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ACCUMULATION OF ZINC (ZN) IN SORGHUM BICOLOR AND CHENOPODIUM ALBUM UNDER DIFFERENT SOIL ZINC CONCENTRATIONS

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ABSTRACT

In this study, we tested the effects of different soil zinc concentrations on the accumulation of zinc (Zn) in two plant species: Sorghum bicolor (sorghum) and Chenopodium album (lambsquarters). These plants have the potential to be used for phytoremediation and zinc biofortification in zinc-deficient locations, thus it is important to understand how they react to varying levels of soil zinc. Plants were cultivated in containers for three months in soils with zinc concentrations of 10, 30, 50, 90, 130, and 210 mg Zn per kilogram of soil. Zn concentration in the plants and bio-available Zn in the soils were measured at the conclusion of the growing season in addition to plant height, chlorophyll a/b/total content, biomass, and Zn availability in the soils. Plant height, a and b content, total chlorophyll, and biomass were all found to be significantly (p0.05) reduced with increasing Zn concentration in soil. Soil Zn concentration of 2100 mgzn/kgsoil resulted in a maximum Zn content of 1213 mg/kg in Common lambsquarter.

Keywords: Zinc, Soil, Sorghum bicolor, Chenopodium album, Phytoremediation

I. INTRODUCTION

Zinc (Zn) is an essential micronutrient for plants, playing a pivotal role in various physiological processes such as enzyme activation, protein synthesis, and nucleic acid metabolism. Adequate zinc uptake is vital for plant growth, development, and overall health. It is also crucial for human nutrition, as zinc is an essential element for various enzymatic activities in the human body. However, both zinc deficiency and excess can have detrimental effects on plant health and productivity, impacting global agriculture and human well-being. As a result, understanding how different plant species respond to varying soil zinc concentrations is of significant importance for sustainable agriculture and environmental management.

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The accumulation of zinc in plants depends on several factors, including the plant species, soil characteristics, and environmental conditions. Some plant species have developed mechanisms to efficiently accumulate and tolerate high levels of zinc, making them potential candidates for phytoremediation, a process that uses plants to remove or detoxify pollutants from the environment. On the other hand, other species exhibit a high capacity for zinc translocation from roots to shoots, holding promise for biofortification efforts in regions with zinc-deficient soils, aiming to increase the nutritional value of crops for human consumption.

Two plant species, Sorghum bicolor (commonly known as sorghum) and Chenopodium album (lambsquarters), have shown potential in zinc accumulation studies due to their adaptability and prevalence in various agroecological regions. Sorghum bicolor, a drought-tolerant cereal crop, is a staple food for millions of people in arid and semi-arid regions, where zinc deficiency in soils and humans is a prevalent issue. Chenopodium album, commonly regarded as a weed, is a hardy and fast-growing plant, often found in disturbed and nutrient-deficient soils. Studying these species under varying soil zinc concentrations can provide valuable insights into their suitability for specific agricultural and environmental applications.

II. REVIEW OF LITERATURE

Ilker Ugulu et al., (2022) An overflow of plant-developing supplements can be found in wastewater sources. The reason for this examination was to portray metal development in the goosefoot plant (Chenopodium collection L.) because of its openness to wastewater utilized for rural water system, and to survey the potential dangers this openness stances to human wellbeing. This study was directed in the field in Khushab, Pakistan. Nuclear assimilation spectrometer-AAS examination was utilized to ascertain the degrees of Disc, Cu, Cr, Fe, Zn, Ni, and Mn. Goosefoot tests flooded with groundwater (GWI), canal water (CWI), and sugar plant water (MWI) had Disc, Cr, Cu, Fe, Ni, Zn, and Mn items in 0.84-1.08, 0.55-1.78, 0.23-1.70, 2.09-13.53, 0.53-1.13, and 0.32-0.39 mg/kg, separately. The factual examinations showed that the Cr, Cu, and Zn contents in C. collection tests taken from three destinations didn't change fundamentally because of wastewater applications, albeit the Compact disc, Fe, Mn, and Ni focuses changed altogether ($p>0.05$). The discoveries additionally demonstrated that cadmium's wellbeing risk record esteem was mutiple. These discoveries propose that ongoing ingestion of C. collection tests filled in the review region might prompt Cd development and diseases influencing different tissues and organs.

