Impact of antioxidants on plants following exposure to iron

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abstract

Heavy metal toxicity, a problem of growing importance for ecological, evolutionary, nutritional, and environmental reasons, is one of the major environmental pollutants. The heavy metal contamination of soil has evolved to be a worldwide concern, resulting in reduced productivity in agriculture, for these reasons this research aimed to exam the effect of Fe element on *Capsicum annuum*L plant and the results recorded the toxic effect for Ironelement(Fe) on some biochemical characteristic,at iron concentrations (0,750, 1500, 3000) ppm were determined from $(FeCl_3)_2$ in addition to control (D.W.) astriplicate for each concentration *Capsicum annuum*L buds irrigate with age (30) day and afterimplantation in fertilized soil and the irrigation continue for(5weeks). On the other hand, regarding soil pH, E.C. and soil texture values were determined to detect the soil characteristics after implant.The results have confirmed at the end of the experiment and from plant species analysis that iron concentration in irrigation water were led to change in ROS, SOD, CAT, MDA, GSH-px, chlorophyll & moisture content in *Capsicum annuum*L.

Key words: *Capsicum annuum* L, Biochemical factors, chlorophyll, antioxidants parameters, heavy metal, Fe

تأثير مضادات الأكسدة على النباتات بعد تعرضها للحديد

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الخلاصة:

سمية المعادن الثقيلة (الملوثات البيئية الكبيرة) التي كانت مشكلة ذات أهمية متزايدة لأسباب بيئية وتطورية وغذائية وبيئية. أصبح تلوث التربة بالمعادن الثقيلة مشكلة في جميع أنحاء العالم، مما أدى إلى فقدان الإنتاجية الزراعية، ولهذه الأسباب يهدف هذا البحث إلى فحص تأثير عنصر الحديد على نبات الفليفلة السنوية وسجلت النتائج التأثير السام للعنصر الحديدي (Fe) على بعض الخصائص الكيميائية الحيوية، عند تركيزات الحديد (0،750، 1500، 3000) جزء في المليون تم تحديده من 2 (FeCl3) بالإضافة إلى التحكم (.D.W) أستريبليكات لكل تركيز تري براعم الفليفلة السنوية مع العمر (30) يوما وبعد الزرع في التربة المخصبة ويستمر الري لمدة (5 أسابيع). من ناحية أخرى، فيما يتعلق بدرجة الحموضة في التربة، تم تحديد قيم .E.C وقيم نسيج التربة للكشف عن خصائص التربة بعد الزرع. وقد أكدت النتائج في نهاية التجربة ومن تحليل الأنواع النباتية أن تركيز الحديد في مياه الري أدى إلى التغيير في ROS و SOD و CAT و MDA و GSH-px والكلوروفيل ومحتوى الرطوبة في *Capsicum annuum L*

Introduction

In particular in environmental situations, heavy metal (H.Ms) can be When a dense metal or metalloid is recognized to be toxic as a harmful properties [1].Excessive concentrations of heavy metals—which are naturally occurring but have become concentrated due to human activity—may attach to important biological components in plants, animals, and human tissues and interfere with their ability to function. Heavy metals can also enter these tissues through ingestion, diet, and manual handling [2]

H. Ms were important environmental contaminants, and for ecological, evolutionary, nutritional, and environmental reasons, their toxicity is a growing concern [3] Heavy metal poisoning of soil has grown to be a global issue, resulting in decreased agricultural productivity [4].

It is generally recognised that high concentrations of heavy metals have an impact on several physiological and metabolic processes, and that plants have a remarkable capacity to absorb and accumulate heavy metals from their external environment[5]. However, when animals and humans consume plants that retain heavy metals, the organisms may become hazardous to them[6]. H. Ms are regarded as a significant stressor for plants. Plants have a great ability to absorb heavy metals, which is helpful in bioremediation [8,9] if there is a natural concentration of heavy metals in the soil [7]. However, plants' cellular and physiological functions are negatively impacted by excessive quantities of heavy metals [10].

Iron effected plant by primarily engaged in photosynthesis in plants. The pH of the soil determines which micronutrients are available to plant roots; low pH soil has more easily available iron, Manganese (Mn) and iron (Fe) are both vital for plant growth and development, but because an abundance of one of these micronutrients decreases the other's availability to plant roots, they usually compete with one another for absorption[11].

In addition to that Fe considered as a major constituent of the cell redox systems such as heme and proteins including cytochromes, catalase, peroxidase and hemoglobin and ironproteinsincludingferredoxin,aconitase and superoxide dismutase (SOD) [12].

