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Research Article **BOTANY**

Retrieving the growth and mineral nutrition of wheat plants subjected to lead or nickel stress by priming in *Sonchus oleraceus* extract

Afaf A. Nessem[1], Awatif A. Mohsen[1], Amira M. Atlam* [1], Gehad A. Ragab [1]

1 Botany Department, Faculty of Science, Tanta University, Tanta 31527, Egypt.

*Corresponding author email: amiramiroatlam@gmail.com

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Triticum asetivum, heavy metals, *Sonchus oleraceus* extract, carbohydrates, proteins, minerals.

ABSTRACT

Heavy metal pollution is a widespread issue that directly threatens global food security. An experiment was carried out on wheat (*Triticum asetivum* L.) to assess the toxic effects of Pb or Ni stress and the role of *Sonchus oleraceus* (S) extract as a grain priming application in ameliorating the stress effects. The data showed that 100 mM Pb or Ni stress significantly reduced wheat plant growth parameters, total soluble carbohydrates (TSC), total amino acids and minerals content; while the levels of total soluble proteins (TSP) and the contents of Pb or Ni ions in the root and shoot tissues were significantly increased. The priming with S extract restored most of the metabolic activities, improving growth criteria, TSC and mineral levels. Surprisingly, priming with S extract reduced heavy metal accumulation in wheat root and shoot tissues. In a conclusion, using natural S extract as a simple priming application could be presented as a long-term, and a risk-free method for mitigating the negative effects of Pb or Ni stress on wheat.

Introduction

Heavy metals are inorganic chemical elements that are non-biodegradable. They have atomic masses greater than 20 and densities greater than 5 g cm^{-3} **(Hesse *et al.*, 2018)**. Heavy metals are significant contaminants that have disrupted the balance in the atmosphere, water, and soil **(Emamverdian *et al.*, 2018)**. After arsenic, lead is the second most dangerous element, accounting for 0.002 percent of the Earth's crust **(Zulfiqar *et al.*, 2019**)**.** Because of its poor solubility and strong binding capacity, it could enter the food chain and endanger human health, water quality, and the environment **(Zhou *et al.*, 2017).** Pb, as a non-essential metal, has no metabolic function in plant body, thus its continuous release to the environment could cause economic losses of agricultural output (**Ashraf *et al.*, 2017**)**.** Pb stress could cause a detrimental impact on plant development, cellular structure distortion, nutrition and hormone imbalance, photosynthesis suppression, DNA deformation, and reactive oxygen species overproduction resulting in oxidative stress (**Dubey *et al*., 2018; Rizwan *et al.*, 2018).** Ni is the 22nd most abundant element, making up about 0.008 percent of the earth's crust **(Shahzad *et al*., 2018).** It is essential metal required by plants as a micronutrient for normal growth and development **(Kotapati *et al*., 2017)**. Excessive accumulation of Ni in plants, as a result of intense anthropogenic activities, can hamper growth, photosynthesis, mineral uptake, assimilates transition, respiration, and yield productivity **(Aqeel *et al*., 2021).** Ni high levels are dangerous because they can disrupt cell membrane function and alter lipid composition, resulting in oxidative damage and toxicity symptoms like chlorosis, necrosis, and wilting (**Kotapati *et al*., 2017).**

To tolerate various stresses, plants develop adaptive mechanisms at the physiological, biochemical, and molecular levels. The priming of grains with natural plant extract is an eco-friendly method for the amelioration of heavy metal stress **(Kasim *et al*., 2017a)**. *Sonchus oleraceus* L. (sow thistle) is a winter weed found worldwide that germinates primarily after fall rains **(Puri *et al*., 2018)**. This plant can be found in a variety of environments, including crop fields, orchards, canal banks, gardens, woodlands, native ecosystems, roadsides, fallow lands, and even areas where there is uncontrolled water runoff (**Peerzada *et al.*, 2019**). It was reported that its leaves contained bioactive chemicals such as phenolics, alkaloids, flavonoids, terpenes, tannins, steroids, lignans, and glycosides **(Fouad *et al.*, 2020)**.

