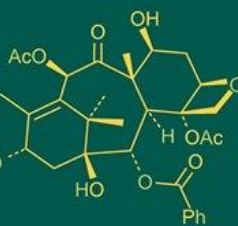
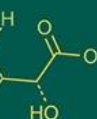
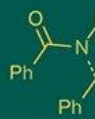


## International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693  
ISSN Online: 2617-4707  
NAAS Rating (2026): 5.29  
IJABR 2026; SP-10(6): 383-386  
[www.biochemjournal.com](http://www.biochemjournal.com)  
Received: 01-04-2026  
Accepted: 04-05-2026

**M Rajeevalochan**  
PG Students, School of  
Agriculture, Uttaranchal  
University, Dehradun,  
Uttarakhand, India

**Dr. Rajat Singh**  
Assistant Professor, School of  
Agriculture, Uttaranchal  
University, Dehradun,  
Uttarakhand, India

**Sharad Pandey**  
Professor, School of  
Agriculture, Uttaranchal  
University, Dehradun,  
Uttarakhand, India

**Nirbhay Simha**  
PG Students, School of  
Agriculture, Alpine Institute  
of Technology, Dehradun,  
Uttarakhand, India

**Harshitha Tyagi**  
PG Students, School of  
Agriculture, Uttaranchal  
University, Dehradun,  
Uttarakhand, India

**Corresponding Author:**  
**M Rajeevalochan**  
PG Students, School of  
Agriculture, Uttaranchal  
University, Dehradun,  
Uttarakhand, India

## A study on the influence of foliar spray of micronutrients on the performance of barley (*Hordeum vulgare* L.)

**M Rajeevalochan, Rajat Singh, Sharad Pandey, Nirbhay Simha and Harshitha Tyagi**

DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i6Se.8624>

### Abstract

One of the four most significant grains in the world, Barley (*Hordeum vulgare* L.) is used for both industrial and human use. One of the main factors limiting the productivity and quality of barley production is the lack of micronutrients in the soil. Since the process of mineral fixation or leaching can be avoided in contrast to traditional soil application procedures, foliar spray of micronutrients has become an accurate and environmentally benign way to give plant nutrients. Based on recent research and experimental findings, this study aims to discuss the impact of foliar applications of several essential micronutrients, including zinc (Zn), manganese (Mn), copper (Cu), boron (B), iron (Fe), and molybdenum (Mo), on the physiological, agronomical, and qualitative aspects of barley plants.

**Keywords:** Barley, foliar fertilisation, micronutrients, zinc, boron, copper, grain quality, yield, sustainable agriculture

### 1. Introduction

One of the oldest cereal crops, barley (*Hordeum vulgare* L.) is still essential to global agriculture because of its versatility, nutritional value, and industrial significance. It is grown in a variety of agro-ecological conditions, such as temperate, semi-arid, and marginal regions where other cereal crops frequently experience significant productivity limitations. Because it can withstand drought, salinity, nutrient-poor soils, and low temperatures, barley is a promising crop for sustainable agricultural production in a changing climate (Karunaratne *et al.*, 2023) [3].

Micronutrients are elements required in small quantities and are required for normal growth and development of plants. They are involved in many biological and chemical reactions such as chlorophyll formation, photosynthesis, enzymes activation, cellular respiration, reproductive development and antioxidants metabolism. The micronutrients of interest are zinc (Zn), boron (B) and copper (Cu). These micro nutrients are important as they play an important role in the metabolic processes involved in development of grains, yield formation and quality improvement. However, intensive farming activities, soil erosion, depletion of nutrients and decline in soil organic matter have resulted in increase in the cases of micronutrient deficiencies in agriculture soil.

Because of the binding, precipitation, and loss processes involved in soil fertilisation with micronutrients, nutrient utilisation inefficiency has always been prevalent. On the other hand, foliar feeding is a good way to give plants micronutrients. It delivers nutrients to the tissues of plants quickly and effectively. Foliar feeding improves nutrient uptake and increases nutrient-use efficiency when compared to soil fertilisation (Alheidary, 2023) [1].