Fe as an essential element for all plants has many important biological roles in the processes as diverse as photosynthesis, chloroplast development and chlorophyll biosynthesis. Although most mineral soils are rich in iron, the expression of iron toxicity symptoms in leaf tissues, occurs only under flooded conditions which involves the insoluble Fe+3 microbial reduction Fe+2 insoluble[13]. Reductions in plant photosynthesis and yield,Tobacco, canola, soybean, and Hydrilla contain iron that is linkedas hazardousverticillate to elevated levels of oxidative stress and ascorbate peroxidase activity [14]. High Fe+2 uptake through the sources and mode of transportationare linked to the emergence of iron toxicity in plants. through the transpiration stream and to leaves.

The generation of free radicals from the Fe+2 excess damages cellular structure permanently and damages membranes [15], although iron poisoning is rare, certain plants do release acids from their roots that cause the pH of the soil to drop [16]. These vegetation may become poisonous if they absorb too much iron. Numerous research have examined the impact of antioxidant activity on plants under heavy metal stress across a range of plant species [17,18]. Fe has grown more dangerous among agricultural soil contaminants as a result of its use in fungicides, fertilizers, and pesticides[19]

Materials & Methods

Soil preparation for agriculture: Soil samples were collected from an area known as the fertility of their agricultural soil and then distributed in plastic sticks with equal weights of (1 kg) each to growplant*capsicum annuum* budsby age (30 days) thenwas:

Watered with solution ($FeCl_3$) for (Concentrations 0,750,1500,3000) ppm. with three replicates per concentration with 3 replicates for control .replicates per concentration with 3 replicates forthe plants were still wateringin the concentrations for 5weeks**.**

Environmental parameters: Hydrogen Ions// were measured by a pH meter Type Hanna (Portugal) after calibration by standard solutions provided with instrument in the soil extract 1:1 [20]

Electrical conductivity (E.C)// A conductivity meter in Spilled saturated soil paste was used to measure the Electrical conductivity and results was expressed as (µs/cm). Soil Texture was estimated using Hydrometer (Gm/L) capacitor (ASTM) (15H) and depending on the method described by [21] **Biochemical parameters for plant//** The amount of chlorophyll was estimated for plant leaves using a chlorophyll measuring device chlorometer and by unit values SPAD.

Preparation of plant extracts// A method which [22] was used to prepare the plant extract, where it was taken (0.1 gm) from fresh leaves and crushed in 1 ml of the Phosphate buffer solution and added (0.03gm) Poly vinyl pyrrolid one (PVP) in a pre-cooled ceramic veneer placed on ice packs to prevent enzyme breakdown. Centrifuge at 10,000 cycles 10 minutes under 4 ° C.

Antioxidant Enzymes Determination: Reactive oxygen species (ROS)// is determine using method [25] and given as micro molar H2O2 equivalent per liter (Equiv. H_2O_2 µmol/L). Measurements of glutathione peroxidase (GHS-px), catalase (CAT), and superoxide dismutase (SOD) in plants in addition to Malon dialdehyde (MDA) by using enzyme linked immune sorbent assay (sand wash Elisa) technology according manufacturing company (PARS BIOCHEM ,CHINA)

Results and discussion

The chlorophyll in results was neutral and ranged between (37-40) in *capsicum annuum L.* were results of the absence of significant differences in the content of chlorophyll after exposure to Fe element of evidence of plant tolerance to these concentrations of the due to the low concentration of heavy element in the vegetative part of them was collected in the root as noted in results. complexes with dissolved organic matter [23].The results of this study excepted with results of [24], which showed that the pH values for plant nutrient solutions at neutral condition which had been decrease for most measured parameters, whereas pH didn't write more than 4.0.

The nutritional solutions' pH increased as a result of the other Fe treatments. While the excretion of riboflavin decreased with increasing added Fe, the pH of the solution, the mass of roots and shoots, and the chlorophyll content of the apical leaf remained rather constant at the three highest Fe concentrations.

