International Journal of Education, Modern Management, Applied Science & Social Science (IJEMMASSS)
ISSN : 2581-9925, Volume 02, No. 01, January - March, 2020, pp.209-212

EFFECT OF HEAVY METALS ON FRESH WEIGHT OF SEEDLINGS OF RAPHANUS SATIVUS VARIETY PUSA RASHMI

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ABSTRACT

This research explored the suppressive impact of metallic elements of considerable weight, specifically copper (Cu), cadmium (Cd), lead (Pb), nickel (Ni), and zinc (Zn), on the unfettered mass of seedlings from the Raphanus sativus cultivar Pusa rashmi. The findings revealed that as the levels of metallic elements escalated, there was a notable decline in the mass of seedlings. At the minimum concentration (10 ppm), the mass of seedlings was 0.26 g/seedling (Cu), 0.24 g/seedling (Cd), 0.26 g/seedling (Pb), 0.27 g/seedling (Ni) and 0.28 g/seedling (Zn). Nevertheless, when subjected to a higher concentration (500 ppm) of metallic elements, the unfettered mass experienced a significant decrease, ranging from 0.08 g/seedling (Cd) to 0.19 g/seedling (Ni), compared to the control that displayed as 0.20-0.27 g/seedling. Statistical analysis unveiled highly significant disparities between the reference and treatment groups, as well as among the diverse treatments of metallic elements. However, no significant dissimilarities were observed among the various chemicals themselves. Within the Pusa rashmi cultivar, cadmium emerged as the most detrimental metallic element concerning the unfettered mass of seedlings. The decline in seedling unfettered mass can be attributed to a reduction in the number of cells and the inhibition of root and shoot elongation caused by elevated levels of metallic elements. Moreover, the toxicity of metallic elements might impede the thickening of cell walls in roots and shoots, leading to a decrease in seedling unfettered mass. Prior investigations on pigeon pea, soybean, Vigna radiata, and Sorghum bicolour have also reported analogous decreases in seedling mass as a consequence of exposure to metallic elements.

Keywords: *Fresh Weight, Seedlings, Heavy Metals, Cultivar Pusa rashmi, Control conditions, Petri Dishes*.

Introduction

The presence of metallic elements in the environment poses a significant risk to both ecosystems and human communities. These elements, including copper (Cu), cadmium (Cd), lead (Pb), nickel (Ni), and zinc (Zn), are common pollutants that can infiltrate the soil through various human activities such as industrial processes, mining, and agriculture. Once in the soil, these heavy metals can be absorbed by plants and subsequently enter the food chain, potentially causing adverse effects.

Understanding the impact of heavy metals on plant growth and development is crucial for assessing the risks associated with environmental contamination. Among the various plant responses to heavy metal exposure, measuring the fresh weight of seedlings has been widely used as a reliable indicator of plant vitality and well-being. Changes in seedling fresh weight can indicate alterations in cellular processes, including cell division, elongation, and differentiation, which are vital for plant growth and development.

Within this context, the main objective of this study was to investigate the inhibitory effects of specific metallic elements (copper, cadmium, lead, nickel, and zinc) on the growth of young plants from the Pusa rashmi variety of Raphanus sativus, specifically in terms of overall weight. By exposing the

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seedlings to different concentrations of heavy metals, ranging from 10 ppm to 500 ppm, we aimed to explore the dose-dependent relationship between heavy metal exposure and subsequent decreases in seedling fresh weight. Additionally, statistical analyses were conducted to assess the significance of the observed differences between the control group and the treatment groups, as well as among the different heavy metal treatments.

Moreover, this study sought to evaluate the relative toxicity of the heavy metals and identify any specific metal that had the most detrimental effects on seedling fresh weight. Additionally, we investigated the potential mechanisms underlying the observed decrease in seedling fresh weight, including the influence of heavy metals on cell count, root and shoot elongation, and cell wall thickening.