Wheat (*Triticum asetivum* L.) is a major cereal crop as a staple food for nearly one-third of the world's population and belongs to Poaceae family **(Ma *et al.*, 2014).** It is the main food in Africa and an essential part of the Egyptian diet **(Nessem and El-Shenody, 2018).** Its importance is related to the production of flour, which is used to make bread, cookies, cakes, and pasta, whereas wheat straw is used as animals feed **(Farahat *et al.*, 2017; Wang *et al.*, 2020).** Using high-doses of chemical fertilizers may result in heavy metal accumulation in crops including wheat. Hence, the purpose of this study was to investigate the physiological and mineral imbalance caused by Pb and Ni on the vegetative growth of *Triticum asetivum*. In addition, assessing the effectiveness of grain priming with *Sonchus* extract in recovering the phytotoxicity of Pb or Ni stress was aimed as a natural bio-stimulant application.

Materials and methods

Plant material and preparation of *Sonchus* extract

Wheat grains (cv Sakha 94) were provided by Gimmizza Agricultural Research Station, Gimmizza, Gharbia governorate, Egypt, and selected for uniform size and shape for experimental use. Concerning, *Sonchus* extract preparation, the fresh shoots were collected from nearby cultivated fields. The samples (100g) were washed several times and ground with 100 ml tap water. The crude extract was centrifugated and filtered using Whatman No.1 filter paper, then completed to 100 ml and considered as 100% *Sonchus* (S) extract.

Soil analysis

The analysis of soil sample before sowing was performed at Arid Land Agricultural research and services Center, Faculty of Agriculture, Ain Shams University. The soil pH, EC, cations, anions, organic matter, $CaCO_3$, N, P, K, and heavy metals were all recorded.

Experimental design

Grains of wheat were divided into two groups during the growing season (December) for priming applications. The first group soaked for 12 h in tap water (water-soaked). The second group was primed for 12 h by immersing in 100% *Sonchus* extract (S-soaked).

Following that, the soaked grains of each group were sown in a plastic pot (15 cm diameter and 20 cm depth) filled with 5 kg clay-sandy soil (2:1w/w); where three pots were used as a replica for each treatment. The sown grains were left to grow in the green house under normal conditions (10 hours of light and 14 hours of darkness, at 21°C±2 and 15°C±2, respectively, with 62 % relative humidity) while they were irrigated with tap water twice during the first week (before seedling emergence). The first group (water-soaked) was divided into three subgroups on the 10th day of growth. The first subgroup represented the control, which was irrigated with water until the end of the experiment. The second and third were irrigated either with Pb or Ni solutions as single stress treatments (100 mM Pb acetate or 100 mM Ni sulphate, respectively) until 60% field capacity. The second group (S-soaked) was divided into two sets that were irrigated either with 100 mM Pb as a combined Pb and S extract treatment (Pb+S) or 100 mM Ni as a combined Ni and S extract treatment (Ni+S). Meanwhile, the plants were given additional doses of stress treatment (100 mM Pb or 100 mM Ni at day 20 from sowing). Following that, all the pots were watered once weekly till the end of the experiment at 30 days of growth.

Growth quantification

The vegetative plants were harvested, washed with distilled water to remove soil particles, and then divided into roots and shoots. The growth criteria were measured (root and shoot lengths, fresh and dry masses of root and shoot, and leaf area). Furthermore, the remaining vegetative plant samples were oven-dried at 50°C until constant weights were obtained. The dried samples were ground to fine powder, then used to estimate total soluble carbohydrates and proteins, total amino acids as well as mineral nutrient content.

Quantitative estimation of total soluble proteins and carbohydrates

The dried plant samples from roots or shoots were extracted using borate buffer (pH 8.0) as described by **Naguib *et al*., (1968).** The content of TSP was determined as described by **Bradford (1976)**. Exactly 0.1 ml of borate buffer extract was thoroughly mixed with 3 ml of Commasie Brillient Blue reagent. The absorbance was measured at 595 nm after two minutes. The TSP concentration was calculated as mg/g dry mass (d.m) using a calibration curve of bovine serum albumin as a standard protein.