Over consumption of riboflavin can act as a ferredoxin replacement by forming flavodoxin with Fe stress[25]. A study of iron toxicity on, revealed that the concentration of was shown to impede the development of species of 3000 ppm whole Fe agreement with [26]. Acid soils restrict *Capsicum annuum L*production and element shortage combine to create a macronutrient imbalance in*Capsicum annuum L*.High concentrations of reduced iron (Fe2+) in the flooded soils had a significant impact on the yield of perished plants. High absorption of Fe2+ by roots, acropetal translocation into leaves, yellowing of the capsicum leaves, and yield loss are characteristics of iron toxicity in capsicum[26] in PH value was Heading to the base higher value 6.13 in con.750 ppm of Fe

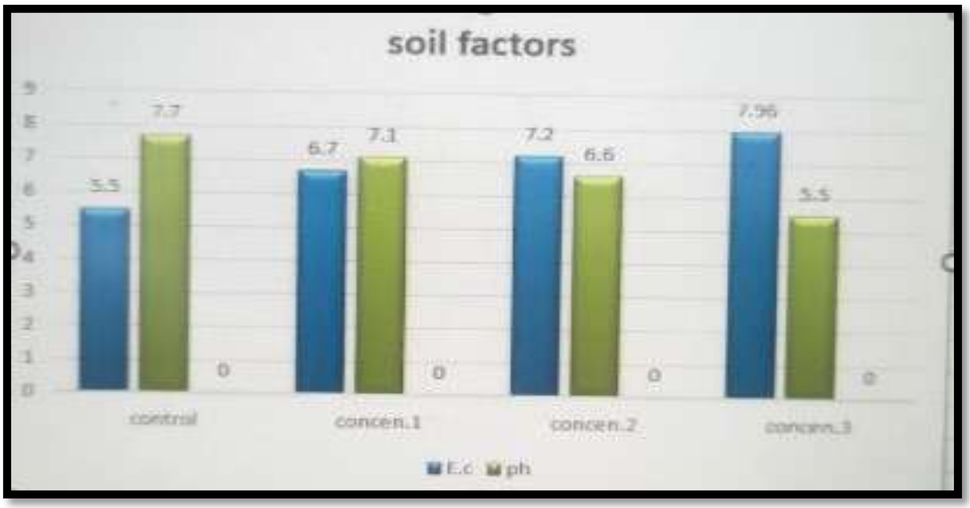

Figure (1): Environmental parameters on soil exposure to Fe H.Ms

This finding is consistent with the hypothesis that hydrolysis of Fe Ferrous iron is changed into ferric iron, which releases hydrogen ions and raises metabolic acidity, as a result of free iron interfering with oxidative phosphorylation [27].

Additionally, lipid peroxidation brought on by free iron can seriously harm microsomes, mitochondria, and other cellular organelles [28]. Because iron is toxic to cells, it can cause tissue damage through cellular oxidizing and reducing pathways as well as toxicity to intracellular organelles including mitochondria and lysosomes. An excess of iron in the diet produces a broad range of free radicals that are thought to have the ability to damage cells. Free radicals generated from iron damage DNA, causing cellular damage, mutations, and malignant changes that ultimately lead to a variety of diseases [29]and that the presence of differences in the concentration of GPX after the exposure Fe H. M in *Capsicum annuum L*,agreement with [30] which reported that GPX behaved as a plant growth regulator and maintains the osmotic adjustments, protects cells against ROS accumulation under Fe stress**.**

GPX degreased in *Capsicum annum L.*, the decrease in MDA activities that block important functional groups, substitute heavy metals for vital metals, alter the structure or integrity of a material, or any combination of these could be cytotoxic. of SOD Sensitivity to heavy metals toxicity has been reported among different plant species [31]. The MDA content of the plant may be obtained when exposed to some of the heavy elements as it is exposed was decreased.

Table (1): Biochemical Environmental Factors comparison on *Capsicum annuum L.* exposure to different concentrations of Fe (H. Ms)

FACTORS	CONTR. M± S.D.	CONC. 1 M± S.D.	CONC. 2 M± S.D.	CONC. 3 M± S.D.
ROS	0.373±0.211 b	0.94±0.079 a	1.183±0.023 a	0.000 c
SOD	11.277±1.424 a	5.463±1.27 b	4.757±0.4887 b	0.000 c
CAT	0.948±0.0271 b	1.205±0.139 ab	1.116±0.089 ab	0.000 c
GSH	4.1±0.361 b	6.39±2.125 b	11.647±0.821 a	0.000 c
MDA	0.286±0.055 a	0.228±0.099 a	0.207±0.134 a	0.000 c
wet weight	86.2 a	87.233333 a	86.5 a	0.000 b
chlorophyll	37.067 a	40.43 a	39.7 a	0.000 b

different letters per class indicates significant differences (P≤ 0.05).M: Mean, S.D.: Standard deviation

Chloroplast is very sensitive to ROS because of high fat content of fatty acids. In addition, the ROS group from the photovoltaic construction process is under Oxidative tensile stress is compounded by Thylakoid membrans [33], and degreased the value MDA in *Capisum annum* possible cause is due to the increased the time of exposure to heavy elements, which led to necrosis and damage to plant cells , which would stop production MDA after that and this agreement with [34].