Khan, Zafar, et al., (2020) Excess trace metals in wastewater are a major cause of soil and crop contamination. To evaluate how wastewater affects zinc buildup in forages and the health risk they pose, a pot study was conducted. Forages both of summer (Zea mays, Echinochloa colona, Pennisetum typhoideum, Sorghum vulgare, Sorghum bicolor, Sesbania rostrata, and Cyamopsis tetragonoloba) and winter (Trifolium alexandrinum, Medicago sativa, Brassica campestris, Trifolium resupinatum, Brassica juncea, and Brassica napus) were grown with sewage water and tap water treatment. The five duplicates of the experiment followed a completely randomized design. Using an atomic absorption spectrophotometer, the zinc concentration in water, root, and fodder samples was determined. Zinc was found at concentrations of 0.498 mg/L in potable water and 0.509 mg/L in effluent. Brassica napus, a winter-grown fodder plant, has the highest zinc content at 3.582 mg/kg in the leaves. Brassica juncea had a bioconcentration factor for zinc of 2.88 in the winter when it was cultivated outdoors. Zinc load indices below 1 indicate low levels of contamination. Zinc levels in all forages were below the safety threshold set by the health risk index, so eating them poses no health risks.

Badamasi, Hamza et al., (2020) Citric acid's effects on sorghum (Sorghum bicolor (L.) Moench) Zn absorption and phytoextraction potentials were investigated in greenhouse hydroponic studies . Hydroponic solutions containing 5, 25, 50, 100, or 200 mg/L of Zn were used to treat two-week-old seedlings either alone or in conjunction with 10 mM citric acid. The plants were taken after 21 days of cultivation, dissected into roots and shoots, and then dried. The Zn uptake in the roots and shoots was calculated using atomic absorption spectrometry, and fresh and dry weights were assessed using a Sartorius balance. The root-to-shoot ratio was used to calculate the translocation factor (TF), while the root-to-hydroponic solution ratio was used to calculate the bioconcentration factor (BCF). Spectrophotometric analyses of proline, pigments, proteins, and ascorbic acid were conducted using acid ninhydrin, acetone, the Lowry test, and dinitrophenyl hydrazine, respectively. After citric acid was applied, there was a statistically significant (p 0.05) increase in Zn absorption, fresh and dry weights, TF, BCF, proline, and ascorbate contents. However, the pigment and protein content were drastically reduced with increasing Zn concentrations and gradually appreciated after citric acid was added. Although Sorghum bicolor LM was not a Zn hyperaccumulator, it might be employed for phytoremediation of Zn-contaminated areas if treated with citric acid to increase phytoextractability of Zn and decrease Zn-induced toxicity.

Hamza Badamasi and Muhammad Dagari (2019) One of the most serious natural dangers to food security and human wellbeing is abiotic stress, particularly that brought about by weighty metals. The morphological and biochemical reactions of Sorghum bicolor L.M to fluctuating centralizations of Zinc (Zn) were researched in this work utilizing nursery aqua-farming analyses. Zn (gave as $ZnSO_4 . 5H_2O$) was applied at groupings of 5, 25, 50, 100, and 200 mg/L to fourteen day old seedlings that had been relocated into aqua-farming arrangements. The roots and branches were eliminated from the plants following 21 days in development, then, at that point, smudged dry. Non-enzymatic biochemical information, including proline, Chlorophyll a, b, and Carotenoids (colors), as well as root and shoot lengths and dry loads, were estimated. The lengths of root and shoot, dry loads, and color levels were all essentially (P0.05) diminished by Zn medicines contrasted with untreated plants (control). Zn dose supported the power of the impacts. Notwithstanding, as Zn fixations are raised, treated plants in the long run gather more metal and proline (P0.05). It is suggested that sorghum bicolor L.M not be developed at a Zn centralization of more than 3.2 mg/L because of the modifications in these boundaries, which have prompted harmfulness side effects and generally speaking development hindrance, particularly at raised focuses.

Stephan Clemens (2017) The leaf Zn items in Zn hyperaccumulating plants can be a few hundred times more noteworthy than the qualities focused on for Zn-biofortified crops. Scope What is had some significant awareness of Zn hyperaccumulating plants proposes that this super trademark is pertinent for Zn biofortification in various ways. Ends It's essential to take note of that Zn hyperaccumulation is made by modifications the metal homeostasis networks utilized by every single higher plant. It doesn't necessarily need plentiful soil Zn. Subsequently, the rearing and designing of Zn-biofortified harvests can profit from the robotic experiences acquired from the exploration of Zn hyperaccumulators. A subsequent finding is that some plant families, the Brassicaceae specifically, appear to be hereditarily inclined toward develop upgraded Zn collection, demonstrating the presence of transitional species with raised Zn focuses in their passes on underneath the hyperaccumulation limit or the possibility to raise for such plants. This requires careful screening, especially of planned vegetable yields, obviously educated by data with respect to the unquestionably somewhat united advancement of Zn hyperaccumulation. Third, adding Zn-rich verdant vegetables to the eating regimen, or even Zn hyperaccumulator leaves, could be a substantial extra biofortification technique.