The phenol sulfuric acid method was used to estimate total soluble carbohydrates according to **Dubois *et al.* (1956)**. About 0.1 ml borate extract was added to 1ml 5% phenol and 5ml concentrated sulfuric acid, then incubated at 30°C for 20 minutes. The absorbance of the resultant color was measured at 490 nm. Using a glucose sugar calibration curve, the total soluble carbohydrate content was calculated as mg/g d.m.

Quantitative estimation of total amino acids

The total amino acids were determined using plant ethanolic extracts of the dry samples based on the method of **Lee and Takahashi (1966)**. Briefly, 0.1 ml of plant extract was mixed with 1.9 ml ninhydrin-citrate glycerol buffer (pH 5.5). The mixture was boiled for 12 min and cooled in a water bath. The tubes were shaken well and the absorbance of the sample mixture was then measured at 570 nm. The total amino acids content was calculated as mg/g d.m using a prepared calibration curve by standard glycine.

Determination of minerals content

According to **Allen *et al*., (1974),** the mixed acid–digestion method was used for minerals determination of the root and shoot samples. A half-gram of oven-dried plant samples was combined with 5 ml nitric acid and 3 ml H_2O_2 and heating till obtaining clear solutions. The atomic absorption flame emission spectrophotometer was used to determine K, Pb and Ni contents of the extract (Model Perkin Elmer 2380 Atomic Absorption Spectrophotometer). The nitrogen content was estimated according to **Tetlow and Wilson (1964).** Phosphorous was determined by the molybdenum blue method of **Allen *et al*. (1974)**.

Statistical analysis

The results were statistically analyzed using one-way Analysis of Variance (ANOVA) to determine the degree of significance of the recorded results by COSTAT statistical program (**Bishop, 1983**). The significance level $P \leq 0.01$ was used.

Results

Soil analysis

The obtained results in Table 1 depicted the analysis of the soil sample before sowing. The pH of the soil was 8.34, indicating that it was slightly alkaline. The highest content of cations was represented by Ca^{++} and the lowest was recorded for K^+. As for the anions, HCO_3^- revealed the highest amount by 5.55 ml equivalent/liter and Cl^- had the lowest level. The analysis of N, P, and K exhibited that their soil values were 18.8, 4.0 and 184.9 ppm, respectively. Moreover, the heavy metals Pb, Ni, Cd, and Co were detected with limited values.

Growth criteria

The results in Table (2) showed that subjecting wheat plants to Pb or Ni stress caused a significant reduction in all growth parameters. Both Pb and Ni reduced the root and shoot lengths, as well as leaf area compared to the control. Meanwhile, the decrease percentages with Pb stress treatment were 20%, 17%, and 34%, respectively, and with Ni stress treatment were 28%, 23%, and 48%, respectively. Furthermore, the data in Table (2) demonstrated that Pb or Ni stress treatment reduced the root and shoot fresh and dry masses. In comparison to the control, the fresh masses of root and shoot decreased by 22% and 56% under Pb stress, while they reduced by 31%, and 54%, respectively with Ni stress. The root and shoot dry masses were both inhibited by 20% under Pb stress, while with Ni stress treatment, they decreased by 28% and 40%, respectively relative to the control.

On the other side, priming of wheat grains with S extract resulted in a significant recovery from Pb or Ni toxic effects and restored plant growth. The root and shoot lengths and leaf area increased than single stress values by 24%, 20%, and 59%, respectively under Pb stress, while increased by 34%, 25%, and 64%, respectively under Ni stress. Moreover, the root and shoot fresh and dry masses were significantly enhanced compared to Pb or Ni stress treatments due to S extract priming application (Table 2).

