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THE IMPACT OF METALLIC ELEMENTS ON THE GROWTH OF RAPHANUS SATIVUS CULTIVAR PUSA CHETKI SEEDLINGS' MASS

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ABSTRACT

This study investigated the inhibitory effect of heavy metals, namely copper (Cu), cadmium (Cd), lead (Pb), nickel (Ni), and zinc (Zn), on the fresh weight of seedlings of the Raphanus sativus cultivar Pusa chetki. The findings indicated that as the levels of heavy metals rose, there was a noteworthy reduction in the fresh weight of seedlings. At the lowest concentration (10 ppm), the fresh weight of seedlings ranged from 0.23 g/seedling (Pb) to 0.27 g/seedling (Ni). However, when treated with a higher concentration (500 ppm) of heavy metals, the fresh weight decreased significantly to values ranging from 0.07 g/seedling (Cd) to 0.14 g/seedling (Ni) compared to the control group, which exhibited a fresh weight of 0.26-0.28 g/seedling. Statistical analysis revealed 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. In the Pusa chetki cultivar, cadmium was recognized as the most harmful heavy metal to the seedlings' fresh weight. The reduction in seedling fresh weight may be attributed to a decrease in cell number and inhibition of root and shoot elongation caused by higher levels of heavy metals. Additionally, heavy metal toxicity may inhibit the thickening of cell walls in roots and shoots, leading to a decrease in seedling fresh weight. Previous studies on pigeon pea, soybean, Vigna radiata, and Sorghum bicolor have also reported similar reductions in seedling fresh weight due to heavy metal exposure.

Keywords: *Fresh Weight of Seedling, Heavy Metals, Cultivar Pusa chetki, Treatments, Statistical Analysis, Laboratory Experiments, Petri Dish.*

Introduction

The presence of heavy metals in the environment presents a substantial risk to the well-being of ecosystems and human communities. These metals, namely copper (Cu), cadmium (Cd), lead (Pb), nickel (Ni), and zinc (Zn), are prevalent pollutants that have the potential to infiltrate the soil due to diverse human-made actions, including industrial processes, mining, and agricultural practices. Once present in the soil, these heavy metals can be taken up by plants and subsequently enter the food chain, potentially causing detrimental effects.

Understanding the impact of heavy metals on plant growth and development is essential for assessing the risks associated with environmental pollution. Among the various plant responses to heavy metal exposure, the measurement of seedling fresh weight has been widely employed as a reliable indicator of plant health and vigour. Changes in seedling fresh weight can reflect alterations in cellular processes, including cell division, elongation, and differentiation, which are essential for plant growth and development.

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In the given framework, the primary objective of this research was to explore the suppressive impact of certain metallic elements (Copper, Cadmium, Lead, Nickel, and Zinc) on the growth of young plants from the Raphanus sativus variety Pusa chetki, specifically in terms of their overall weight. By exposing the seedlings to different concentrations of heavy metals, ranging from 10 ppm to 500 ppm, we sought to examine the dose-dependent relationship between heavy metal exposure and the subsequent reduction in seedling fresh weight. Additionally, statistical analyses were performed to determine the significance of the differences observed between the control and treatment groups, as well as among the different heavy metal treatments.

Furthermore, the study aimed to assess the relative toxicity of the heavy metals and identify any specific heavy metal that exhibited the most detrimental effects on the fresh weight of the seedlings. Additionally, the potential mechanisms underlying the observed reduction in seedling fresh weight were explored, including the influence of heavy metals on cell number, root and shoot elongation, and cell wall thickening.

The findings of this study contribute to expanding our knowledge regarding 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, the results will help in comprehending the broader implications of heavy metal toxicity on plant physiology and environmental sustainability. Ultimately, this research will aid in developing effective strategies for mitigating the harmful impacts of heavy metal pollution on plant systems and, by extension, human health.

Objectives

- Examine the suppressive impact of certain heavy metals (copper, cadmium, lead, nickel, and zinc) on the overall growth of Pusa chetki cultivar seedlings of Raphanus sativus.
- Determine the relationship between increasing concentrations of heavy metals and the decrease in seedling fresh weight.
- Compare the fresh weight of seedlings at different concentrations of heavy metals (10 ppm and 500 ppm) with the control group.
- Analyse the statistical significance of the differences between the control group and the treatment groups, as well as among the different heavy metal treatments.
- Assess the relative toxicity of different heavy metals on the fresh weight of seedlings, with a specific focus on cadmium.
- Explore the potential mechanisms underlying the reduction in seedling fresh weight, including the impact on cell number, root and shoot elongation, and cell wall thickening.
- Establish a connection between the findings of this study and previous research on other plant species (pigeon pea, soybean, Vigna radiata, and Sorghum bicolor) that have reported reductions in seedling fresh weight due to heavy metal exposure.

