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The effects of heavy metals on seed germination and growth of the plant Brassica nigra L.

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Abstract

Toxicity of heavy metals is the major abiotic stress causing harmful effects on seed germination and plant growth. The aim of this present study is to reveal the effects of the heavy metals Zn and Pb on germination and growth behaviour of Brassica nigra L.. Different concentrations of Zn and Pb were used during experiment to understand their effects on seed germination as well as plant growth behaviour. Shoot length and root length of plants, viability of seeds decreased with the increased concentration of those heavy metals. In higher concentrations the seed germination and plant growth were significantly affected by Zn and Pb. Although the lower concentration of Zn helps to perform various important physiological functions such as promotion of the shoot growth but higher doses of Zn may be fatal. Pb can strongly inhibits seed germination, plant growth, seedling development and chlorophyll content with its higher concentrations.

Keywords: *Brassica nigra*, Heavy metal, Plant growth, Seed germination, Toxicity.

Introduction

Heavy metals are naturally occurring elements present in all over the earth. Soil contains the trace levels of many heavy metals. Most of these heavy metals are essential elements for plants, but in higher concentration they reveal different effects on its physiological functions. Heavy metals are absorbed mainly through the root from the soil but they are also intake from the atmosphere through the over ground vegetative organs. The quantity of heavy metals absorption in plants depends on the concentration of the metals, physical and chemical composition of the soil and also varies in different plant species. There are several studies have been done emphasizing the influence of heavy metals on plant growth[1-7].

In this study the influence of Lead and Zinc on the plant *Brassica nigra* L. has been considered. The effect of Pb depends on the properties of the soil, its concentration and plant species on which it is applied. Lead is not essential for higher plants. However, several data indicates that lower concentration of Pb can stimulate plant growth. It has been found that treating seeds with high heavy metals concentration reduces the viability of the seeds and growth of the seedling. Zinc plays an important role for the proper growth and development of plants. It is an important component of several enzymes which regulates various metabolic processes in the plants. Zinc influences the formation of several growth hormones like IAA in plants and also stimulates the pod setting in the seeds. It required in minute quantities by plants. Excessive amounts of these elements are very harmful to organisms.

Other heavy metals such as Cd, Hg and As do not have any profitable effect on plants and they are very harmful to both plants and animals. The seeds are tolerant to the present of all metals. Germinating rate of seeds depend on the type of metals and its concentration. Many studies have been carried out on seed germination and seedling growth of different plant species exposed to Zinc and lead[8-12]. But there is no such evidence on *Brassica nigra* L..

Objective of the study: The prime objective of this work is to reveal the effects of heavy metals like Zn and Pb on the seed germination rate, plant growth, morphological characters and chlorophyll content of the plant *Brassica nigra* L.. Another objective is to determine the lethal dose of Pb and optimum dose of Zn.

Materials and Methods

Seeds of mustard (*Brassica nigra* L.) were collected in local area and analytical grade reagents of $ZnSO_4$ (Merck), Pb $(NO_3)_2$(Merck), HCl (Merck) were used to treat the seeds for the experiments and Ethanol and Petroleum ether were used to extract the chlorophyll from the leaf. Experiments were carried out taking hundred seeds in four replicas containing twenty-five seeds of each. Seeds were scarified with concentrated HCl and washed thoroughly with distil water for the better germination. Then these seeds were treated with different concentrations of Lead and zinc. One set was settled for the control that is without any heavy metals. After 24 hours the seeds were germinated in petri dishes with double layer of filter paper soaked in water.

The root length and shoot length and the germination rate of seeds were recorded after 96 hours. Then seedlings were planted on different pots containing normal field soil. At the maturity of the plants the size of leaves, length of the total plant body, germination rate, flowering time and fruiting time were recorded.

Anatomical section of the stems of the control and treated plants were prepared and observed under microscope to study the abnormalities in the treated plants.

For the extraction of chlorophyll one gm of leaf were taken into a mortar and pestle. 20 ml acetone was added to it and grinded properly. This mixture was centrifuge. Then the supernatant was transferred to a 100 ml volumetric flask. The volume was reached up to 100 ml with 80% acetone[13-19].

Total chlorophyll content of plants measured by the spectroscopy. For spectroscopic measurement, we are used INTECH UV-VIS Double Beam Spectrometer.

Results and Discussion

The effects of the different concentrations of Zn and Pb on seed germination of Mustard plant (*Brassica nigra* L.) were presented in Table-1and Table-2. Results also depicted in Figure-1 and Figure-2.