### 2. Importance of Barley

After corn, wheat, and rice, barley (*Hordeum vulgare* L.) is the fourth most important cereal crop in the world. Because of its ability to adapt to environmental stressors like drought, salinity, and low soil fertility, it is grown in a variety of climatic zones and has gained importance. Because of its environmental adaptability, barley is essential to the development of sustainable agriculture techniques, particularly in regions with varied climates (Czembor, *et al.*, 2023) [2].

Barley is used all throughout the world for a variety of purposes, including animal feed, human consumption, and malt manufacture. The livestock business uses the majority of the harvested barley, although the brewing and malting industries use significant amounts due to the grain's advantageous properties. The crop's economic significance has increased due to the growing use of malt barley. Furthermore, barley is a functional food crop due to its abundance of vital nutrients such as dietary fibres,  $\beta$ -glucan, proteins, vitamins, minerals, and antioxidants (Meng *et al.*, 2023) <sup>[4]</sup>.

Barley's capacity to thrive in harsh climates has increased its significance even further. In order to sustain crop yield under abiotic stress conditions, recent studies have emphasised the importance of utilising barley genetic variety and effective nutrient utilisation (Schmidt *et al.*, 2023) <sup>[5]</sup>.

### 3. Micronutrient deficiencies in barley production

Micronutrients are essential for plant growth and development, despite their modest demand levels. These include involvement in the enzymatic process, photosynthesis, respiration, nutritional metabolism, and reproductive processes, all of which support the highest possible crop output. Micronutrient deficiencies, including zinc (Zn), boron (B), and copper (Cu), have been shown to cause serious nutritional stress in barley (*Hordeum vulgare* L.) under intensive cropping conditions with ongoing farming practices that result in declining soil fertility and fertilization imbalances. In many barley-producing soils, an over-reliance on macro-nutrients as fertilizers has significantly reduced the replenishment of micronutrients. Micronutrient deficiencies in soils are mostly caused by the properties of the soil and the weather. Consequently, micronutrient deficiencies have become a major challenge to sustainable barley production, particularly in marginal and resource-constrained environments (Schmidt *et al.*, 2023) <sup>[5]</sup>.

#### 3.1 zinc deficiency in barley

Zinc-deficient barley plants exhibit symptoms such poor tillering, limited leaf development, impaired photosynthesis, and lower biomass production. The mechanisms of carbon and nitrogen metabolism, as well as membrane integrity, are disrupted by zinc deficiency. These physiological problems ultimately result in poor grain formation, poor grain weight, and reduced yield. Recent research has shown that zinc is necessary for increasing the micronutrient content of grains, which can assist treat human zinc shortages through biofortification (Dhillon *et al.*, 2023) <sup>[7]</sup>.

#### 3.2 Boron deficiency

Plant cell wall production, membrane stability, transport of carbohydrates, reproductive development, and pollen tube development all depend on boron. Although barley crops have relatively low boron requirements, they nonetheless require enough to promote reproduction and optimal grain yield.

Boron deficiencies frequently occur in sandy or alkaline soils, as well as in arid regions with restricted nutrient movement. Because boron is essential for pollen germination and fertilisation, a boron deficiency is extremely dangerous during the reproductive stage of barley. Low boron levels can cause light grains, infertility of

the spikes, and a decrease in the number of grains per spike.

### 3.3 copper deficiency

Copper is an essential component of many enzymes that are involved in lignification, respiration, photosynthesis, and stress defence responses. Additionally, regular grain development and reproductive growth require the element. In organic, peaty, sandy, or highly alkaline soils, where copper is naturally limited, barley plants are more susceptible to copper shortage. The problem of copper feeding in barley plants has been clarified by recent investigations. (Aleksza *et al.* 2024) <sup>[6]</sup> claim that a lack of copper can have a significant impact on barley's ability to synthesise phytosiderophores and absorb micronutrients. As a result, it might have an impact on the organism's overall metabolism rather than just one particular biological function.