Quantitative estimation of proteins, carbohydrates and amino acids

It is clear from fig 1 that Pb or Ni stress significantly decreased TSC in both roots and shoots relative to control by 33% and 46%, respectively with Pb stress, and 35% and 56%, respectively under Ni stress. However, Pb and Ni treatments pronouncedly increased TSP in both roots and shoots by the percentages of 298 % and 151 % with Pb treatment, and 198% and 59%, respectively under Ni stress application compared with control. Alternatively, Pb application significantly decreased the total amino acids of root and shoot by 44% and 53%; while Ni stress reduced their levels by 60% and 50%, respectively, compared with control.

Priming with S extract counteracted the negative effects of Pb or Ni stress and considerably increased shoot TSC by 60%, and 32%, respectively compared to the Pb or Ni stresses. The TSC of roots slightly increased with Pb+S treatment and Ni+S treatment than the single stress treatments and remained lower than the control value. Both Pb+S and Ni+S treatments decreased the root TSP content with percentages of 11% and 36% relative to Pb or Ni stress but the values were still more than the control. Concerning the TSP in the shoot, priming with S extract resulted in different responses with either Pb or Ni stress. The Pb+S treatment significantly increased the shoot TSP by 39% relative to Pb stress; however, Ni+S treatment severely decreased its content by 77% compared to Ni stress. Under Pb stress, S priming successfully increased the total amino acid content of root and shoot by 27% and 38%, respectively, compared to Pb stress. Alternatively, the shift in the total amino acid content was not significantly measurable by S extract priming compared to the single Ni treatment.

Determination of minerals content

Table (3) represented the effect of presoaking of wheat grains in S extract on macronutrients (N, P, and K), and heavy metals (Pb and Ni) contents. When compared to the control, Pb stress application lowered the shoot N, P and K by 6%, 36% and 22%, respectively, while their levels reduced under Ni stress by 8%, 19% and 24%, respectively. Priming in S extract priming caused the restoration of N, P and K levels where their values significantly enhanced to reach near the control values. Furthermore, the application of Pb or Ni stress led to a high accumulation of their ions in plant tissues (Table 3). The Pb or Ni levels significantly increased in the roots by 9 and 17 folds, respectively; while in the shoots, they exhibited a higher increase by 31 and 30 folds, respectively relative to the control. it was clear from the results that wheat plant tended to accumulate Pb in the shoots rather than the roots; while Ni had a higher accumulation in root more than shoot. On the other hand, priming with S extract reduced the damaging effects of Pb or Ni stress by inducing a considerable decline in their content in the root and shoot. Compared to single stress treatments, S priming decreased the root and shoot Pb levels in Pb + S treatment by 20% and 7%, respectively; while Ni contents declined in Ni+ S treatment by 25% and 4%, respectively in the root and shoot.

Table (1): Analysis of soil sample before sowing (pH, EC, cations, anions, organic matter, $CaCO_3$, N, P, K, as well as heavy metals such as Pb, Ni, Cd, and Co).

Properties	Quantified levels	Units	Mineral Elements (ppm)	
pH	8.34		N	18.76
EC	1.06	(dS/m)	P	4.00
Organic matter	0.80	(%)	K	184.93
$CaCO_3$	4.25	(%)	Pb	1.07
Ca^{++}	4.00	milliequivalent/liter	Ni	0.35
Mg^{++}	2.50	milliequivalent/liter	Cd	0.01
Na^{+}	3.73	milliequivalent/liter	Co	0.07
K^{+}	1.07	milliequivalent/liter		
Cl^{-}	3.75	milliequivalent/liter		
HCO_3^{-}	5.55	milliequivalent/liter		

Table (2): Effect of grain presoaking either in water or S aqueous extract (100%) on growth parameters of 30-days old wheat plants irrigated with Pb or Ni stress.