Conclusions:

When plants are grown in soil contaminated with heavy metals, their growth is reduced as a result of altered physiological and biochemical processes. This is particularly true when the heavy metal in question has no favorable effect on the growth and development of plants.Because of the harmful consequences that heavy metal use and presence have on plants, more research is needed to better understand the effects of heavy metal toxicity on plants and related ecosystems in order to preserve the ecological balance of our world. The relationship between plants and heavy metals has two facets. On the one hand, the heavy metal Fe has detrimental effects on plant growth and development. (*Capisum annum L.*) in higher concentration (3000 ppm.) considered lethal dose , and found Plants possess inherent defense systems against harmful substances and for heavy metal detoxification. (750ppm ,1500 ppm). Our research revealed that expansion. The existence of heavy metals has an impact on. Because of their buildup in soil, heavy metals are hazardous.

References

[1] Wuana, R.A. and F. E. Okieimen, "Heavy Metals in Contaminated Soils: A Review of Sources, Chemistry, Risks and Best Available Strategies for Remediation," ISRN Ecology, vol. 2011,no. pp. 402647, 2011.

[2] Manara, A. "Plant Responses to Heavy Metal Toxicity. Plants and Heavy Metals", Springer Briefs in Molecular Science,Springer,pp.27-53,2012.

[3] Kaur, S. N. Kaur, K.H. M. Siddique, and H. Nayyar, "Beneficial elements for agricultural crops and their functional relevance in defense against stresses", Arch Agron Soil Sci,vol.62,no.7,pp. 905-920, 2015

[4] Wang, H., Y. Duan, Y. N. Li and M. Liu, "Experimental Study on Mercury Oxidation

in a Fluidized Bed under O2/CO2 and O2/N2 Atmospheres", Energy Fuels, vol.30, no. 6,pp.5065– 5070,2016

[5] Nagajyoti PC, Lee KD, Sreekanth TVM. (2010). Heavy metals, occurrence and toxicity for plants: a review. Environ Chem Lett 8 (3): 199–216.

[6] Najeeb U, Ahmad W, Zia MH, Malik Z, Zhou W. (2014). Enhancing the lead Phyto stabilization in wetland plant Juncus eff usus L. through some a clonal manipulation and EDTA enrichment. Arab J Chem [in press].

[7] Suda, A., and T.Makino, "Functional effects of manganese and iron oxides on the dynamics of trace elements in soils with a specialfocus on arsenic and cadmium: A review", Geo derma, vol.270, pp. 68–75, 2016.

[8] Patrick, L. (2003). Toxic metals and antioxidants: Part II. The role of antioxidants in arsenic and cadmium toxicity. Altern Med Rev 8(2): 106–128

[9] Shivhare, L., S Sharma, "Effect of Toxic Heavy Metal Contaminated Soil on an Ornamental Plant Georgina wild (Dahlia)", J Environ Anal Toxicol ,vol. 2,no.7,2012.

[10] Ryan TP, Aust SD. (1992). The role of iron in oxygen-mediated toxicities. Crit Rev Toxicol 22: 119–41

[11] Andia JB. (1996). Aluminum toxicity: its relationship with bone and iron metabolism. Nephrol Dial Transplant 11 Suppl 3: 69–73.

[12] Asmelash, F., Bekele, T., & Birhane, E. (2016). The potential role of arbuscular mycorrhizal fungi in the restoration of degraded lands. Frontiers in microbiology, 7,1095

[13] aishankar, M., Tseten, T., Anbalagan, N., Mathew, B. B., & Beeregowda, K. N. (2014). Toxicity, mechanism and health effects of some heavy metals. Interdisciplinary toxicology, 7(2), 60-72.

[14] Sinha S, Guptha M, Chandra P (1997) Oxidative Stress induced by iron in Hydrilla verticillata (i.f) Royle: response of antioxidants. Ecotoxicol Environ Safe 38:286–291.

[15] Rehman, A. U., Nazir, S., Irshad, R., Tahir, K., ur Rehman, K., Islam, R. U., & Wahab, Z. (2021). Toxicity of heavy metals in plants and animals and their uptake by magnetic iron oxide nanoparticles. Journal of Molecular Liquids, 321, 114455.

