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Amino Chelate Fertilizers as the Latest Novelties in Plant Nutrition: A Review

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ABSTRACT

Chelates are synthetic compounds which are widely used in cropping systems particularly in Horticulture to improve the micronutrients deficiencies or to increase the micronutrients concentrations in plant tissues. When these synthetics chelate fertilizers are applied on plants, it takes away only the element of nutrition, and the chelator goes into the soil. This synthetic chelates are threat to the environment and to the ecosystem. Amino chelate fertilizers are the latest novelties for plant nutrition in agricultural production system. They represent effective fertilizers for both soil and especially for foliar applications. They are prepared using several amino acids in a preferred manner and are more friendly to plant, environment and human health issues. Compared to other fertilizers or several other commercially available synthetics chelates, such as EDTA, EGTA, DTPA, however, amino chelate fertilizers represent the safer and more efficient forms of fertilizers. In many countries, amino chelates have been quickly dominated in fertilizer market. But there is not enough scientific data and other information detailing about how the plants responded to it. Many studies using amino chelate fertilizers show that plant growth, yield and quality of various vegetables and lettuce plants have been improved.

KEYWORDS: *amino chelate fertilizers, foliar, yield, efficient, scientific data*

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1. INTRODUCTION

Agricultural production of food depends on several policy, economic and biophysical conditions. There are many biophysical threats to agricultural food production like climate change, scarcity of natural resources, land degradation and other unsustainable approaches. [1,2]

Chemical fertilizers are being used in higher amounts in order to increase the crop yield. But their overuse can contribute to the soil acidification and soil crust. This reduces the content of organic matter, humus content, altering the pH of the soil. The deleterious effect of chemical fertilizers begins with the processing of chemicals whose products and by-products are certain harmful chemicals or gases that cause air pollution. Hence, the use of chemical fertilizers poses a great risk to both biosphere and lithosphere. It has harmed plants, humans, animals, and other ecosystem health qualities [3-5]. Its continuous use without taking any remedial action to reduce will ultimately deplete all natural resources and threaten the entire life of the earth.

The detrimental effects of these synthetic chemicals on human health and the environment can be reduced or eliminated by adopting new agricultural technological practises. This includes the use of organic inputs such as manure, biofertilizers, biopesticides, slow-release fertilizers and nano fertilizers [6,7]. Thus, moving away from chemical intensive cultivation.

Organic farming adapts a holistic production management system in agriculture that promotes and improves agro-ecosystem health, including biodiversity, biological cycles and soil biological activity. New strategies and policies are always necessary and required to deal with the emerging challenges.

2. MICRONUTRIENTS FOR HEALTHY PLANT GROWTH

The soil having igneous parent material or other rocks which are high in nutrients can supply the necessary micronutrients, some igneous rocks are high in zinc. The clay soils with high cation exchange capacity or micronutrients in the mineral structure may not require the additional micronutrients. These soils with high cation exchange capacity can "capture" micronutrients and maintain them in ionic form for the plants [8].Micronutrients in the mineral structure are released over a period of time. Soils with high organic matter also tends to maintain micronutrients in bio-available form. But not all the micronutrients' requirements are naturally fulfilled. Synthetic micronutrient fertilizers are supplied to the plants [9].These in the ionic form are available to plants within a very narrow pH range (pH 6.5 to 7.5). the soil with high pH (pH> 7.5) decreases the availability of Cu, Fe, Mn, and Zn. When the soil pH is low, the macronutrients Ca, Mg, Mo may also be limited. This soil application of synthetic micronutrients is challenging and can be more problematic especially in sandy soils or when growing crops which have high micronutrient demands [10].Over a period, many synthetic and organic chelated micronutrients were developed that are less reactive to soil conditions [11].

3. CHELATED MICRONUTRIENTS FOR PLANT GROWTH

Many chelating agents are introduced and applied in cropping systems particularly in horticultural sections, to combat different deficiencies, where routine fertilizers were not able to correct them. Therefore, different synthetic chelates were used extensively in soil to improve the micronutrients bioavailability and plant tissue concentrations.

Soil is heterogeneous and complex and applied traditional micronutrients may become unavailable to the plant because of oxidation or precipitation. Use of chelated micronutrients improves the bioavailability of micronutrients and can contribute to crop quality and yield [12].

Chelated micronutrients are considered when the plant display micronutrient stress, in alkaline soils that limit micronutrient availability or when soil micronutrient supplementation is insufficient. Chelation is a natural plant response to nutrient limitation, particularly under iron and phosphorous deficiency [13]

Chelated micronutrients are fertilizers where the micronutrient ion is surrounded by a larger molecule called a ligand or chelator. Ligands can be natural or synthetic chemicals. These chelated micronutrients are protected from oxidation, precipitation and immobilization in certain conditions. Chelates are molecules with a neutral charge, which is very important. Micronutrients, usually have an electrical charge on them. Soil is generally negative in charge, especially clay soils. These charged metal ions react with soil and be insoluble and not available for plants to use. The pores on the leaves of plants are negatively charged, so positively charged molecules trying to penetrate the plant get tied up at the stomata entrance thus slowing the absorption. The neutral charge of chelated minerals allows them to enter the stomata unimpeded. There are many naturally occurring chelating agents such as amino acids, organic acids, humic, fluvic acids, lignosulphonates, lignin polycarboxylates, sugar acids, phenols, polyphosphates, flavonoids and siderophores. These are generally less expensive, functional over a wider pH range and less toxic to plants.