Sepideh Bagheri-Noviair and Hossein Mirseyed (2015) Despite the fact that zinc assists plants with flourishing, a lot of it very well may be terrible for the climate and the actual plants. This study took a gander at the connection between developing sorghum and an expansion in zinc content in two soils with comparable physical and compound elements however varying weighty metal fixations. Zinc was given to the two soils at different fixations (250, 375, and 500 mg kg-1, comparative with the underlying nitric corrosive extractable substance). Arrangement of development boxes (Rhizobox) involved utilizing plastic boxes to hold 8 kg of soil. Nylon net plates were utilized to isolate within the case into three particular zones: S1 (the rhizosphere), S2 (the dirt promptly around the rhizosphere), and S3 (the mass soil). The outcomes showed that BCF were more noteworthy than units at all zinc focuses in both soil types, proposing that sorghum can be considered a plant for collection of zinc utilizing this sign. All root-adjoining areas of contaminated soil showed diminished microbial breath and dehydrogenase action. It is notable that substrates and inhibitors (weighty metals) contend in the development of substrate-catalyst and inhibitor-compound buildings; notwithstanding, sorghum development expanded organic and chemical action records in soil 1 (non-dirtied) to a more noteworthy degree than soil 2 (contaminated), conceivably because of enhancements in microbial movement close to the roots, even at fixations higher than stress condition levels for zinc in soil.

Ping Zhuang et al., (2009) An option in contrast to phytoremediation of weighty metal-polluted soils is the development of high biomass crops using suitable agronomic systems. Three unique kinds of the great biomass energy plant sweet sorghum (Sorghum biocolor L.) were tried in a field preliminary to decide how well they phytoextracted certain metals. The capacity of

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ethylene diamine tetraacetate (EDTA), ammonium nitrate (NH4NO3), and ammonium sulfate ((NH4)2SO3) to increment sweet sorghum's leeway of Pb, Compact disc, Zn, and Cu from dirtied agrarian soil was explored. The leaves of sorghum plants were reliably the best in eliminating Pb, though the stems were the best at eliminating Album, Zn, and Cu. The aggregation of weighty metals in Keller, Rio, and Mray sweet sorghums was not fundamentally unique. Pb development in sweet sorghum filled in contaminated rural soil was upgraded by EDTA treatment more so than by ammonium nitrate or ammonium sulfate. Foundations of sorghum plants aggregated more zinc and cadmium subsequent to being prepared with ammonium nitrate and ammonium sulfate. The discoveries of this examination demonstrate that sorghum editing supported by agronomic strategies can possibly be a harmless to the ecosystem technique for the incomplete disinfecting of weighty metal dirtied soils.

III. MATERIALS AND METHODS

Urmia University in Urmia, Iran, was the site of the experiment. Soil was chosen from the agriculture department's field and measured using the Bauder and Gee (1986) method. Plants were cultivated in containers for three months in soils with zinc concentrations of 10, 30, 50, 90, 130, and 210 mgzn/kgsoil.

Plants were collected three months after culture, and the biomass in each container was measured and documented. To prepare the plant material for examination, it was first washed with distilled water to remove any surface soil or dust deposits, then oven-dried at 75°C for 72 hours, and finally milled. There was a 40:4:1 ratio of concentrated HNO3, HCLO4, and H2504 used to break down 2 g of plant material. Zn content was calculated using flame atomic absorption spectrometry.

Estimating Relative Yield

Yield reductions of the plants were computed to evaluate the phytotoxicity of Zn by comparing the dry biomass of a plant in each treatment (Ye) to the dry biomass of the same plant in the control treatment (the treatment with no additional Zn).

RY = 100 * (Yc/Y0)

Estimating Bio-concentration Factor

Bio-concentration factors of soil Zn by plants were also determined to evaluate plant absorption of Zn.

$$BCF = \frac{\text{total Zn in plant dry matter (mg kg}^{-1}\text{)}}{\text{total Zn in soil (mg kg}^{-1}\text{)}}$$

In which the bio-concentration factor, BCF (-), is used.

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Estimating Metal Extraction

Metal extraction of soil Zn by plants was also estimated in order to estimate the plants' capability for phytoremediation of Zn.

