COMPARATIVE EFFECTS OF FE^{2+} AND FE^{3+} ON THE PLANT GROWTH

EFECTE COMPARATIVE ALE FE^{2+} SI FE^{3+} ASUPRA DEZVOLTĂRII PLANTELOR

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Abstract. *The vegetables contain iron, the highest level of Fe being in plant leaves. The plants absorb iron more as* Fe^{2+} *than ferric compounds. Iron is an essential element required for respiration, photosynthesis, and many other cellular functions such as DNA synthesis, nitrogen fixation, and hormone production. In this work the effects of* Fe^{2+} *and* Fe^{3+} *cations on tomato plant growth.*

Key words: cations, tomato plant, germination, height of plant

Rezumat. *Plantele horticole contin fier, frunzele fiind in cea mai mare parte purtatoarele acestui element. Plantele absorb fierul mai mult sub forma de* Fe^{2+} *din combinatii feroase decat ca* Fe^{3+} *din combinatii ferice. Fierul este un component al unor enzime si transportori de ioni cu functii in sistemul redox al celulei, tocmai datorita capacitatii sale de a-si schimba valenta. Noi am studiat efectul tratamentului cu* Fe^{2+} *si* Fe^{3+} *asupra dezvoltarii plantelor de tomate. In acest scop semintele de tomate au fost mentinute timp de o saptamana in solutii ale unor saruri ce contin acesti cationi, dupa care au fost plantate in ghivece in laboratorul de Biofizica unde s-au dezvoltat la temperaturi de 18-20^{0}C. Studiul nostru a permis evidentierea unor diferente privind efectele celor doua stari ale fierului asupra dezvoltarii plantelor de tomate.*

INTRODUCTION

Iron is an essential element for all living organisms. Although iron is also the most abundant transition metal in the earth's crust, its chemical properties hinder its availability to plants and animals. In the presence of oxygen, iron is essentially under the oxidized form $Fe^{3+,}$ whereas in the organism it is required in the reduced form Fe^{2+}, highlighting the need for a reduction step. In addition, because Fe^{3+} has a very low solubility at neutral pH in oxygenated fluids, the transport of iron under physiological conditions requires a preliminary step that consists of chelation of Fe^{3+} or acidification of the rhizosphere [2]. Anaerobic conditions in acidic soils can lead to cellular iron overload, which causes serious damage to plants because free iron catalyzes the formation of reactive oxygen species. Thus plants need mechanisms to both solubilize and take up Fe^{3+} from their environment, and to store it in a soluble form for later use. n nature, many redox reactions are dependent on iron-containing enzymes whereby electron transport is facilitated by changes in the oxidation state of the metal. Nitrogen fixation and photosynthesis are examples of processes in which iron-containing enzymes play vital roles.

The vegetables contain iron, the highest level of Fe being in plant leaves. The plants absorb iron more as Fe^{2+} than ferric compounds. In all living organism iron is an element of many proteins that participates in metabolic processes. Iron is an essential element required for respiration, photosynthesis, and many other cellular functions such as DNA synthesis, nitrogen fixation, and hormone production. Iron is essential for the production of chlorophyll so symptoms take the form of chlorosis of the youngest leaves, sometimes to the extent of turning white, while the veins stay green, followed by shoot die back. The redox potential of Fe^{2+}/Fe^{3+} enables its use, in the form of iron - sulfur clusters, in a number of protein complexes, especially those involved in electron transfer.

Although abundant in nature, iron often is unavailable because it forms insoluble ferric hydroxide complexes in the presence of oxygen at neutral or basic pH [6]. The transport of iron from the environment, iron distribution to various tissues and organs and intracellular compartmentalization are essential for physiological processes. Iron deficiency chlorosis is a major nutritional problem affecting cultivated plants, characterized by yellowing of young leaves that contrast with the green color frequently observed in the more mature leaves. Cultivated plants differ in their susceptibility to Fe deficiency depending on their mechanisms of Fe acquisition, particularly in their ability to release Fe-chelating compound. In sensitive plants, severe Fe deficiency results in high economic losses, particularly in perennial crops. Iron deficiency occurs mainly on high pH soils or where irrigating with hard water has eventually caused the pH to increase. Although Fe chlorosis has traditionally been related to the carbonate content of soil, other properties such as the types of Fe oxide present and their content, organic matter, water content, redox potential, carbonate mineralogy, and nutrient competition may also influence Fe availability to plants. The effects of iron deficiency on the composition of the xylem sap and leaf apoplastic fluid have been characterized in sugar beet by Lopez et al [5]. Larbi and coworkers [4] have been investigated the characteristics of the Fe-chelate reductase activity in mesophyll disks of Fe-sufficient and Fe-deficient sugar beet leaves.

