International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

A Comparative Analysis on Examining Heavy Metal Effects on Seedling Growth (Root and Shoot Length) in Raphanus Sativus Cultivar Pusa Rashmi Seedlings

Dr. Rajshree Gupta

Professor, Botany, B. B. D. Govt. College, Chimanpura, Shahpura, Jaipur, India
Email: *rajshreegupta[at]rocketmail.com*

Abstract: ***The study investigates the impact of copper, cadmium, lead, nickel, and zinc on the growth of Raphanus sativus cv Pusa rashmi, a prominent radish variety. Through controlled experiments with varying metal concentrations, this research observes their effects on seedling growth over ten days. Higher concentrations of these metals significantly reduce both shoot and root lengths in the radish seedlings. Cadmium and lead notably hinder shoot growth, while all metals inhibit root length, particularly at higher concentrations. Comparison with control groups highlights substantial growth reduction in metal - treated seedlings. Interestingly, Raphanus sativus cv Pusa rashmi shows relative resistance to heavy metal toxicity at lower concentrations of copper and nickel. These findings shed light on the nuanced impact of heavy metals on plant growth, suggesting a complex interplay involving enzyme function, hormonal regulation, and cellular alterations. Ultimately, this research enriches our understanding of how heavy metal pollution impedes radish plant growth, offering insights into the intricate mechanisms involved in these inhibitory effects.***

Keywords: Laboratory experiment, Petri dishes, Root length, Shoot Length, Pusa rashmi

1. Introduction

The subject of this study, Raphanus sativus cv Pusa rashmi, has a rich historical background, having been cultivated by ancient civilizations such as the Assyrians, Egyptians, Romans, and Greeks. Its widespread cultivation as an edible plant produce has transcended geographical boundaries, notably thriving in China, Japan, and India. The genus Raphanus was established by Tournefort and later formally documented by Linneaus in 1735, encompassing an estimated 8 to 10 species within its classification.

Raphanus sativus L. belonging to the family Brassicaceae is a very popular root crop grown throughout India and is commonly known as ‘Muli’. Raphanus sativus cultivar Pusa rashmi was released by IARI, New Delhi. It is a main season variety in asiatic group, suitable for growing from middle (early) september to early october, i. e. early sowing in cooler months, roots are 30 - 65 cm long, tapering with sharp end, white, with small green shoulder (top or stem end) and cut leaves. It matures in about 55 to 60 days.

Heavy metals, among various harmful elements, display significantly severe effects. They infiltrate soil, vegetation, and subsequently enter the food chain, resulting in health concerns for humans. The level of heavy metal toxicity fluctuates depending on their concentration levels.

The water gets polluted as washouts from catchment areas bring along with it various metallic ions, eg. arsenic, lead, cadmium, mercury, nickel, barium, beryllium, cobalt, molybdenum, tin, vanadium, etc. Many of these metals are highly toxic and when present in rivers or pond water, affect plant and animal life**.**

2. Material and Methods

This study utilized certified Pusa rashmi seeds obtained from the National Seed Corporation in New Delhi. To ensure uniformity based on size and color, the seeds were carefully selected and subsequently surface sterilized using a 0.1% HgCl2 solution for two minutes, followed by thorough washing with distilled water. Submersion in various concentrations (10, 50, 100, 200, and 500 ppm) of copper sulfate, cadmium chloride, lead nitrate, nickel sulfate, and zinc chloride solutions occurred for two hours. A control group was treated similarly but soaked in distilled water.

Each treatment involved soaking 60 seeds, with three replications. Germination and seedling growth were facilitated by placing the treated seeds in petri dishes containing wet filter paper under controlled laboratory conditions of approximately 25±2°C and diffused light. Daily watering with distilled water ensured proper progress.

After 10 days, on the experiment's termination day, the number of germinated seeds and parameters related to seedling growth—specifically, shoot and root lengths—were recorded and averaged across the triplicate experiments. Additionally, the root and hypocotyl length of 10 - day - old seedlings were measured in triplicate. From each petri dish, five seedlings were randomly selected to assess plumule (longer leaf) and radicle lengths, comparing growth between the control and treated seedlings after the 10 - day period.

