STUDY OF LEAD POLLUTION ON LEGUMINOUS PLANTS *PHASEOLUS MUNGO* AND *LENS CULINARIS*

Hadia Hameed[1], Manzoor Iqbal Khattak[2], Mahmood Iqbal Khattak[3], Rukhsana Jabeen[4] and Shaheen Wali[5]
1-2&5- Chemistry Deptt. UOB, Quetta.
3- PCSIR Laboratories, Peshawar.
4. Sardar Bahdar Khan University, Quetta.

ABSTRACT: *The aim of this research work is to study the toxic effect of lead on two important crops of Phaseolus mungo L and Lens culinaris Medik. that are extensively consumed across South Asia and Pakistan and are imported into Pakistan from other countries. Keeping in view of this, the present research work was planned to examine/investigate how these two crops and their roots and shoots react to, acquire, and tolerate different concentrations of the deadly heavy metal Lead. According to the investigation of the data, it was revealed that Lead significantly affects Lens culinaris as compared to Phaseolus mungo L. While the heavy metal lead was not present throughout the growth of the plants in the control treatment.*

Keywords: Atomic Absorption Spectroscopy and Lead Pollution

INTRODUCTION

Lead is a heavy metal that is a significant member of the IV group and has the mark of Lead. It has a high density, is harmful to living things even at low concentrations, and originates from the Latin word plumbum. It has 82 atomic no and a mass of 207.59. Metal lead is regarded as generally protoplasmic toxic. After being censored, metallic lead has discolored into a bluish-white tinge, although it rapidly becomes light grey when exposed to air. At high temperatures, lead also becomes a beautiful, shimmering silver hue. The physical structure/shape of lead is given in Fig.1

Fig.1 Lead

Lead exposure in humans also has a broad spectrum of dramatic health impacts. Lead poisoning is affected by a number of variables, including exposure time and intensity. Although the degree of efficacy varies and depends on the kind of plant, lead buildup not only negatively impacted humans but also plants. A significant drop in agricultural yield was shown by high levels of lead poisoning.

Due to the rising industrialization and urbanization of the World, lead pollution of the air, water, and soil has created environmental hazards in the biosphere. The mining and smelting of metalliferous ores and the combustion of lead gasoline are the main sources of this metal. Lead-enriched municipal sewage sludge and paints were also disposed of explosively.

There are numerous different types of lead in the environment. Lead is one of the most pervasive heavy metals that severely pollutes natural ecosystems, and as a result, biotic components of ecosystems are chronically damaged. For example, exposure to Lead in the environment has a significant impact on the physiology and morphology of plants [5]. Numerous studies have documented the adverse effects of lead exposure on living things, such as nucleoli and mitosis toxicity and disruption [7-9], inhibition of shoot/root growth [9], leaf chlorosis induction [10], photo-synthesis decrease [11], enzymatic activities activation/inhibition [9,12,13].

Lead toxicity in cells and cell organelles has been the subject of several studies, and changes in physiology and histomorphology in response to heavy metal stress have also been well reported [9, 14,15]. However, the processes underlying Lead tolerance remain poorly understood. Heavy metal absorption and buildup are reported to be resistant in the onion (*Allium sativum* L.) [16]. For twenty days, onion seeds were cultivated in nutrient solutions containing varying concentrations of lead

(10-5, 10-4, and 10-3 M), and it was discovered that the root and shoot development of Allium sativum L. was inhibited, with gradations on physiological processes[9]. The root meristematic cells of Allium sativum were used to examine lead toxicity in the mitochondria, dictyosomes, and plasma membrane to explain the lead-induced mechanisms, synthesis, and distribution of cysteine-rich proteins.

It is well knowledge that plants absorb certain ions to varying degrees depending on the other ions present in the culture medium and that some ions' toxicity is likewise inhibited by other ions. Under low dosage conditions, the root is where lead is first absorbed, and the root acts as a barrier to lead moving from root to shoot and leave. However, under conditions of severe lead toxicity, lead moved from root-shoot-leave. One of the cases is that $CaCl_2$ and NaCl are likely at odds with one another. Since it has been possible for Lead to be displaced by any other absorbed ions in the case of Lead, $CaCl_2$ has the power to change the plasma membrane's permeability potential and rendered the membrane less permeable to NaCl [17]. Potassium (K), calcium (Ca), and magnesium (Mg) did not exhibit any antagonistic behaviour against lead. Mg, Ca, and K has little potential to be displaced by Lead [18] but no antitoxic effect. Additionally, it was determined that none of the other cations can displace lead since they have far less displacing ability than lead.

Black gram, urad, and black bean are all names for the plant Phaseolus mungo L. The annual, herbaceous, erect black gram plant grows quickly, reaching heights of 30 to 100 cm. as given below in Fig.2

Fig-2: Phaseolus mungo L.