Treatments	Plant length (cm/organ)		Fresh mass (g/organ)		Dry mass (g/organ)		Leaf area (cm^2/leaf)
	Root	Shoot	Root	Shoot	Root	Shoot	
Control	31.97± 0.06a	33.53± 0.06a	0.32± 0.01b	0.95± 0.015a	0.064± 0.001a	0.10± 0.00a	4.82± 0.02b
Pb	25.67± 0.58b	27.83± 0.29c	0.25± 0.01d	0.42± 0.017c	0.051± 0.001b	0.08± 0.00c	3.16± 0.05d
Ni	23.17± 0.29c	25.83± 0.58d	0.22± 0.01e	0.44± 0.015c	0.046± 0.002c	0.06± 0.00d	2.51± 0.01e
Pb + S	31.70± 0.26a	33.27± 0.25a	0.3± 0.00c	0.65± 0.025b	0.053± 0.002b	0.08± 0.00c	5.02± 0.03a
Ni + S	31.13± 0.23a	32.17± 0.29b	0.38± 0.01a	0.62± 0.012b	0.053± 0.002b	0.09± 0.00b	4.11± 0.02c
LSD	0.853	0.871	0.016	0.045	0.004	0.001	0.081
F value	451.4	321.1	284.6	436.6	60.9	2468.5	3540.6

Values are means of the three replicates with ± SD. The different letters indicate significant differences at $p < 0.01$ according to the LSD test

Table (3): Effect of grain presoaking either in water or S aqueous extract (100%) on mineral nutrient (N, P, and K) and heavy metals (Pb and Ni) levels of 30-days old wheat plants irrigated with Pb or Ni stress. Values with small letters are significant at $p< 0.01$ according to the LSD test

Treatments	**Macronutrients (mg/g d.m)**			**Heavy metals (ppm)**			
	N	**P**	**K**	**Pb**		**Ni**	
	Shoot			**Root**	**Shoot**	**Root**	**Shoot**
Control	3.73±0.02b	0.36±0.02a	6.72±0.02a	28.29±1.09c	11.67±0.5c	24.70±0.8c	4.61±0.3b
Pb	3.52±0.02d	0.23±0.02c	5.23±0.02c	274.49±4a	367.62±7a	22.00±1.0c	5.24±0.12b
Ni	3.45±0.03e	0.29±0.02b	5.12±0.03d	25.07±0.70c	11.44±0.33c	451.15±6a	144.56±4a
Pb + S	3.65±0.01c	0.31±0.03ab	6.24±0.03b	220.00±3b	343.45±3b	22.06±1.5c	4.39±0.19b
Ni + S	4.36±0.02a	0.34±0.01ab	6.18±0.08b	24.33±1.5c	10.45±0.07c	338.87±5b	139.24±8a
LSD	0.054	0.052	0.103	8.13	8.84	71.84	10.36
F value	895.02	18.01	898.98	7350.24	9161.32	184.85	1056.89