Concentration of zinc in plant biomass (mg/kg) multiplied by yield (kg/pot) gives metal extraction (mgzn/pot).

Statistical analysis

SAS, the Statistical Analysis Software, was used for the statistical analysis. To determine whether or not the changes in means were statistically significant, the Duncan multiple range test was used ($P \leq 0.05$).

IV. RESULTS AND DISCUSSION

Growth and Biomass Yield

Table 1 shows that as soil zinc content was raised, relative yield rose for Chenopodium album up to 300.7mg/kg but dropped at greater concentrations, whereas the opposite was true for Sorghum bicolor.It's possible that zinc's nutritional role in plant development is responsible for the first surge. At greater doses, Zn's harmful effect on plant development may be responsible for the decline in relative yield.

Table 1: Changing zinc concentrations and their effects on biomass output in Chenopodium album and Sorghum bicolor

Zn concentration(mgzn/kgsoil)	Relative yield (%)		Zn concentration(mgzn/kgplant)	
	Sorghum bicolor	Chenopodium album	Sorghum bicolor	Chenopodium album
100.7	100	100	272.97	86.23
300.7	70.45	109.2	2208.33	462.06
500.7	60.9	89.5	2538.12	666.62
900.7	56.95	85.54	2022.83	1001.36

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1300.7	51.91	33.46	1629.1	1067.82
2100.7	41.31	20.08	1714.6	1213.20

Bio-concentration factor

Bio-concentration factor (BCF) values for Zn are shown in Table 2 for plants cultivated in soils with varying Zn contents. Except at 2100.7 mgzn/kgsoil, the BCF values for sorghum were higher than 1. Sorghum's highest BCF was recorded at 7.3 (300.7 mgzn/kgsoil). Chenopodium album had BCF values that were greater than 1 between 300.7 and 900.7 mgzn/kgsoil, with a maximum BCF of 2.3 occurring at 500.7 mgzn/kgsoil. A plant's phytoremediation capability can be estimated using either its bio-concentration factor (BCF) or its translocation factor (TF). However, phytoextraction is only a viable option for plants with a high bio-concentration factor (BCF; metal concentration ratio of plant biomass to soil) and high translocation factor (TF; metal concentration ratio of plant shoots to roots). Based on these findings, plants may be useful for cleaning up Zn-contaminated soils, but only if their biomass output is boosted.

Metal Extraction

The typical upsides of Zn extraction from plants developing in soils with differing Zn fixations are displayed in Table 2. The most elevated and least metal extractions for Sorghum bicolor and Chenopodium collection, separately, were 90.7 and 16 mgzn/pot (in 300.7 and 100.7 mgzn/kgsoil), and 19.7 and 2.2 mgzn/pot (in 900.7 and 100.7 mgzn/kgsoil).

Table 2: Bio-concentration factors (BCFs) and metal extraction (mgzn/pot) for Zn in Sorghum bicolor and Chenopodium album cultivated in soil with varying concentrations of additional Zn were calculated

Zn concentration(mgzn/kgsoil)	BCF (-)		Metal extraction(mgzn/pot)	
	Sorghum bicolor	Chenopodium album	Sorghum bicolor	Chenopodium album
100.7	2.5	0.9	16	2.2
300.7	7.5	1.4	90.7	12
500.7	4.9	2.6	90	14
900.7	2.5	1.8	67.5	19.5
1300.7	1.7	0.5	50	7.9

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2100.7	0.9	0.8	41.1	5.5

Extraction Efficiency

Table 3 displays the results of the three tested methods for Zn extraction. When compared to the CaC12 and NaNO3 methods, the Zn extractability obtained using the NH4NO3 method was superior. The NaNO3 method resulted in the worst extraction efficiency. Plants' reactions to Zn pollution were also shown to be significantly correlated with the amount of soil Zn that could be extracted using NH4NO3.