Iron toxicity is another phenomenon which affects the plants. Fe content in affected plants is usually high (300-2,000 mg Fe kg^{-1}), but the critical Fe content depends on plant age and general nutritional status. The critical threshold is lower in poor soils where nutrition is not properly balanced. The principal causes of Fe toxicity are large Fe^{2+} concentration in soil solution because of strongly reducing conditions in the soil and/or low pH, low and unbalanced crop nutrient status, poor root oxidation and Fe^{2+} exclusion power because of P, Ca, Mg, or K deficiency (K deficiency is often associated with low soil base content and low soil pH, which result in a large concentration of Fe in the soil solution, accumulation of substances that inhibit respiration (e.g., H_2S, FeS, organic acids,), application of large amounts of undecomposed organic matter, application of urban or industrial sewage with a high Fe content [7]. ynalem and Righetti [1] developed a digital-image evaluation system to study in wire-stored plantlets. Image analysis was compared to visual observations in an experiment designed to determine if the improved vigor of growthroom plantlets on medium with sequestrene iron would be maintained during cold storage and whether the mean storage duration would change with changes in the iron content of the medium. The authors concluded that changes in the health of the plantlets could be observed both visually and through digital image analysis. Recent years we studied the effects of other cations on tomato plant development [3].

In this work we studied the effects of Fe $^{2+}$ and Fe $^{3+}$ cations on tomato plant growth.

MATERIAL AND METHOD

In order to study the effects of Fe $^{2+}$ and Fe $^{3+}$ cations on tomato plant growth, we putted 20 seedlings of tomato (Buzau variety) in Petri dishes containing water and solutions of 5% concentrations from two salts which contain iron. We sorted the following variants

1-control
2- treatment with K4[Fe(CN)6] (Fe^{2+})
3- treatment with [Fe(CN)]K3 (Fe^{3+})

and we maintained them there, during a week. First we monitored the dynamics of germination and after a week only the control seedlings were germinated. Then we planted the tomato seedlings in pots. After that we monitored the plant growth during four weeks.

RESULTS AND DISCUSSIONS

The dynamics of plant germination is presented in figure 1. Figure 2 presents the height of tomato plants after two weeks.

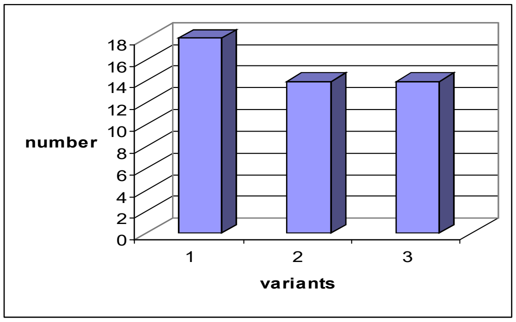

Figure 1 **The number of plant after two weeks**

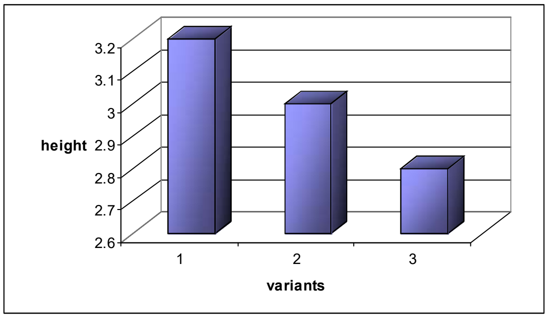

Figure 2 - **The height of plant after two weeks**

From figure 1 we can see that iron produces an inhibition of germination by comparison with the control but no difference exist between the treatments with the two salts which contain iron. From figures 2 we can see that the height of treated plants is smaller that the control ones; this means that these treatments are toxic for studied plants. The toxicity is higher for treated plants with Fe^{3+}. These differences are attenuated after 24 days (the height of plants after 24 days is presented in figure 3).

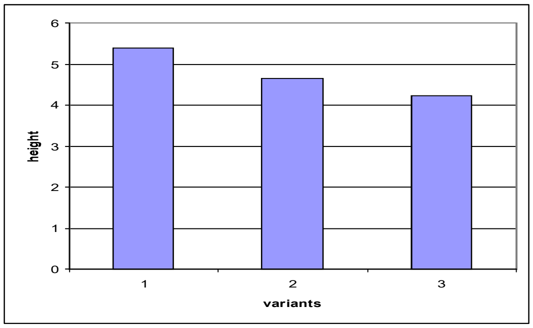

Figure 3 - **The height of plant after 24 days**

CONCLUSIONS

Our measurements showed that iron salts produce an inhibition of germination and a decrease of the height of plants by comparison with the control ones and the effect is higher for salt which contain Fe^{3+}.

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