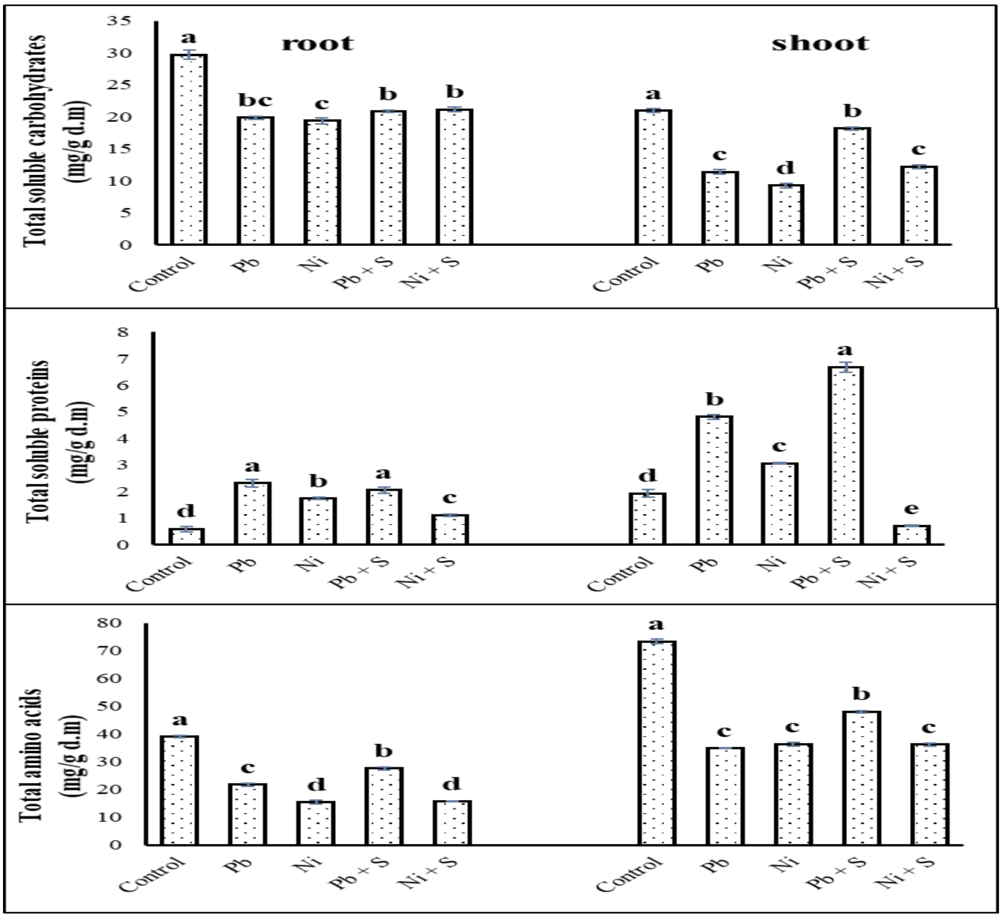

Fig (1): Effect of grain presoaking either in water or S aqueous extract (100%) on TSC, TSP and total amino acids contents of 30-days old wheat plants irrigated with Pb or Ni stress. Values with small letters are significant at $p < 0.01$ according to the LSD test

Discussion

The irrigation with Pb or Ni stress significantly lowered all vegetative growth parameters such as root and shoot lengths, fresh and dry masses of root and shoot, and leaf area. These results were corroborated by earlier reports on various plants such as *Oryza sativa, Zea mays* and *Hordeum vulgare* **(Ashraf *et al.*, 2021; Mahfouz and Rayan, 2016)**. Under Pb or Ni stress, the growth and biomass loss might be attributed to excessive interference of accumulated Pb or Ni ions with biochemical and physiological processes relevant to normal plant growth and development **(Ashraf *et al.*, 2021; Nabi *et al.*, 2021)**. Pb's high solubility, biochemical activity, and carcinogenicity in plant cells resulted in a reduction in mitotic activity and phytotoxic effects on plant growth **(Kazouz *et al.*, 2020).** In a similar way, Ni toxicity were observed in rice seedlings' leaves including leaf chlorosis and necrotic lesions **(Shahzad *et al.*, 2018).** Furthermore, the results revealed that Pb or Ni application resulted in a significant decrease in leaf area resulting in a reduction in the photosynthesis apparatus which could alter the physiological, and biochemical nature of stressed plants. Those findings were similar to the previous results on wheat under Ni **(Uruç Parlak, 2016)** or Pb stress **(Nas and Ali, 2018)**. The recorded decrement in nutrient uptake was responsible for the decline in growth parameters where Pb or Ni could compete with other cations and inhibit their uptake as similarly observed in maize, rice, and cowpea (**Zulfiqar *et al.*, 2019).**

In the present study, priming of wheat grains with S extract resulted in a significant increase in growth criteria (root and shoot lengths, leaf area, and fresh and dry masses of both roots and shoots) than Pb or Ni stressed plants. Similar results were reported by **Kasim *et al.*, (2017a)** and **(2019)** in *Vicia faba* seedlings primed with yeast extract, carrot roots and garlic extracts. The *Sonchus* extract was reported to contain various beneficial constituents including antioxidants such as ascorbic acid and phenolic compounds that could enhance its antioxidant activity to relieve metals toxicity and improve growth criteria **(Aissani *et al.*, 2022; Saxena and Kumar, 2020).** Moreover, S extract was known for its rich mineral nutrients' levels such as (N, P, K, Ca, Mg, Zn, Cu, Mn and Fe) which play a crucial role in increasing plant growth and photosynthesis (data under publication).