Amino chelate fertilizers are the latest novelties regarding plant nutrition in agriculture [14]. They are the new formulae of fertilizers which are synthesized using various amino acids. There are 20 amino acids and are the building blocks of protein. Amino acids are moderately strong chelating agents, once inside the plant, the mineral is released, and the remaining amino acid forms the protective shell and are used by the plants as a source of water-soluble nitrogen. The use of amino chelates generally results in higher nutrient uptake efficiency and less negative side effects. This application of amino chelate fertilizers by farmers has increased during recent years. This has claimed on correcting many nutrient deficiencies too.

4. EFFECTS OF AMINO CHELATES ON PLANT GROWTH

In the science literature, it is quite difficult to find a detailed and deep informative study on amino chelate effects on plant metabolism. But, several well organised experiments highlighted the importance of amino chelate compounds as efficient, effective and suitable fertilizers for agricultural applications.

In a recent paper, lysine chelated zinc (Zn-Lys) as foliar application in three concentrations R(0mM, 12.5 mM and 25mM) on maize, growing in different concentrations of tannery wastewater was studied. Foliar spray of Zn-Lys on maize increased the biomass and improved the plant growth. Photosynthetic pigments such as total chlorophyll, chlorophyll a, chlorophyll b and contents of carotenoids also increased with Zn-Lys application [15]

Another 3-year field experiment was conducted on rice seeds where they were sprayed with Zn-EDTA, Zn-Gly and Zn-Glc. It was shown that Zn-Gly was the best at a high spraying rate. The third- year results

demonstrated that two sprays of 0.81% of Zn-Gly by UAV achieved equivalent Zn biofortification levels as those after three sprays of 0.27% $ZnNO_3$ by manual spraying [16]

The efficacy of seed priming, and foliar application of zinc-amino acid chelates including Zn $(His)_2$ and Zn $(Met)_2$ in comparison with $ZnSO_4$ on yield and grain nutritional quality of two common bean cultivars was investigated in a severely Zn-deficient calcareous soil. Seed priming with Zn $(His)_2$ and Zn $(Met)_2$ led to 24.1 and 11.6 % increase in the grain yield of bean [17]. Field experiments were conducted in 2019 and 2020 on two sweet potato cultivars to study the effects of foliar spraying of $ZnSO_4$,Zn-EDTA and ZnGly at normal to high spraying Zn rates of 1.19,2.39, 4.78 and 7.16 kg ha^{-1}. Results showed that ZnGly achieved a higher biofortification level than ZnEDTA and higher yield level than $ZnSO_4$. ZnGly facilitated the most efficient storage of Zn in the edible roots and the highest Zn use efficiency was observed under ZnGly treatment at spraying rates of 1.19 or 2.39 kg ha^{-1}[18]

A pot experiment using oil seed crop grown under different levels of tannery wastewater (0,33,66 and 100%) in the soil using the foliar application of Zn and Fe-Lys has been conducted. Results concluded that exogenous application of micronutrients chelated with amino acid successfully mitigate Cr stress in B. napus[19]

In another study the antioxidant and antimicrobial activities of basil essential oil in response to different Fe sources (Fe-arginine-glycine, Fe-histidine and Fe-histidine nano-complexes) were examined. Fe-histidine nanocomplex was the most effective treatment to inhibit fungal. Hence,the application of iron nano-complexes significantly altered biological and pharmacological characteristics of basil EO's[20]. In an experiment the foliar application of Zn-Lys (0,12.5 and 25 mM) ameliorated the toxic effect of Cd on growth and physiology in tolerant varieties of wheat and rice as compared to seed priming.[21]

A recent study evaluated the effect of zinc-lysine chelate alone (0.1,0.5.1.0 and 1.5%) as seed priming. Results indicated that Zn contents were 18.5% higher in the seeds primed with 1.5% solution of Zn-Lysine chelate. The increase in 100 grains weight over control was 18.4 % and 15.27%. [22]

The effects of three different amino-acid chelate foliar fertilizers on yield, fruit quality, shoot growth and Fe, Cu, Zn and Mn content of leaves in Williams pear cultivar was studied for three years. Amino acid chelated-Fe increased total yield by 64%. In the consideration means of three years, the highest Fe (325.5 ppm), Zn (82.9 ppm), Cu (28.4 ppm) and Mn (66.5 ppm) content of leaves was reached by amino acid chelated -Fe,Zn and multimineral.[23]

Mn (II), Co(II), Ni(II), Cu(II), Zn(II) and Cd(II) complexes of Lysine amino acids have been prepared. These amino acidschelate were evaluated as foliar fertilizers by treating plants with micronutrient, amino acid solutions and varying concentrations of micronutrient amino acids chelates. Spraying the plant with 2.5 % micronutrient amino acid chelates, gave the best results regarding plant height, stem diameter, leaves area, number of flowers, number of branches per plants and total yield per plant.[24]

Another pot experiment was conducted to study the effect of foliar and soil application of amino acids and organic acids chelated micronutrients on growth yield and quality of blackgram. The results showed that foliar application of 1% ferrous glycinate chelate resulted in maximum plant height, PAD value, number of pods $plant^{-1}$, number of seeds pod^{-1}, pod length and 100 grain weight, starch content and protein content of blackgram in calcareous black soil. [25]

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