular system	Important for several cardiovascular processes, including electrical activity, bioenergetics, and programmed cell death.

Agronomic biofortification techniques

There are several agronomic biofortification methods, and their ef ficacy has been studied globally. The main methods involve soil appli cation, foliar application and seed priming to absorb nutrients (Fig. 1), and foliar application via diluted fertilizer sprays, Nutri priming, bio fertilizers, and nano fertilizer application can also be used. The use of agronomic biofortification has proven to be the most efficient method for enhancing wheat grain quality. The application of Zn and Fe through various agronomic interventions, such as soil, foliar, or seed priming, increases the Zn content in grains and various seed components, including the aleurone layer, endosperm, and embryo.

Soil application

The micronutrients applied through fertilizers in the soil aid in restoring their levels in the soil that support plant or crop growth. This is the most commonly used method for enriching grains with micro nutrients. However, different soil physical and chemical characteristics, along with application methods, times, and fertilizer doses, are responsible for the effectiveness of soil-applied fertilizer. The dose of fertilizer to be applied depends on the crop type in question and the dosage of fertilizer. Higher application rates are typically necessary for problematic soils, such as calcareous and alkaline soils. Regardless of the soil type, the recommended approach in India for alleviating soil Zn shortages is uniform $ZnSO_4.7H_2O$ application @ 5–25 kg ha^{-1}. The soil application of $FeSO_4$ alone increases only the wheat grain Fe content, whereas the application of both Zn and Fe to the soil increases the contents of calcium, magnesium, and copper in wheat grains. It is argued that both soil and foliar applications are more efficient and superior for increasing grain output than their individual applications are.



Foliar application

Compared with soil application, foliar application requires less fertilizer. Since many nutrient fertilizers are soluble in water, they can be sprayed directly onto aerial plant parts. The nutrients applied through foliar fertilization can enter the leaves in many ways, either through the stomata or cuticle penetration, and then they can reach the plant cells for metabolism. After passing through the cuticle, nutrients enter the leaf cells and are then transferred to other areas by plasmodesmata. The important factors influencing foliar absorption include leaf age and spray fluid pH. For example, greater Zn contents accumulate in lentil grains because Zn is applied as a foliar spray during evening hours at the pre-flowering and pod formation stages. Foliar application of Zn is effective because it may easily pass through the cell wall and phloem tissue, reaching both vegetative and developing grain tissues. For all soil types, 0.5 % $ZnSO_4$ spray solution is usually recommended for foliar treatment. Foliar spraying of Fe improved the Fe content in maize kernels. Fe-bio fortified quinoa grains can be produced via foliar Fe treatment. Compared with the control, foliar sprays of iron sulphate, Fe nanoparticles (FeNPs), and chelated Fe fertilizers improved the yield and yield attributes along with the seed weight of broad-bean plants.

Future scope

Although research on biofortification has advanced, certain critical aspects still require attention or improvement to fulfil the primary goal of agronomic biofortification. Initially, a thorough 4R (right source, right amount at the right time, and right place) strategy for Fe and Zn application should be developed at the regional level for different crops. This will help to determine the best combination of fertilizers for achieving high grain Fe and Zn concentrations.