Table 3: Zinc concentrations in soils extracted using three mild methods

Zn concentration(mg_{zn}/kg_{soil})	**Extractor**		
	NH4NO3 (mg_{zn}/kg_{soil})	**NaNO3(mg_{zn}/kg_{soil})**	**CaC12(mg_{zn}/kg_{soil})**
100.7	1.5	0	0
300.7	3.82	0	0.24
500.7	5.63	0	0.15
900.7	13.85	0.7	3.11
1300.7	22.2	1.08	2.35
2100.7	50.7	3.05	4.25

V. CONCLUSION

Common lambsquarter demonstrated tolerance at low and medium concentrations (900 mg/kg), but sorghum was able to tolerate high concentrations of zn. Furthermore, sorghum was superior to Common lambsquarter in its ability to remove zn from soil, meaning that it may be used to clean up low Zn polluted (900 mg/kg) soils. Plants' reactions to Zn pollution were also shown to be significantly correlated with the amount of soil Zn that could be extracted using NH4NO3. Sorghum bicolor and Chenopodium album show promise in tackling agricultural and nutritional difficulties in a number of locations thanks to their prospective uses in phytoremediation and zinc biofortification. These results can help scientists, farmers, and politicians make more well-informed choices about which crops to grow and how to manage their land so that it supports both soil health and human nutrition.

REFERENCES: -

1. Ugulu, Ilker & Rehman, Sidrah & Ahmad, Kafeel & Nawaz, Khalid & Munir, Mudasra & Bashir, Humayun. (2022). Heavy Metal Accumulation in Goosefoot (Chenopodium album L.) Irrigated With Wastewater. Pakistan Journal of Analytical & Environmental Chemistry. 23. 225-236. 10.21743/pjaec/2022.12.05.

2. Khan, Zafar & Ahmad, Kafeel & Safdar, Hareem & Ugulu, Ilker & Wajid, Kinza & Nadeem, Muhammad & Munir, Mudasra & Dogan, Yunus. (2020). Monitoring of Zinc Profile of Forages Irrigated with City Effluent. Pakistan Journal of Analytical & Environmental Chemistry. 21. 303-313. 10.21743/pjaec/2020.12.32.

3. Badamasi, Hamza & Dagari, Muhammad & Sale, Isyaku. (2020). IMPACTS OF CITRIC ACID ON THE PHYTOEXTRACTION OF ZINC (Zn) USING SORGHUM (Sorghum bicolor (L.) Moench) PLANTS. Malaysian Journal of Analytical Sciences. 24. 587-598.

4. Badamasi, Hamza & Dagari, Muhammad. (2019). Responses of Hydroponically Grown Sorghum (Sorghum bicolor L.M) to Zinc Stress.

5. Badamasi, Hamza & Dagari, Muhammad. (2019). Responses of Hydroponically Grown Sorghum (Sorghum bicolor L.M) to Zinc (Zn) Stress. Trends Journal of Sciences Research. 4. 111-120. 10.31586/Chemistry.0403.04.

6. Moameri, Mehdi & Jafari, Mohammad & Ali, Tavili & Motesharezadeh, Babak & Zare Chahouki, Mohammad Ali & Madrid, Fernando. (2018). Investigating lead and zinc uptake and accumulation by Stipa hohenackeriana trin and rupr. in field and pot experiments. Bioscience Journal. 34. 138-150. 10.14393/BJ-v34n1a2018-37238.

7. Clemens, Stephan. (2017). How metal hyperaccumulating plants can advance Zn biofortification. Plant and Soil. 411. 10.1007/s11104-016-2920-3.

8. Bagheri Novair, Sepideh & Mirseyed, Hossein. (2015). Study of Effects of Sorghum Cultivation on Some Soil Biological Indicators at Different Zinc Levels. Majallah-i āb va Khāk. 28. 10.22067/jsw.v0i0.31428.

9. Ray, Prasenjit & Singhal, Sunil & Datta, Siba & Rattan, Raj. (2015). Effect of Zinc Sulphate and Organics on Zn Content and Yield of Chenopodium Grown in Different Soils. Proceedings of the National Academy of Sciences, India Section B: Biological Sciences. 87. 10.1007/s40011-015-0649-z.

10. Soudek, Petr & Petrova, Sarka & Vanková, Radomíra & Song, Jing & Vanek, Tomas. (2014). Accumulation of Heavy Metals Using Sorghum Sp.. Chemosphere. 104. 15-24. 10.1016/j.chemosphere.2013.09.079.

11. Mirshekali, H. & Hadi, Hashem & Amirnia, Reza & Khodaverdiloo, Habib. (2012). Effect of zinc toxicity on plant productivity, chlorophyll and Zn contents of sorghum (Sorghum bicolor) and common lambsquarter (Chenopodium album. Int. J. Agric. Res. Rev.. 2.

12. Zhuang, Ping & Shu, Wen & Li, Zhi An & Liao, Bin & Li, Jin-tian & Shao, Jingsong. (2009). Removal of metals by sorghum plants from contaminated land. Journal of environmental sciences (China). 21. 1432-7. 10.1016/S1001-0742(08)62436-5.

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