The TSC and total amino acids were significantly reduced in both root and shoot, while TSP was significantly increased due to Pb and Ni stress application. Similar results were recorded by **Kasim *et al*., (2017a)** and **Tousi *et al*., (2020)** who recorded TSC decline under heavy metal stress. Moreover, **Nessem and Kasim (2019)** reported an increase in TSP content under abiotic stress. The decrease in TSC might be linked to their increased intake throughout the development process or the up-regulation of genes involved in carbohydrate breakdown **(Tousi *et al*., 2020)**. The reduction in TSC could be attributed to a reduction in CO_2 fixation or dark respiration activity stimulation under heavy metal toxicity **(Kasim *et al*., 2017a).** The decrease in total amino acids after Pb or Ni application might be explained by a lack of carbon skeleton and nitrogen availability, which are involved in amino acid synthesis **(Saad-Allah and Ragab, 2020)**. Also, their depletion may be owing to their role as precursors for protein synthesis or to the down-regulation of their synthetic pathway under stress **(Batista-Silva *et al*., 2019)**. The TSP content is an important indicator of plant physiological status and its increase with Pb or Ni stress may contribute to defense mechanisms under heavy metal stress and act as a cell protector **(Nessem and Kasim, 2019)**. The increase in TSP might correlate to the production of stress proteins that have a role in redox state maintenance as antioxidant enzyme constituents **(Kasim *et al*., 2019).**

Priming wheat grains with S extract stimulated plant tolerance and reversed Pb or Ni impacts by increasing the content of TSC of both root and shoot compared to single stress treatments. The increase in TSC content is associated with the activation of photosynthetic enzymes such as carbonic anhydrase and enhancing ion exchange and carbon diffusion in plant cells **(Nabi *et al*., 2021).** Hence, increased TSC content may be due to the increased gene expression associated with photosynthesis and glucose production **(Szafrańska *et al*., 2016).** The content of total amino acids was induced by S priming under Pb stress as a marked tolerance response by acting as potential ligands and metal chelating compounds to avoid heavy metal toxicity (**Hall, 2002**). The increased amino acids under heavy metal stress could increase the availability of positive charges from amino acid groups allowing electrostatic stabilization to macromolecules and maintaining structural and functional integrity **(Bartwal *et al*., 2013).** On the other side, TSP levels exhibited a significant decrease by S extract priming under Ni stress; however, the shoot TSP was greatly increased under Pb stress. These results revealed the different responses induced by priming application under Pb or Ni stress on wheat. Increased proteins can bind metals forming metallothionein to mitigate cell damage **(Li *et al*., 2016).** Alternatively, TSP reduction might be linked to changes in the expression of stress-responsive genes **(Khanna *et al*., 2019).** The Pb-induced TSP content in shoots after S extract priming indicated a distinct tolerance response to Pb stress. It can be illustrated by the availability of essential elements (N, K, Ca, Mg, Na, and Zn) in *Sonchus* extract causing an increase in protein content by providing N storage source **(Kasim *et al*., 2016).**

The current results indicated that Pb or Ni stress resulted in a severe reduction in N, P, and K contents as essential macronutrients. According to these findings, the deficiency of N, P, and K had a detrimental impact on energy generation, protein and amino acid metabolism, photosynthetic activity, membrane permeability, and other physiological and biochemical processes **(Nazar *et al*., 2012)**. The metals' capacity to hamper ions absorption and uptake might induce oxidative damage and change the distribution of elements in the plant **(Nessem and El-Shenody, 2018)**. Minerals decline may be caused by competition and/or development of chelate-complexes with metal ligands, resulting in stunted growth, chlorosis, and leaf wilting **(Shahzad *et al*., 2018).** The priming with S extract had an enhancing effect on shoot minerals N, P, and K levels, as they significantly increased compared to single stress treatments. This result might be related to exogenous application of active components including amino acids, carbohydrates, vitamins, and proteins that may enhance endogenous minerals and promote growth and development **(Kasim *et al*., 2017b).**

