Chelating Foliar Fertilizers in Vegetable Crops

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ABSTRACT

Agricultural sustainability faces numerous challenges, including climate change, depletion of natural resources, land fragmentation and soil degradation caused by excessive use of chemical fertilizers. The widespread deficiency of micronutrients, resulting from intensive cropping and high-yielding varieties, has further reduced crop productivity. Foliar application of chelated fertilizers emerges as a promising solution to address these issues. Chelating agents are organic compounds that tightly bind metal ions such as Fe, Zn, Cu, Mg, and Ca, enhancing their solubility, stability and availability to plants. This organic coating allows chelated nutrients to penetrate the waxy leaf surface efficiently, facilitating faster absorption and translocation. Amino acid-based chelates, in particular, improve plant performance, enhance nutrient uptake, and increase the vitamin and protein content of crops. They also help mitigate abiotic stresses such as salinity by acting as buffers and bio-stimulants. Compared to inorganic fertilizers, chelates are more effective at lower doses and are compatible with other agrochemicals, though their high cost and potential environmental persistence pose limitations. Overall, foliar feeding of chelated fertilizers offers an efficient strategy to improve crop growth, yield and quality under adverse conditions, supporting sustainable agricultural practices.

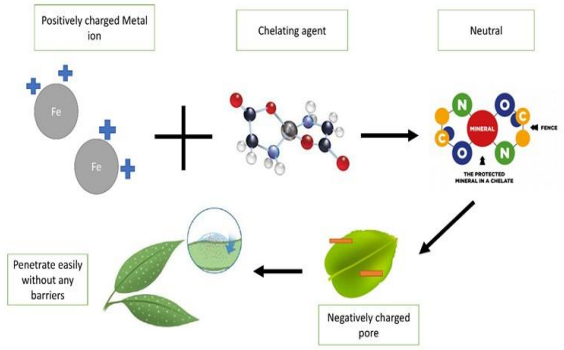
INTRODUCTION

As time progresses, it is evident that we face numerous hurdles in our pursuit of a better and more sustainable world for everyone. Climate change, depletion of natural resources, unsustainable agricultural practices, and land fragmentation, along with an increasing population, question traditional practices in fulfilling the population's needs. Routine chemical fertilizers, which are aimed at increasing yield, are deteriorating the soil at a faster rate. In the past few decades, the deficiency of micronutrients is pronounced due to greater use of chemical fertilizers, intensive cropping, use of high yielding varieties and hybrids, and leaching of micronutrients. These reasons have led to a decrease in the productivity of crops. This creates a need for developing new strategies for coping up with emerging problems. Use of chelating fertilizers is one such approach. Foliar feeding of nutrients is an effective technique towards balanced nutrition and optimum yield, particularly under adverse climatic conditions. In many crops, foliar spray of fertilizers is more preferred to their soil application, especially for the supply of micronutrients such as Fe and Zn under calcareous, drought or salinity conditions. In highly calcareous soils, foliar spray of chelated fertilizers in the form of nutrients has always been the only way to meet micronutrient requirements of crops. Chelated nutrients are more efficient when applied in foliar forms. Plant leaves are characterized by waxy leaves to prevent drying. The wax repels inorganic substances and makes it difficult to penetrate into the leaf. The organic coating around the chelate helps it to penetrate better into the leaf. Once the chelate releases the nutrient in the leaf, the plant makes use of it efficiently.

What are chelating agents?

The word Chelate is derived from the Greek word ‘Chele' which means pincer-like claws of a crab, scorpion or lobster. Chelating agents are chemical compounds that have a greater affinity to bind tightly with a metal ion. A chelating agent is a multidentate ligand, forming at least two and up to eight bonds to a single metal ion. It means inorganic nutrients covered by an organic molecule. The connection between the organic substance and the inorganic metal ion should be sufficiently able to secure the metal ion, yet should be weak enough to deliver the metal ion once it gets into the plant. They protect the metal ions from unwanted chemical reactions and thereby improve their availability for plants (Souri *et al*., 2017).