An edible pulse is a lentil (Lens culinaris Medik.). It is a thorny annual legume plant. In America, beans are among the world's oldest food crops. Agricultural relics of beans reaching back to 4,000 BC were discovered in 100 Mexican camp caverns. Early Greeks and Romans used beans as a voting tool in addition to eating them; white beans represented a yes vote, while colourful beans represented a no vote. In China, the Hangchow coastline area saw the cultivation of roughly 18 distinct types of beans from the third century BC to the second century AD.

Fig-3: Beans

Heavy metals are natural elements that are present in varying amounts in different regions of the globe. For instance, serpentine soil is rich in nickel, chromium, and copper, whereas calamine soil has high concentrations of zinc, lead, and cadmium. Soil has been polluted with heavy metals, which are harmful to micro-organisms, animals, plants growth, and reproduction. Because of human activities, heavy metals are numerous and persistent in the environment [19].

Lead is a significant contaminant in both terrestrial and aquatic habitats. The emission of lead from burning leaded fuels, the wearing out of tyres, the application of sludge to agricultural land, and mining and metal processing are only a few examples of anthropogenic lead contamination [20]. In rare cases, it has been shown that anthropogenically polluted soils have lead amounts of up to 20 mg/g (2%) [20].

Degryse, *et al.* [21] found that up to 1.1 M Lead was present in soil solutions taken from polluted soils throughout Europe. Similarly, Lamersdorf, *et al.* [22] despite contaminated soil from the USA had lead amounts 2 M, [23] employing wheat, it had previously been reported that three extremely acidic pH had 0.85 M Lead, Nolan, *et al.*[24] shown a relationship between Lead's soil solution content and phyto- availability.

In certain plants exposed to lead ions, carbohydrate synthesis in the leaf cells was suppressed, total chlorophyll levels decreased noticeably, and the efficiency of the plant's photosynthetic process was also significantly reduced [25–26]. A decline in the rate of photosynthetic activity of the plant because lead exposure directly causes the shutting of stomata on the process of suppressing photosynthesis [27]. Brunet, *et al*. [28] investigation into the effects of several heavy metals, including Lead and Cadmium, on seedling plants, discovered that the lupine's root tips are where heat shock protein is formed (Lupinus luteus L.). Additionally, it was looked at if photosynthesis activity increased in response to a protective tactic while under stress. Przymusimski, et al. [29] explored this discovery and found that lupine (Lupinus luteus L.) exposed to Pb(NO3)2 exhibited an increase in stress protein production [30]. The protection of cell organelles, particularly the plasma membrane, is facilitated by heat shock proteins.

MATERIALS AND METHOD

From the Sibi region, two kinds of leguminous plants—P. mungo and L. culinaris were employed for the experiment. The aforementioned dominant/common species were gathered during September and October 2022. A total of 7-11 plus sprouts of each kind, remaining together from both the spot and the variegated, were placed in appropriate bags and sent to our research test center for further analysis. In order to remove the dirt and surface powder before analysis, the stalks and leaves of each plant were carefully separated and washed (for about 2-3 minutes) with tap water and deionized water. Sucman *et al*. [31] and AOAC [32] procedures were used to determine the mineral content for various plant sections at various phenological phases. To determine the significance levels between the phenological phases and plant components, the data were statistically examined using ANOVA [33].

RESULTS AND DISCUSSION

As a result of the advancement of industry and urbanisation, pollution is steadily increasing in our atmosphere, and edaphic factors such as heavy metal toxicity are also having an impact. In general, lead is regarded as the most hazardous contaminant among all heavy metals and is quickly incorporated into soil and sediment. Lead is mostly transported by air from stationary or moving sources [34]. Future lead contamination will increase in both the sky and the soil as industrialization progresses. Lead is often emitted into the atmosphere over areas with heavy traffic from the nearby urban region.

A lot of lead is present in the soil along highways, as well as in industrial regions, river silt [35], land and aquatic vegetation [36], and the proximity of factories. Research has shown that plants absorb and store lead mostly in their seeds, roots, nodules, and certain aerial parts of some species, and that as lead stress rises, so does the accumulation percentage in plants [37].

P. mungo and L. culinaris were selected as the study plants to examine how they react to, can accumulate, and can withstand different concentrations of lead in their shoots/roots. No heavy metal (control) was used to develop the plants. Histo-morphology were assessed in two species for lead accumulations and change in morphology, seedling development, and germination were also assessed [38]. The germination index and morphology of roots, shoots, and leaves as well as the results provided in Tables 1 and 2 demonstrate that lead has a considerable impact on these variables.