The analysis of Pb or Ni ions indicated large differences in their accumulation in vegetative plant organs. Varied metal accumulation in the root and shoot might be due to their immobilization in the plant's cell wall **(Chekroun and Baghour, 2013).** The level of accumulated Pb was higher in the shoots rather than the roots which may be due to its binding to amino acids in the xylem enhancing its upper translocation to the shoot parts. Pb stable complexes may be accumulated in the plasma membrane, precipitated in intracellular spaces and cell walls as insoluble metal salts, or accumulated in cell vacuoles **(Zulfiqar *et al*., 2019).** The recorded high level of Ni in the roots may support its low translocation to the above-ground sections. Due to its great distribution within the root tissue, limited Ni amounts could travel to the shoot, causing its movement across the endodermal barrier **(Emamverdian *et al.*, 2015).** The rise in Pb or Ni content in root and shoot with distinct distributions may represent varied cellular mechanisms for bioconcentration of essential and non-essential metals **(Uruç Parlak, 2016)**. This high accumulation of Pb or Ni in plant tissues might be attributed to the oxidative damage in the plasma membrane structure disrupting its permeability **(Hassan *et al.*, 2019; Nessem and El-Shenody, 2018).** Wheat priming with S extract reduced harmful effects and decreased Pb and Ni concentrations in root and shoot. The decrease in Pb and Ni concentration may be linked to the boosted tolerance mechanisms, due to S extract components and their protective impacts **(Juhaimi *et al.*, 2017)**.

Conclusion

The current study showed that wheat responded differently to Pb or Ni stress, resulting in decreased vegetative growth and mineral imbalances. The priming with S extract as a natural and eco-friendly application could successfully restore cellular homeostasis, growth, total soluble carbohydrates and proteins, total amino acids and minerals level. Hence, S extract is regarded as a potential source of highly bioactive constituents and may be recommended as a long-term method of alleviating Pb or Ni stress in wheat.

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استعادة النمو ومحتوي المعادن لنبات القمح تحت اجهاد الرصاص أو النيكل عن طريق النقع المسبق في مستخلص الجعضيض

عفاف نسيم، عواطف محسن، أميرة عتلم[*]، جهاد رجب

قسم النبات، كلية العلوم، جامعة طنطا، طنطا، مصر

يعد التلوث بالعناصر الثقيلة مشكلة واسعة الانتشار تهدد بشكل مباشر الأمن الغذائي العالمي. تم إجراء تجربة على نبات القمح لتقييم التأثيرات السامة لإجهاد الرصاص والنيكل ودور مستخلص الجعضيض من خلال النقع المسبق للحبوب في تخفيف تأثيرات الإجهاد. أظهرت النتائج أن إجهاد ١٠٠ ملي مولار من الرصاص أو النيكل قلل بشكل كبير من معدلات نمو نبات القمح، والمحتوي الكلي من الكربوهيدرات، ومحتوى الأحماض الأمينية الكلية. بينما تم زيادة المحتوي الكلي للبروتينات ومحتوي المعادن ومحتويات الرصاص أو النيكل في أنسجة الجذور والمجموع الخضري بشكل كبير.علي العكس فان النقع المسبق في مستخلص نبات الجعضيض ادي إلى استعادة معظم انشطة التمثيل الغذائي، وتحسين معدلات النمو، والمحتوي الكلي للكربوهيدرات، ومحتوي المعادن، وقلل من تراكم المعادن الثقيلة في جذر القمح وأنسجة النبتة. بالتالي فانه يمكن استخدام مستخلص الجعضيض الطبيعي كطريقة طويلة الأجل وخالية من المخاطر لتخفيف الآثار السلبية لاجهاد الرصاص أو النيكل على القمح.