### 4. Scope of foliar nutrition research

Research on methods of maximising nitrogen utilisation and reducing environmental risks related to conventional fertiliser use has intensified as the demand for sustainable agricultural development has grown. One such method of managing nutrients that can improve crop quality and yield while also avoiding nutrient loss into the environment is foliar nutrition. Because nutrients are delivered directly to plant tissue, the foliar system is more efficient than alternative nutrient delivery methods like soil (Fernández & Brown, 2013) <sup>[9]</sup>.

Since factors including high soil pH, salinity, low organic content, drought stress, and nutrient fixation might hinder nutrient availability, foliar nutrition in barley production is currently gaining a lot of attention. In these situations, foliar fertilisation is a crucial method of addressing nutritional deficiencies and supplying nutrients to meet plant demands when those demands are high. Research has demonstrated that applying micronutrients like Zn, B, and Cu through leaves can significantly improve physiological processes like photosynthesis, enzymatic reactions, chlorophyll synthesis, reproductive development, grain filling, and yield improvement (Dhillon *et al.*, 2023) <sup>[7]</sup>.

Recent developments in foliar nutrition research go beyond just adding nutrients to plants; they now encompass initiatives to improve crop nutritional quality, crop response to different environmental conditions, and nutrient use efficiency. New insights into foliar nutrition, including studies on nutrient uptake, transport, gene-nutrient interactions, stress reduction, and agronomic biofortification, have been made possible by plant physiology, plant molecular biology, and precision agriculture. In order to combat human malnutrition, micronutrient application to leaves has been considered as a means of raising the micronutrient content in cereals (Stadnik *et al.*, 2025) <sup>[10]</sup>.

### 5. Foliar fertilization in barley

#### 5.1 Concepts and principles

Foliar fertilisation is the process of directly delivering nutrients to plant leaves using aqueous solutions or suspensions. Foliar fertilisation allows the use of leaves as entry sites to enable direct nutrient intake and utilisation, in contrast to traditional soil fertilisation, which necessitates nutrient absorption via the roots and subsequent delivery to aerial plant parts. This approach is especially crucial when

conditions restrict the availability of nutrients from the soil or when crops demand more nutrients during specific growth phases. Due to a number of soil constraints, including high soil pH, high salinity, low amounts of organic matter, fixation of soil nutrients, and water stress situations, foliar fertilisation has become increasingly important in barley cultivation as a means of managing crop nutrient requirements.

## 5.2 Nutrient absorption and translocation

In foliar application, nutrients are absorbed through the epidermis, stomata, and cuticle of the leaf. Since the leaf cuticle is the waxy layer covering the leaf, it serves as the main channel for nutrition entry. When nutrients are applied to leaves, they breakdown in the moisture layers and spread via the cuticle's microscopic pores and channels. The process of nutrient uptake is influenced by a number of environmental conditions, including as temperature, humidity, duration of wetness, and light.

Through the apoplast and symplast routes, nutrients are dispersed throughout the plant after entering the leaves. The ability of the plants to transfer nutrients will determine how those nutrients are distributed. For example, boron and copper have weak mobility, whereas zinc has intermediate mobility and can therefore be dispersed to growing portions and grains.

## 5.3 Benefits and limitations

When growing barley, foliar fertilisation has numerous benefits. First and foremost, this approach is advantageous due to its quick action in addressing nutritional deficits, particularly when the amount of nutrients available from the soil is limited. The procedure improves fertiliser usage efficiency by removing soil constraints like as nutrient fixation, precipitation, and loss from leaching. Additionally, since crops only require a small number of nutrients, this strategy is advantageous since extremely little amounts of nutrients may be applied. Lastly, nutrients are supplied to crops throughout critical developmental phases, which can result in increased photosynthesis, reproductive growth, grain filling, yield, and grain quality.