The findings of this study contribute to expanding our understanding of the effects of heavy metal contamination on the growth and development of Raphanus sativus seedlings. Furthermore, by establishing connections with previous research conducted on other plant species, these results will enhance our comprehension of the broader implications of heavy metal toxicity on plant physiology and environmental sustainability. Ultimately, this research will aid in the development of effective strategies to mitigate the harmful impacts of heavy metal pollution on plant systems and, consequently, human health

Objectives

- Investigate the inhibitory effects of specific metallic elements (copper, cadmium, lead, nickel, and zinc) on the overall development of Pusa rashmi cultivar seedlings from Raphanus sativus.
- Correlate the rise in heavy metal concentrations with a decline in the fresh weight of seedlings.
- Contrast the fresh weight of seedlings exposed to different levels of metallic elements (10 ppm and 500 ppm) with the control group.
- Evaluate the statistical significance of disparities between the control group and the treatment groups, as well as among the various metallic element treatments.
- Appraise the relative toxicity of diverse metallic elements on the fresh weight of seedlings, with specific emphasis on cadmium.
- Investigate the potential mechanisms underlying the decrease in seedling fresh weight, including effects on cell count, elongation of roots and shoots, and thickening of cell walls.
- Establish a connection between the findings of this study and prior investigations involving other plant species (pigeon pea, soybean, Vigna radiata, and Sorghum bicolour) that have documented reductions in seedling fresh weight resulting from exposure to metallic elements.

Materials and Methods

The authorized seeds of Raphanus sativus L. variety Pusa rashmi were procured from the National Seed Corporation located in New Delhi. These seeds were then stored in glass stopper containers to maintain their quality. In order to ensure uniformity based on seed size and colour, an initial screening process was conducted. To eliminate any contaminants, the seeds were treated with a 0.1% HgCl2 solution for a duration of 2 minutes, followed by multiple rinses with distilled water. Distilled water solutions containing different concentrations (10, 50, 100, 200, and 500 PPM) of copper sulphate and nickel sulphate were prepared. A separate control group was established using distilled water. Each treatment was replicated three times.

Subsequently, the seeds were thoroughly washed and transferred onto petri plates lined with moist filter paper soaked in distilled water to facilitate germination and seedling growth.

The laboratory experiment spanned a period of 10 days and was conducted under controlled conditions with a temperature of 25 ± 2 °C and diffused light. The seeds received regular irrigation using distilled water to monitor their growth. At the conclusion of the experiment, the fresh weight of the seedlings was measured, and the average values from three identical trials were recorded. The weight of five standardized seedlings was measured using an electric balance and expressed in grams per seedling.

Germination was visually assessed by observing the emergence of radicals, and the fresh weight of the seedlings was recorded for subsequent statistical analysis

Results and Discussion

The presence of heavy metals had a suppressive impact on the weight of seedlings. The seedling fresh weight was recorded as 0.26 g/seedling (Cu), 0.24 g/seedling (Cd), 0.26 g/seedling (Pb), 0.27 g/seedling (Ni), and 0.28 g/seedling (Zn) at the lowest concentrations (10 ppm) of these heavy metals.

Table 1: Showing the Effect of Heavy Metals on Fresh Weight (g) Seedlings in Raphanus Sativus cv Pusa Rashmi

Sr. No.	Name of the Chemicals	Concentration (ppm)					
		Control	10	50	100	200	500
1	Copper sulphate	0.27	0.26	0.24	0.22	0.18	0.16
2	Cadmium chloride	0.29	0.24	0.20	0.15	0.11	0.08
3	Lead nitrate	0.29	0.26	0.23	0.19	0.16	0.12
4	Nickel sulphate	0.27	0.27	0.26	0.24	0.21	0.19
5	Zinc chloride	0.29	0.28	0.26	0.23	0.19	0.14

Values represent the mean of three replicates.
Analysis of Variance
F-ratios
Control vs treatment = 43.5***
Among treatments = 16.72***
Among chemicals = -4.98 (Ins)

The fresh weight of the seedlings exhibited a decrease when exposed to concentrations of 500 ppm of heavy metals. Specifically, the seedling weights were recorded as 0.16 g/seedling for copper (Cu), 0.08 g/seedling for cadmium (Cd), 0.12 g/seedling for lead (Pb), 0.19 g/seedling for nickel (Ni), and 0.14 g/seedling for zinc (Zn). In contrast, under control conditions, the seedling weights ranged from 0.20 g/seedling to 0.27 g/seedling.