Table 1 Growth and morphology of P. mungo under influence of lead

Pb (ppm)	Germination (%)	Root (cm)	Shoot (cm)	Leaves color	Leave size (cm)	Stems morphology
0	85	6.2+0.2	11.5+ 0.3	Light green	3.2 0.2	Erect
50	68	4.7 0.3	12.0 0.4	=	2.4 0.3	=
100	49	2.6 0.2	16.3 0.5	Dark green	2.3 0.4	Down
150	42	1.7 0.3	10.4 0.2	=	2.1 0.3	=
200	12	1.2 0.1	5.2 0.2	=	2.0 0.3	=
250	7	0.4 0.1	3.3 0.2	=	1.4 0.2	=

Table 2 Growth and morphology of L. culinaris under influence of lead

Pb (ppm)	Germination (%)	Root (cm)	Shoot (cm)	Leaves color	Leave size (cm)	Stems morphology
0	85	4.61±02	15±02	Light green	2±01	Erect
50	45	2.35±03	10.4±03	=	1.50±02	=
100	35	1.45±02	5.10±04	Dark green	1±01	Down
150	25	1.43±03	3.45±03	=	0.80±01	=
200	10	0.85±02	2.61±04	=	0.80±01	=
250	5	0.43±03	2±03	=	0.70±01	=

Lead leaves had normal growth and colour up to a concentration of 50 ppm, but at higher concentrations, the size of the leaves shrank and they took on a black tint. Reduced morphological traits, biomass accumulation, and yield were the results of adverse changes in physiological and biochemical traits brought on by an increase in lead concentration in plant leaves. The relative water content, leaf area, and root of the above-ground plant components, as well as their dry matter mass, were all dramatically reduced by the high lead concentrations.

Table 3. *P. mungo* fresh/dry weight(gm)

Pb(ppm)	Fresh weight (gm)			Dry weight (gm)			Dw/Fw (gm)		
	Leaf	Shoot	Root	Leaf	Shoot	Root	Leaf	Shoot	Root
0	0.669± 0.021	1.764±. 0.08	0.71 1± 0.02	0.075± 0.01	0.108± 0.039	0.034± 0.10	0.112± 0.10	0.061± 0.10	0.047± 0.10
50	0.672± 0.03	1.575± 0.11	0.602± 0.1	0.071± 0.01	0.101± 0.386	0.039± 0.02	0.105± 0.002	0.064± 0.02	0.064± .02
100	0.506± 0.03	1.3161± 0.1	0.452± 0.11	0.061± 0.012	0.106± 0.10	0.024± 0.01	0.120± 0.01	0.080± 0.11	0.053± 0.10
150	0.418± 0.02	1.508± 0.111	0.358± 0.12	0.051± 0.010	0.104± 0.03	0.019± 0.10	0.122± 0.11	0.068± 0.10	0.053± 0.11
200	0.436± 0.03	1.264± 0.20	0.375± 0.10	0.062± 0.003	0.096± 0.03	0.018± 0.03	0.142± 0.12	0.075± 0.12	0.048± 0.10
250	0.246± 0.02	0.942± 0.37	0.184± 0.11	0.040± 0.01	0.082± 0.001	0.017± 0.10	0.162± 0.010	0.087± 0.10	0.092± 0.02

Table-4 *Lens culinaris* fresh/dry weight(gm)

Pb(ppm)	Fresh weight (gm)			Dry weight (gm)			Dw/Fw (gm)		
	Leaf	Shoot	Root	Leaf	Shoot	Root	Leaf	Shoot	Root
0	0.103±.01	0.246±.02	0.054±.004	0.032±.01	0.041±.005	0.022±.002	0.112± 0.004	0.0612 ± 0.015	0.04781 ± .004
50	0.045±.11	0.164±.01	0.036±.003	0.025±.20	0.035±.003	0.013±.002	0.105± 0.07	0.064 ± 0.004	0.064 ± 0.01
100	0.038±.01	0.161±.02	0.030±.010	0.014±.04	0.031±.003	0.018±.010	0.120± 0.004	0.080 ± 0.01	0.053 ±.013
150	0.026±.02	0. 124±.01	0.019±.010	0.015±.004	0.03 1±.00 1	0.018±0.10	0.122± 0.10	0.068 ± 0.01	0.053 ±. 001

200	0.022+.01	0.134+0.1	0.011+0.04	0.012+0.04	0.029+.002	0.007+.004	0.142± 0.070	0.075 ± 0.01	0.048 ± 0.01
250	0.021+.01	0.017+.02	0.007+0.04	0.004+.002	0.012+.002	0.007+.003	0.162± 0.004	0.087 ± 0.01	0.092 ± 0.01

High lead concentration reduced seed germination by 20 to 70% in L. culinaris and 15 to 60% in P. mungo. Lead decreased the number of seeds that germinated in both species (Tables 1 and 2) and created elongated hypocotyls with shorter roots. Figures (1 and 2) demonstrate how lead has a negative impact on the seed.