Materials and Methods

The authorised seeds of Rafanus sativas L. variety Pusa chetki were obtained from National Seed Corporation in New Delhi. They were subsequently placed in glass stopper containers for storage. To ensure consistency based on seed size and color, an initial screening process was conducted. The seeds were then treated with a solution of 0.1% $HgCl_2$ for 2 minutes to remove any contaminants, followed by multiple rinses with distilled water. Solutions of 10, 50, 100, 200 and 500 PPM concentrations of Copper sulphate and Nickel sulphate individually were prepared in distilled water. The 60-60 seeds were soaked in these different solutions for 2 hours. A control with distilled water was also being run simultaneously. Each treatment was replicated thrice.

Then, seeds were washed thoroughly and then transferred into petri plates over wet (with distilled water), filter paper for germination and seedling growth.

The laboratory experiment lasted for a duration of 10 days, conducted at a temperature of 25 ± 2 °C and with diffused light. The seeds received daily irrigation using distilled water to monitor their growth. Upon completion of the experiment, the fresh weight of the seedlings was measured and the average values from three identical trials were documented. The weight of 5 uniform seedlings was measured using an electric balance and expressed in grams per seedling.

The emergence of radicals was visually observed to determine germination. The fresh weight of the seedlings was recorded and subjected to statistical analysis.

Results and Discussion

Table 1 shows the effect of heavy metals on fresh weight of seedling in Raphanus sativus cultivar Pusa chetki.

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), 0.23 g/seedling (Pb), 0.27 g/seedling (Ni), and 0.24 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 Chetki

Sr. No.	Name of the Chemicals	Concentration (ppm)					
		Control	10	50	100	200	500
1	Copper sulphate	0.28	0.26	0.23	0.20	0.14	0.11
2	Cadmium chloride	0.28	0.24	0.20	0.14	0.10	0.07
3	Lead nitrate	0.26	0.23	0.19	0.18	0.11	0.08
4	Nickel sulphate	0.28	0.27	0.25	0.22	0.17	0.14
5	Zinc chloride	0.26	0.24	0.21	0.17	0.12	0.90

Values represent the mean of three replicates.
Analysis of Variance
F-ratios

- Control vs treatment = 48.76***
- Among treatments = 18.16***
- Among chemicals = -8:6 (Ins)

The weight of the seedlings decreased when exposed to 500 ppm concentrations of heavy metals (0.11 g/seedling for Cu, 0.07 g/seedling for Cd, 0.08 g/seedling for Pb, 0.14 g/seedling for Ni, and 0.09 g/seedling for Zn) compared to the control conditions where it ranged from 0.26 g/seedling to 0.28 g/seedling.

Significant statistical results were observed when comparing the control group with the treatment groups and among the different treatments. However, no significant differences were found among the various chemicals themselves.

This study aimed to enhance understanding of the impact of different concentrations of five metals (copper, cadmium, lead, nickel, and zinc) on the Pusa chetki cultivar of Raphanus sativus. The results of this investigation are discussed below.

Among all the heavy metals, considered in the present work, cadmium was most toxic to the fresh weight of seedling in the cultivar Pusa chetki of Raphanus sativus. The percentage decrease in the fresh weight of seedlings due to heavy metals application as compared to control is given below-

Cultivar	Cu	Cd	Pb	Ni	Zn
Raphanus sativus cv Pusa chetki	39%	25%	30%	50%	34%

Upon closer analysis of the data regarding the weight of young plants, it was observed that there was a notable decline as the concentrations of various heavy metals increased. This decline could possibly be attributed to the fact that higher levels of heavy metals reduce cell count and hinder the growth of the root and shoot, consequently affecting the overall weight of the seedlings. Alternatively, this phenomenon may arise from the inhibition of cell wall thickening in the root and shoot cells due to the toxic effects of heavy metals, leading to a decrease in the weight of the seedlings.

Earlier also several researchers have observed the reduction in seedling fresh weight due to heavy metals (Singh and Singh 1997 in pigeon pea, Aery and Sarkar 1991 in soyabean, and Balashouri and Prameela Devi 1995 in Vigna radiata and Sorghum bicolor).

Cadmium toxicity may be due to the interference with the functions of a vital-SH groups of biochemicals (Moore and Moore, 1976) or due to the interaction with DNA (Mitra and Bernsten, 1978) thereby interfering with its functioning or due to the combination of these factors.

Bhatia et al (1998) also reported that in Sorghum sudanensis, the plant sensitivity to heavy metals applications was found to be in the order of Cd > Pb > Zn which is in conformity with the present work.

Conclusions

In conclusion, this study provides valuable insights into the inhibitory effect of heavy metals on the fresh weight of seedlings of the Raphanus sativus cultivar Pusa chetki. The findings demonstrate a clear and significant decrease in seedling fresh weight with increasing concentrations of heavy metals. The lowest concentration (10 ppm) resulted in fresh weights ranging from 0.23 g/seedling (Pb) 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 0.07 g/seedling (Cd) to 0.14 g/seedling (Ni) compared to the control group, which exhibited a fresh weight of 0.26-0.28 g/seedling.

The 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 comparable inhibitory effect across the heavy metals tested. Among the heavy metals, cadmium emerged as the most toxic, causing the greatest reduction in seedling fresh weight in the Pusa chetki cultivar of Raphanus sativus.

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

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

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