Statistical analysis revealed significant differences when comparing the control group with the treatment groups and among the different treatments. However, no significant variations were observed among the individual chemicals themselves.

The primary objective of this study was to enhance our understanding of the effects of varying concentrations of five metals (copper, cadmium, lead, nickel, and zinc) on the Pusa rashmi cultivar of Raphanus sativus. The results of this investigation are discussed in detail below.

Among all the heavy metals investigated in this study, cadmium exhibited the highest toxicity to the fresh weight of seedlings in the Pusa rashmi cultivar of Raphanus sativus. The following percentages represent the decrease in fresh weight of seedlings due to heavy metal application compared to the control conditions:

Cultivar	Cu	Cd	Pb	Ni	Zn
Raphanus sativus cv Pusa rashmi	59%	27%	41%	70%	51%

Upon detailed examination of the data pertaining to the weight of young plants, it became evident that there was a noticeable decline as the concentrations of different heavy metals increased. This decline could potentially be attributed to the higher levels of heavy metals causing a reduction in cell count and impeding the growth of the root and shoot, ultimately impacting the overall weight of the seedlings. Alternatively, this phenomenon could arise from the inhibitory effects of heavy metals on cell wall thickening in the root and shoot cells, leading to a decrease in seedling weight.

Previous studies conducted by various researchers have also reported reductions in seedling fresh weight due to heavy metal exposure. For instance, Singh and Singh (1997) observed such reductions in pigeon pea, Aery and Sarkar (1991) in soybean, and Balashouri and Prameela Devi (1995) in Vigna radiata and Sorghum bicolour.

Cadmium toxicity can be attributed to its interference with the functions of vital-SH groups of biochemicals (Moore and Moore, 1976) or its interaction with DNA (Mitra and Bernsten, 1978), thereby disrupting their normal functioning. It is likely that a combination of these factors contributes to the observed toxicity.

Furthermore, Bhatia et al. (1998) reported that in Sorghum sudanensis, the plant's sensitivity to heavy metal applications followed the order of Cd > Pb > Zn, which aligns with the findings of the current study.

Conclusion

In conclusion, this investigation provides valuable insights into the suppressive impact of heavy metals on the fresh weight of seedlings belonging to the Raphanus sativus cultivar Pusa rashmi. The results clearly demonstrate a significant decrease in seedling fresh weight as the concentrations of heavy metals increase. The lowest concentration (10 ppm) resulted in fresh weights ranging from 0.24 g/seedling (Cd) to 0.27 g/seedling (Ni). However, exposure to higher concentrations (500 ppm) of heavy metals led to a substantial reduction in fresh weight, with values ranging from 0.08 g/seedling (Cd) to 0.19 g/seedling (Ni), compared to the control group, which exhibited a fresh weight of 0.20 - 0.27 g/seedling.

Statistical analysis confirmed highly significant differences between the control and treatment groups, as well as among the different heavy metal treatments. However, no significant differences were observed among the various chemicals themselves, indicating a similar inhibitory effect across the tested heavy metals. Among them, cadmium emerged as the most toxic, causing the greatest reduction in seedling fresh weight in the Pusa rashmi cultivar of Raphanus sativus.

The observed decrease in seedling fresh weight can be attributed to several factors. It is likely that higher levels of heavy metals result in a decline in cell number and hinder the elongation of roots and shoots. Moreover, heavy metal toxicity may impede the thickening of cell walls in roots and shoots, contributing to the reduction in fresh weight. These findings align with previous research on various plant species, including pigeon pea, soybean, Vigna radiata, and Sorghum bicolour, which have reported similar reductions in seedling fresh weight due to heavy metal exposure.

Overall, this study enhances our understanding of the detrimental effects of heavy metal contamination on the growth and development of Raphanus sativus seedlings. The findings underscore the importance of implementing effective strategies to mitigate the impact of heavy metal pollution on plant systems, emphasizing the significance of environmental sustainability and the preservation of human health

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