Zn promote seed germination rate at a fixed concentration but in higher concentration (1M) germination rate totally inhibited.

Seed germination rate gradually decrease with the increase of Pb concentration and in 1(M) concentration germination rates totally inhibited. So, when the seeds were treated with higher concentration it become toxic and reduced the germination rate.

Table-1: Rate of germination in presence of Zn.

Concentration of Zn (M)	Rate of Germination (%)
0	95±1.8
0.0001	94±2.28
0.001	93±1.8
0.01	93±1.8
0.1	98±2.28
1	0±0

Table-2: Rate of germination in presence of Pb.

Concentration of Pb (M)	Rate of Germination (%)
0	95±3.6
0.0001	92±3.2
0.001	85±6
0.01	83±6
0.1	3±4.68
1	0±0

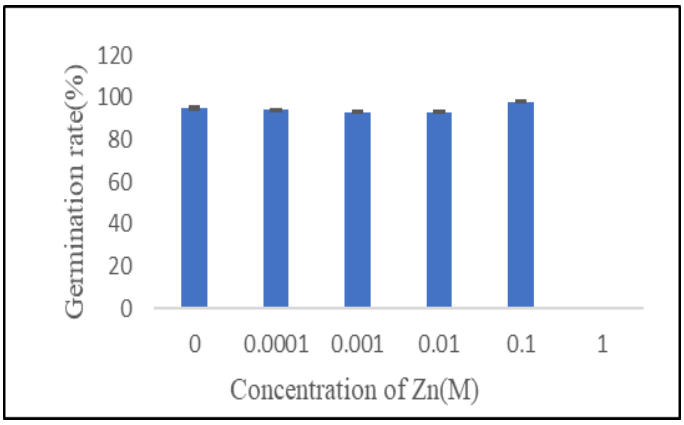

Figure-1: Seed germination after two weeks of exposure to Zn.

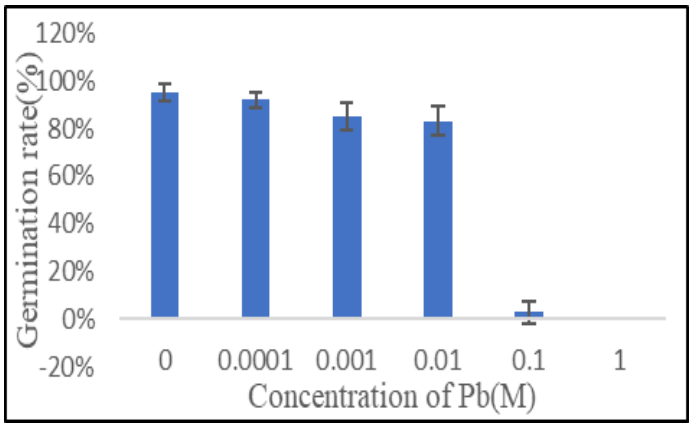

Figure-2: Seed germination after two weeks of exposure to Pb.

The effects of heavy metals (Pb and Zn) on shoot length presented in Figure-3 and Figure-4. In lower concentration zinc promote the root length and shoot length to a fixed rate but in higher concentration (1M) it has toxic effect (Table-3 and Table-4). Root length and shoot length gradually decreased with the increase of lead concentration and in 1(M) concentration it is totally inhibited.

The effects heavy metals on root length presented in Table-5 and Table-6. Results also depicted in Figure-5 and Figure-6. Root length, shoot length and germination rate gradually increase with increasing of the concentration of Zn but the optimum dose is 0.1(M). Zinc and Pb showed lethal effects over the *Brassica* plants at 1(M) concentrations.

Table-3: Average shoot length in presence of Pb.

Concentration of Pb(M)	Shoot length(cm)
0	0.95±0.008
0.0001	0.82±0.024
0.001	0.8±0.017
0.01	0.7±0.016
0.1	0.25±0.008
1	0±0

Table-4: Average shoot length in presence of Zn.