This method's application in climate-smart agriculture is its second advantage. Because there is less moisture in the soil during droughts, roots are less able to absorb nutrients; however, foliar feeding can offer an alternative. Even attempts to improve the nutritional value of grains by bio-fortification employ this technology.

## 6 Zinc nutrition in barley

### 6.1 Physiological functions of zinc

The micronutrient zinc (Zn) is an extremely important element which is indispensable to the growth and development of barley (*Hordeum vulgare* L.). Despite its low requirement, zinc plays a vital role in many biological, biochemical, and molecular processes that control the metabolism of plants. Zinc is both an active and structural element in more than 300 enzymes which participate in protein biosynthesis, carbohydrate metabolism, nucleic acid synthesis, membrane stability, and as a protective antioxidant. Zinc is equally important in the biosynthesis of chlorophyll and photosynthetic assimilation of carbon.

### 6.2 Zinc deficiency and its impact on barley

One of the most prevalent micronutrient deficiencies in

cereals worldwide is zinc insufficiency. Barley is frequently deficient in zinc in calcareous, alkaline, sandy, and low-organic matter soil. Zinc availability and solubility in the soil are reduced by high pH values.

Stunted plant development, reduced internodes, chlorosis in juvenile foliage, and inadequate tillering are signs of zinc deficiency in barley. On a physiological level, a lack of zinc causes problems with photosynthesis, the production of carbohydrates, and chlorophyll. Crop biomass accumulation is impacted by impaired photosynthesis. Additionally, protein synthesis and nitrogen metabolism are hampered by zinc shortage.

## 7 Foliar application of Boron in barley

### 7.1 Importance of Boron application

Barley requires boron (B) as a micronutrient for optimal growth, reproduction, and grain development. Even while crops only require modest levels of boron, a lack of it can significantly reduce output. Cell wall formation, cell membrane integrity, glucose translocation, nucleic acid metabolism, and reproductive processes all depend on boron. Deficits are frequently found in coarse-textured, alkaline, and water-deficient soils because boron availability is dependent on soil moisture, soil texture, soil organic matter, and soil pH. Foliar boron sprays are helpful in overcoming the limitations imposed by soil conditions in these situations.

## 8. Impact of Foliar Micronutrient application and yield and grain quality

Micronutrient foliar treatment has been shown to improve barley crop yield and grain quality. It is simpler to boost nutrient utilisation efficiency and promote the physiological processes of plants that are essential for reproductive development when nutrients are delivered straight into the tissues of the plants. In situations when the soil lacks nutrients, Zn, B, and Cu are crucial for improving growth, vegetative development, yield characteristics, and grain yield and quality.

Zn, B, and Cu applied topically improve barley's vegetative growth. The height, number of tillers, leaf area, chlorophyll content, and dry weight of these plants are all increased as a result of improved photosynthesis and metabolism.

## 9. Challenges and future perspectives

Despite the advantages of foliar fertilisation, the procedure has several limitations. Plant nutrient uptake may be impacted by environmental variables such as temperature, humidity, rainfall, and wind. The leaves may become toxic if the fertilisers are applied too slowly or in the wrong amount. Furthermore, plants have low mobility for micronutrients like copper and boron.

## 10. Conclusion

It has been demonstrated that foliar fertilisation with zinc, boron, and copper is a successful method for increasing barley yield. These micronutrients carry out vital tasks for enzymes, photosynthesis, nutrition, reproduction, and stress tolerance. Foliar fertiliser application increases nutrient-use efficiency and helps overcome nutrient deficits brought on by soil issues. The importance of foliar nutrition in sustainable barley production has increased with recent advancements in fertiliser technology and nutrient management systems. The optimisation of foliar

micronutrient fertilisation strategies for effective barley production will be made possible by additional research on nutrient application methods and technologies.