Lead highly affected the germination of both species, particularly *Lens culinaris* Medik.

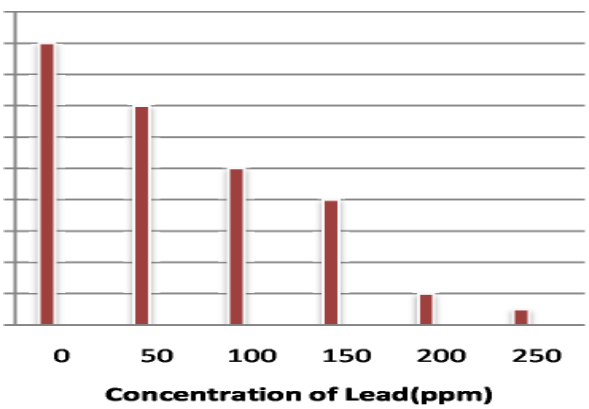

Fig-1: P. mungo germination under influence of lead toxicity

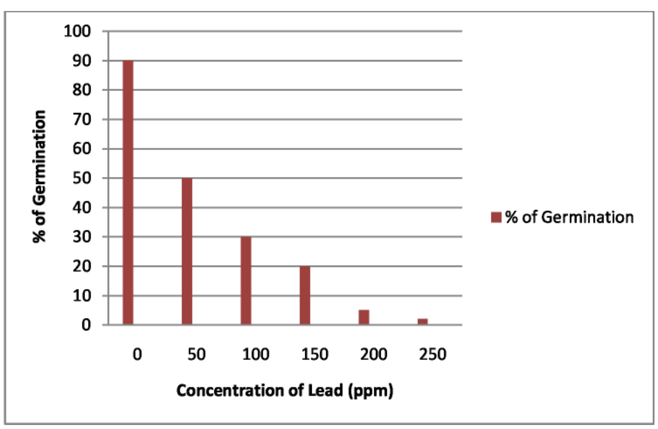

Fig-2: L. culinaris germination under influence of lead toxicity

This could be linked to the toxic effects of lead, which restrict water absorption and hinder embryo growth. Lead mostly travels down the apoplast route into the root, then travels back and forth across the cortex, accumulating close to the endodermis. Lead is partially blocked from moving between the root and shoot by the endodermis.

The findings presented in Tables 4.1–4.4 made it abundantly evident that lead buildup had a negative impact on both species (p.001). The buildup of Lead was found to be more evident in the roots than the shoots of the plants, and it was proportionate to the different concentrations of PbCl2. The pace of plant development, which varies from species to species [39–41], is an important indicator of the metal stress.

The relative growth rates of P. mungo and L. culinaris were significantly reduced as a result of the harmful element Lead, as previously reported by [42] as given below in Fig.3.

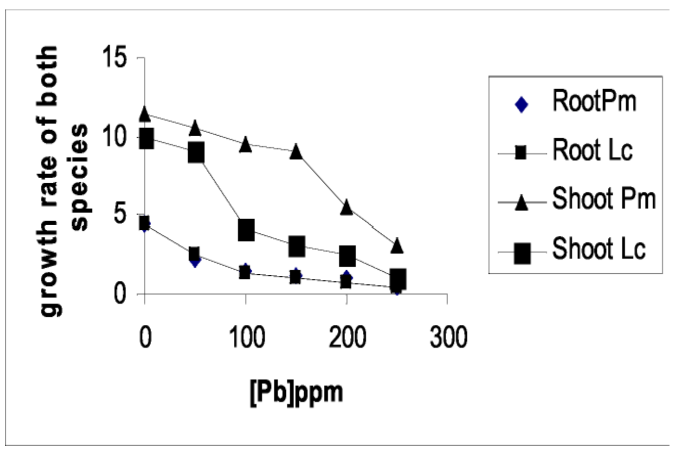

Fig-3: Comparison of P. mungo and L. culinaris seedlings growth rate under lead stress

CONCLUSION

The examination of the effects of lead contamination on two commonly consumed staple foods revealed that lead is a significant pollutant with significant negative effects on the environment. According to the study's findings, lead in plants accumulates predominantly in the roots, but when levels are excessive, lead is transported to the aerial part of the plant. Due to the root endodermis's barrier function, only a little amount of lead was translocated from the root to other organs. According to investigations, lead poisoning was a major factor in the development of both species. Lead accumulated more quickly in the roots before moving into the shoots, where it harmed the tissue structure of the roots and leaves. Lead prevented plants from absorbing calcium and had harmful effects on plant development by limiting water intake, which eventually hampered seedling growth.

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