Concentration of Zn (M)	Shoot length(cm)
0	0.80±0.016
0.0001	0.85±0.017
0.001	0.91±0.022
0.01	0.95±0.008
0.1	0.97±0.032
1	0±0

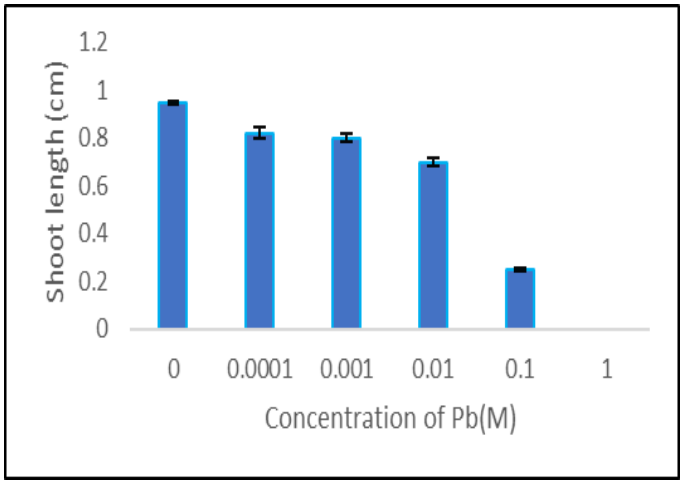

Figure-3: Average shoot length (cm) after treated with Pb.

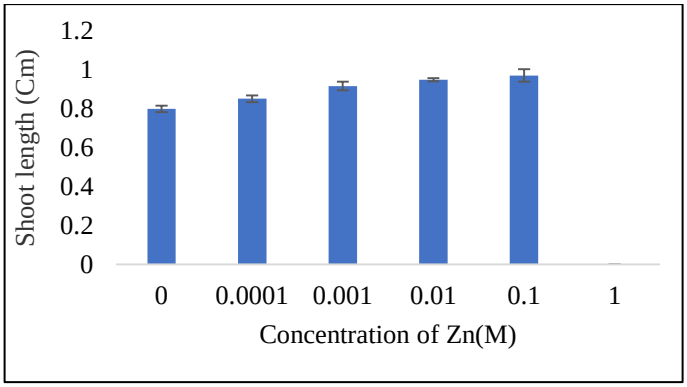

Figure-4: Average shoot length (cm) after treated with Zn.

Table-5: Average root length in presence of Pb.

Concentration of Pb (M)	Root length(cm)
0	0.95±0.008
0.0001	0.85±0.017
0.001	0.80±0.016
0.01	0.75±0.041
0.1	0.31±0.133
1	0±0

Table-6: Average root length in presence of Zn.

Concentration of Zn (M)	Root length(cm)
0	0.8±0.016
0.0001	0.82±0.024
0.001	0.91±0.009
0.01	0.95±0.008
0.1	0.98±0.028
1	0±0

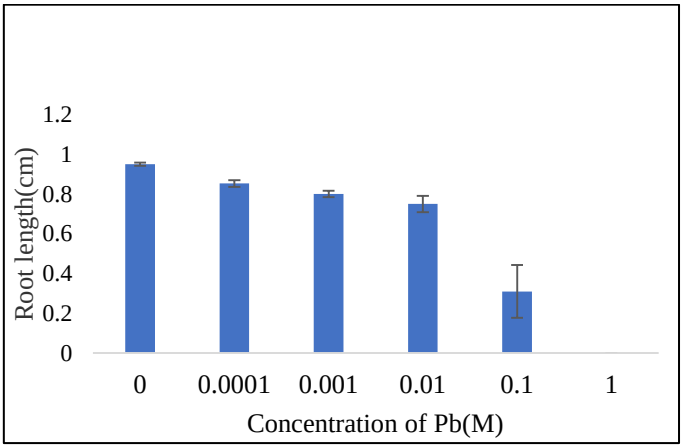

Figure-5: Average root length (cm) after treated with Pb.

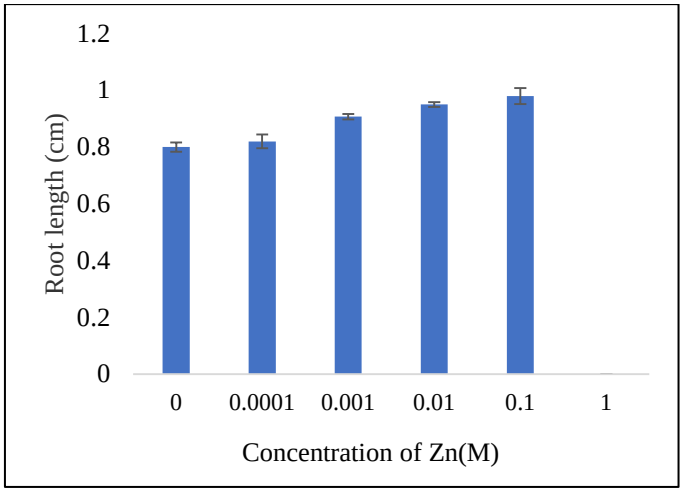

Figure-6: Average root length (cm) after treated with Zn.