## References

- Alheidary MHR. Spraying technology and foliar application result in a smooth layer of the spray: a literature review. *Basrah J Agric Sci.* 2023;36(2):310-323. doi:10.37077/25200860.2023.36.2.25.
- Czembor JH. Barley genetic resources: advancing conservation and applications for breeding. *Agronomy.* 2023;13(12):2901. doi:10.3390/agronomy13122901.
- Karunaratne S, Walker E, Sharma D, Li C, Han Y. Genetic resources and precise gene editing for targeted improvement of barley abiotic stress tolerance. *J Zhejiang Univ Sci B.* 2023;24(12):1069-1092. doi:10.1631/jzus.B2200552.
- Meng G, Rasmussen SK, Christensen CSL, Fan W, Torp AM. Molecular breeding of barley for quality traits and resilience to climate change. *Front Genet.* 2023;13:1039996. doi:10.3389/fgene.2022.1039996.
- Schmidt SB, Brown LK, Booth A, Wishart J, Hedley PE, Martin P, *et al.* Heritage genetics for adaptation to marginal soils in barley. *Trends Plant Sci.* 2023;28(5):544-551. doi:10.1016/j.tplants.2023.01.008.
- Aleksza D, Spiridon A, Tarkka M, Hauser MT, Hann S, Causon T, *et al.* Phytosiderophore pathway response in barley exposed to iron, zinc or copper starvation. *Plant Sci.* 2024;339:111919. doi:10.1016/j.plantsci.2023.111919.
- Dhillon BS, Ram H, Kaur H. Yield enhancement and grain vis-à-vis malt quality of barley (*Hordeum vulgare* L.) genotypes as influenced by clipping and foliar application of zinc. *J Plant Nutr.* 2023;46(19):4606-4626. doi:10.1080/01904167.2023.2237526.
- Khan WA, Penrose B, Shabala S, Zhang X, Cao F, Zhou M. Mapping QTL for mineral accumulation and shoot dry biomass in barley under different levels of zinc supply. *Int J Mol Sci.* 2023;24(18):14333. doi:10.3390/ijms241814333.
- Fernández V, Brown PH. From plant surface to plant metabolism: the uncertain fate of foliar-applied nutrients. *Front Plant Sci.* 2013;4:289. doi:10.3389/fpls.2013.00289.
- Stadnik B, Tobiasz-Salach R, Migut D. Impact of foliar application of copper, manganese, molybdenum, and zinc on the chemical composition and malting quality of barley cultivars. *Agronomy.* 2025;15(11):2667. doi:10.3390/agronomy15112667.
- Joško I, Kusiak M, Sozoniuk M, Feculak M, Wu KCW, Fitzgerald M, *et al.* Analysis of multiple biomarkers revealed the size matters of Cu particles for barley response under foliar exposure. *Sci Total Environ.* 2024;918:170673. doi:10.1016/j.scitotenv.2024.170673.
- Stadnik B, Tobiasz-Salach R, Migut D. Influence of foliar application of microelements on yield and yield components of spring malting barley. *Agriculture.* 2024;14(3):505. doi:10.3390/agriculture14030505.
- El Hanafi H, El Ramady H, Qaddoury A, *et al.* Barley responses to copper foliar spray concentrations when grown in a calcareous soil. *J Plant Nutr.* 2018;41(17):2266-2272. doi:10.1080/01904167.2018.1509993.
- Dai F, Zhou M, Shabala S. Understanding the mechanistic basis of ameliorative effects of boron on salinity in barley (*Hordeum vulgare*). *Environ Exp Bot.* 2024;220:105690. doi:10.1016/j.envexpbot.2024.105690.
- Chandrawanshi LR, Singh R. Response of nitrogen and foliar application of boron on growth and yield of barley (*Hordeum vulgare* L.). *Int J Environ Clim Change.* 2023;13(8):418-424. doi:10.9734/ijecc/2023/v13i81969.