[16] Tripathi, D. K., Singh, S., Gaur, S., Singh, S., Yadav, V., Liu, S., ... & Sahi, S. (2018). Acquisition and homeostasis of iron in higher plants and their probable role in a biotic stress tolerance. Frontiers in Environmental Science, 5, 86. United Nations Environmental Protection/Global Program of Action

[17] Kumar, A., & Prasad, M. N. V. (2018). Plant-lead interactions: transport, toxicity, tolerance, and detoxification mechanisms. Ecotoxicology and environmental safety, 166, 401-418.

[18] Gjorgieva, D., KadifkovaPanovska, T., Ruskovska, T., Bačeva, K., and Stafilov,T.(2013). Influence of heavy metal stress on antioxidant status and DNA damage in Urticadioica. BioMed research international, 2013

[19] Yaashikaa, P. R., Kumar, P. S., Jeevanantham, S., & Saravanan, R. (2022). A review on bioremediation approach for heavy metal detoxification and accumulation in plants. Environmental Pollution, 301, 119035.

[20] Emamverdian, A., & Ding, Y. (2017). Effects of heavy metals' toxicity on plants and enhancement of plant defense mechanisms of Si-mediation “Review. International Journal of Environmental and Agriculture Research, 3(4), 41-51.

[21] Ryan, J. (2000). Data presentation, interpretation, and communication: Soil and plant analysis in the Mediterranean region: Limitations and potential. Communications in soil science and plant analysis, 31(11-14), 2147-2154.

[22] Wong, D. W., Voragen, A. G., and Whitaker, J. R. (2003). Handbook of food enzymology. Marcel Dekker.

[23] Yabanli, M., Yozukmaz, A., and Sel, F. (2014). Heavy metal accumulation in the leaves, stem and root of the invasive submerged acrophyte Myriophyllum

spicatum L.(Haloragaceae): an example of Kadin Creek (Mugla, Turkey). Brazilian Archives of Biology and Technology, 57(3), 434-440.

[24] Shabbir, Z., Sardar, A., Shabbir, A., Abbas, G., Shamshad, S., Khalid, S., ... & Shahid, M. (2020). Copper uptake, essentiality, toxicity, detoxification and risk assessment in soil-plant environment. Chemosphere, 259, 127436

[25] Draszawka-Bołzan, B. (2017). Effect of pH and soil environment. World News of Natural Sciences, 8, 50-60.

[26] Furnell, S., Tsaganidi, V., & Phippen, A. (2008). Security beliefs and barriers fornovice Internet users. Computers & Security, 27(7-8), 235-240.

[27] Becker M, Asch F. (2005). Iron toxicity in rice – conditions and management concepts. J Plant Nutr Soil Sci 168: 559–553.

[28] Albretsen J. (2006). The toxicity of iron, an essential element. Veterinary medicine 82–90

[29] Grazuleviciene R, Nadisauskiene R, Buinauskiene J, Grazulevicius T. (2009). Effects of Elevated Levels of Manganese and Iron in Drinking Water on Birth Outcomes. Polish J of Environ Stud 18(5): 819–825.

[30] Ghosh, U. K., Islam, M. N., Siddiqui, M. N., Cao, X., & Khan, M. A. R. (2022). Proline, a multifaceted signalling molecule in plant responses to abiotic stress: understanding the physiological mechanisms. Plant Biology, 24(2), 227-239

[31] Kalisz, A., Húska, D., Jurkow, R., Dvořák, M., Klejdus, B., Caruso, G., & Sękara, A. (2021). Nanoparticles of cerium, iron, and silicon oxides change the metabolism of phenols and flavonoids in butterhead lettuce and sweet pepper seedlings. Environmental Science: Nano, 8 (7), 1945-1959.

[32] Okereafor, U., Makhatha, M., Mekuto, L., Uche-Okereafor, N., Sebola, T., & Mavumengwana, V. (2020). Toxic metal implications on agricultural soils, plants, animals, aquatic life and human health. International journal of environmental research and public health, 17(7), 2204.

[33] Aras, S., Aydin, S. S., Körpe, D. A., & Dönmez, Ç. (2012). Comparative genotoxicity analysis of heavy metal contamination in higher plants. In Ecotoxicology. IntechOpen.

[34] Rehman, A. U., Nazir, S., Irshad, R., Tahir, K., ur Rehman, K., Islam, R. U., & Wahab, Z. (2021). Toxicity of heavy metals in plants and animals and their uptake by magnetic iron oxide nanoparticles. Journal of Molecular Liquids, 321, 114455.