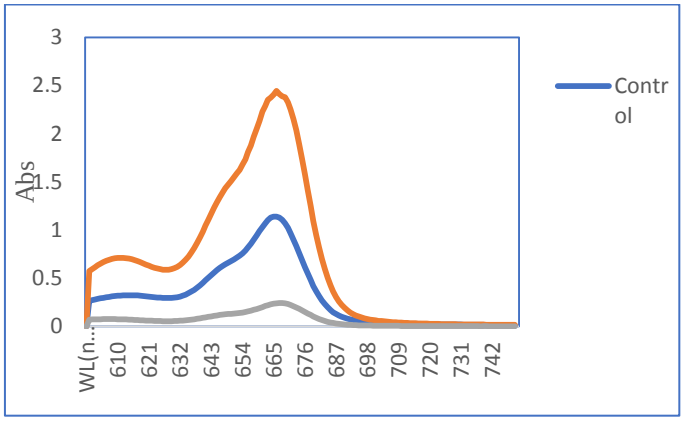

Figure-7: Chlorophyll content of leaves after treated with Zn and Pb.

In 1(M) concentration root length, shoot length and germination rate totally inhibited Spectroscopic data also support the root length, shoot length and morphological data of the plants (Figure-7). Total chlorophyll content of leaves become decrease when treated with Pb but chlorophyll content become high in Zn treated plants when it was compared with the controlled plants.

Total chlorophyll content of leaves increased with increasing concentrations of Zn (Figure-8). After 2 months from the heavy metals treatment some morphological changes were observed which present in Table-7. According to obtained data, the Zn have positive effects on the growth of the mustard plant and the optimum dose is 0.1(M). However, Pb showed lethal effects over the Mustard plants at 1(M) concentrations.

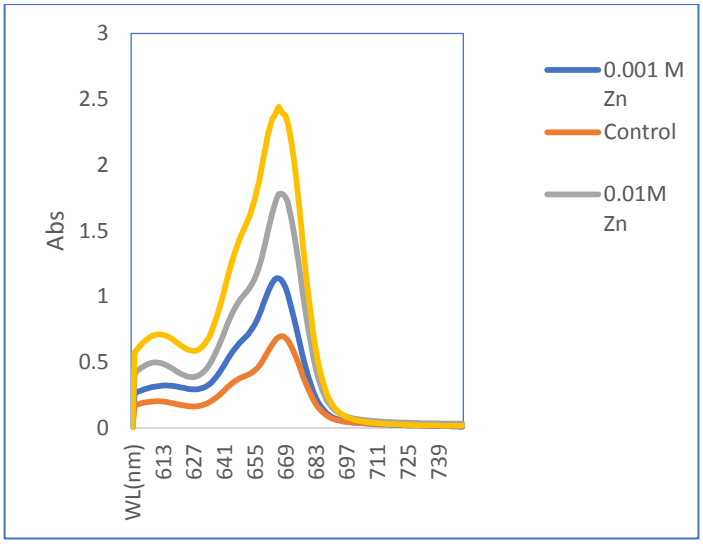

Figure-8: Chlorophyll content of leaves after with different concentration of Zn.

Conclusion

According to the results, the seed germination of the mustard plant is seriously affected by Zn and Pb. By this experiment we have determined the beneficial dose of Zn and toxic dose of Pb in case the growth of the *Brassica nigra.* Lead is the most toxic metal for seed germination of mustered plant. If we impart the proper dose of Zn for better germination and growth of Brassica to the farmer than they will be gained by their Brassica cultivation. Also, we can prescribe the toxic effects of Pb to them.

Table-7: There are some changes in morphological characters when treated with Zn and Pb in 0.1 (M) concentration.

Characters	Treated with Lead	Treated with Zinc	In controlled
Germination rate	low	high	high
Growth rate	low	high	high
Flowering and fruiting time	late	early	early
Pollen grains	Not effected in lower concentration	Not effected in lower concentration	Normal
Leaf size	small	Large	Large
flower	Small	Large	Large
fruits	Small	Large	Large

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