Out of all nutrients, only few of them can be chelated. They are, Iron, zinc, copper, magnesium and calcium. This is because these metal ions have empty d- orbitals which can easily accept electrons donated by the ligand and form a chelate. An enormous number of metal-chelating agents are accessible to chelate micronutrients. They exist in both synthetic and natural forms. Among the synthetic chelators, EDTA (ethylenediaminetetraacetic acid), EDDHA (ethylenediamine hydroxyphenyl acetic acid), diethylenetriaminepentaacetic acid (DTPA), imidodisuccinic acid (IDHA), and N-(2-Hydroxyethyl) ethylenediamine-N, N, N'-triacetic acid (HEDTA) are well known. On the other hand, natural organic chelating agents are amino acids, polyflavonoids, humic and fulvic acids, lignosulfonates, and polyphosphates. Among them, aminochelates are widely used. They are amino acid-based chelate fertilizers of single or multiple micronutrients. They are a safer and more efficient form of fertilizers, resulting in less environmental risk and better plant performance (Rafie *et al*., 2017).



Advantages

Chelates are known to be beneficial to plants. They are known to enhance the growth and development of plants, thereby increasing the yield. They help the plant to perform better in problematic soils, giving a good yield. They improve nutrient uptake and are involved in agronomic fortification by improving the quality of the crop by increasing its vitamin and protein content. They reduce the toxicity of a few nutrients.

Lower quantities of fertilizers are necessary compared to inorganic compounds since they are completely assimilated by crops. Chelates are thus cost-effective even though they are expensive. They are more easily absorbed by plant leaves because of their organic nature. The leaf pores are negatively charged. When micronutrients are sprayed in their inorganic form, they bind to the pore due to attraction due to opposite charge. During the chelation process, the chelating agent removes the positive charge from the micro nutrients, making them neutral in charge. This allows them to penetrate the leaf surface faster since there will be no restriction barriers. Chelates are more easily translocated within the plant and are easily assimilated by plants. With the use of chelates, the chances of 'scorching' of crops is less because of their organic nature. Chelating fertilizers are compatible with a wide variety of liquid fertilizers and pesticides, as they do not react with their components. Most of them can be mixed with liquid fertilizers and dry mixes. Amino acid chelates are complex chelates where ions are bonded to a mixture of ligands, including glycine, lysine, glutamine, and/or organic acids. Higher Vitamin C content and TSS % were observed with amino acid foliar sprays (Sadak *et al*., 2015). Salt stress is one of the most severe among abiotic stresses, which limits plant productivity. It leads to a rise in toxic levels in older transpiring leaves, it reduces photosynthesis by reducing stomatal conductance. They cause an increase in reactive oxygen species (ROS), ultimately leading to premature senescence. Amino acids, natural chelates contain both acid and basic groups. They act as buffers, which maintain favorable pH in the plant cell. They act as bio-stimulant, having positive effects on plant growth and yield by mitigating the injuries caused by abiotic stresses.

Disadvantages

Chelated compounds are significantly more expensive than inorganic fertilizers. The difference in cost may restrict adoption within areas of low farming incomes. Some common chelating agents (like EDTA) degrade very slowly (are non-biodegradable or have low biodegradability). They may persist in soil or water systems, mobilizing heavy metals or affecting soils' natural chemical balances. The stability of most chelates is pH-dependent; in highly alkaline soils, certain chelates may still break down or become ineffective. Foliar application of chelates is usually a short-term fix (Kaya *et al*., 2008). New leaves that grow subsequent to the application might still be lacking unless soil correction is undertaken as well. Lack of knowledge among farmers or extension agents about how to properly apply foliar chelates.

CONCLUSION

Foliar application of chelating fertilizers is a promising technique for improving the growth, yield and quality of vegetable crops. It

provides a feasible strategy for combating the effects of stress conditions such as salinity, toxicity, and calcareous soils. Various studies have demonstrated that chelated fertilizers exert a superior influence on plant growth and productivity compared to conventional chemical salt fertilizers. Future research should place greater emphasis on comparing nutrient absorption efficiency between soil application and foliar feeding approaches.

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