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Investigating the morphophysiological and biochemical indicators of parsley (*Petroselinum sativum*) using iron chelate and iron nano-chelate

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Extended Abstract

Introduction: Parsley (*Petroselinum sativum*) is a widely cultivated herb, renowned for its rich content of essential micronutrients, vitamins, and phytochemicals, which contribute to its broad application in food, pharmaceutical, and cosmetic industries. Iron (Fe) is one of the critical micronutrients in plant metabolism, necessary for various physiological processes such as photosynthesis, respiration, and nitrogen fixation. However, its availability in alkaline soils is often limited due to its low solubility, which can cause iron deficiency and result in chlorosis and reduced plant performance. Iron chelates, particularly nano-iron chelates, are gaining attention as innovative fertilizers due to their enhanced solubility and plant uptake efficiency. This study investigates the impact of iron chelate and nano-iron chelate on the morphophysiological and biochemical traits of parsley, assessing their potential to improve plant growth and nutritional quality.

Methods: The study was conducted in a commercial greenhouse in Garmsar, Iran, using a completely randomized design with five treatments, three replications, and each replication consisting of three pots. Parsley seeds (*Petroselinum sativum*) were planted in pots filled with sandy loam soil and grown under controlled conditions. Iron chelate (Fe-EDDHA) and nano-iron chelate, at concentrations of 0, 2.5, and 5 g/L, were applied as foliar sprays during the 4-leaf and 6-leaf growth stages. The study measured several growth and biochemical parameters, including fresh and dry weights of shoots and roots, total chlorophyll content, iron concentration in plant tissues, and the activities of key antioxidant enzymes such as superoxide dismutase (SOD) and peroxidase (POD). Statistical analysis was performed using SAS software, and mean comparisons were made using Duncan's multiple range test at 1% and 5% significance levels.

Results: The results indicated that the application of both iron chelate and nano-iron chelate significantly influenced various growth and biochemical parameters. The highest fresh and dry weights of both shoots and roots were observed in the treatment with nano-iron chelate at 5 g/L. This treatment also resulted in the highest total chlorophyll content (4319.5 mg/g fresh weight) and the highest iron content in plant tissues (79.23 mg/g dry weight). The enzyme activity results showed that the highest superoxide dismutase (SOD) activity (46.2 units/mg fresh weight) was recorded in the nano-iron chelate 5 g/L treatment, while the highest peroxidase (POD) activity (41.8 units/mg fresh weight) was observed in the iron chelate 5 g/L treatment. These findings suggest that nano-iron chelate provides superior plant nutrition, enhancing both growth and antioxidant defense mechanisms.

Discussion: The results of this study are consistent with previous research indicating that the availability of iron plays a critical role in enhancing plant growth and improving metabolic functions. Iron is integral to photosynthesis and chlorophyll synthesis; hence, its adequate supply directly impacts plant health and productivity. The increased chlorophyll content and higher iron accumulation observed in plants treated with nano-iron chelate can be attributed to the enhanced bioavailability and uptake of iron due to the nano-structural properties of the chelate. These findings are in line with studies that report improved plant growth and higher chlorophyll content with nano-iron applications compared to traditional chelates. Furthermore, the increased activity of antioxidant enzymes in treated plants reflects enhanced stress resistance, which is vital for maintaining plant health under various environmental conditions. The superior performance of nano-iron chelates over traditional iron chelate could be explained by the higher surface area and reactivity of nanoparticles, which facilitate more efficient nutrient uptake. Additionally, the slower and controlled release of nutrients from nano-chelates minimizes nutrient leaching and enhances nutrient use efficiency, making them an effective alternative to conventional fertilizers.

Conclusion: This study demonstrates that foliar application of iron chelate and nano-iron chelate significantly improves the morphophysiological and biochemical characteristics of parsley. Among the treatments tested, nano-iron chelate at a concentration of 5 g/L was most effective in enhancing plant growth, chlorophyll content, iron accumulation, and antioxidant enzyme activity. Therefore, the use of nano-iron chelate is recommended for improving parsley growth and quality, offering a sustainable alternative to conventional iron fertilizers. Further research is needed to explore the long-term effects of nano-iron chelates on different plant species and under varying environmental conditions.

Keywords: Iron, Iron Chelate, Iron Nano Chelate, Parsley