3. Result and Discussion

The figures regarding different harmful metallic elements on root length and shoot length of Raphanus sativus cv Pusa rashmi is recorded in the following table-

S. No.	Name of the chemical	Concentrations (ppm)											
		Control		10		50		100		200		50	
		S. L.	R. L.	S. L.	R. L.	S. L.	R. L.	S. L.	R. L.	S. L.	R. L.	S. L.	R. L.
1	Copper Sulphate	10	9.2	10	9.2	9.6	8.7	9	8.2	8.3	7.3	7	6.1
2	Cadmium Chloride	10	9.5	9.4	8.8	8.7	7.9	8.1	7	6	5.4	4.8	4.2
3	Lead Nitrate	10.2	9.6	9.9	9.1	9.5	8.6	9	8.1	7.4	7.2	6.4	6
4	Nickel Sulphate	10	9.2	10	9.2	9.8	9	9.5	8.5	8.8	7.8	7.4	6.7
5	Zinc Chloride	10.2	9.6	10	9.4	9.7	9	9.2	8.5	8.5	7.7	7	6.4

(Values represent mean of three replicates)
Analysis of Variance:
Shoot length Root length
F - ratios: (i) Control Vs Treatments = 67.8714*** 46.9470***
(ii) Among Treatments = 49.4725*** 26.6182***
(iii) Among Chemicals = - 4.2838 (Ins) - 5.0863 (Ins)

Shoot length: The greater the concentrations of toxic metals, the shorter the shoot length of seedlings. Cd and Pb had a more pronounced impact on shoot length compared to Zn, Cu, and Ni. The change in shoot length at 50 and 500 ppm concentrations of different heavy metals was recorded as Cu (9.6 cm, 7 cm), Cd (8.7 cm, 4.8 cm), Pb (9.5cm, 6.4 cm), Ni (9.8 cm, 7.4 cm) and Zn (9.7 cm, 7 cm), respectively.

The control exhibited shoot lengths ranging from 10 to 10.2 cm. At 10 ppm of heavy metals, Cu measured 10 cm, Cd 9.4 cm, Zn 10 cm, Pb 9.9 cm, and Ni 10 cm, indicating minimal difference compared to the control. Results showed significant disparity between control and treatments, as well as across different concentrations, with no notable differences among the various chemicals.

Root length: Statistically, control and various treatments among themselves showed highly significant differences for root length of the seedling in Raphanus sativus cv Psa rashmi. However, there were no such differences among various chemicals The lower concentrations (10 ppm and 50 ppm) of heavy metals were associated with slight inhibition of radical length. However at higher concentrations (100, 200 and 500 ppm) there was significant inhibition in root length of this variety. In general, all the concentrations, except 10 ppm of Cu and Ni which were inhibitory to root length, the extent of inhibition increased with increasing concentrations of heavy metals.

In this study, the experimental plant's seeds, Pusa rashmi, were exposed to varying concentrations of copper, cadmium, lead, nickel, and zinc salts individually in a controlled lab environment. Previous research has explored how heavy metals affect root and shoot lengths in different crops. This investigation aimed to expand understanding regarding the impact of different concentrations of Cu, Cd, Pb, Ni, and Zn on Pusa rashmi.

The findings indicated that higher concentrations (100, 200, and 500 ppm) of all heavy metals notably reduced seedling growth in Pusa rashmi. Comparatively, there were significant reductions in shoot and root lengths in plants treated with different heavy metal concentrations when compared to the control group.

The current study clearly demonstrates that Pusa rashmi, on the basis of seedling growth, seemed to be more resistant to heavy metal pollution. The shoot growth in Pusa rashmi was more inhibited than root growth. And the shoot length and root length of seedlings at 10 ppm concentrations of Cu, Ni individually were the same as in control.

The decline in radish seedling growth may be linked to elevated levels of heavy metal concentration, absorbed by the seeds pre - germination, potentially hindering the uptake of vital elements necessary for plant growth. Additionally, heavy metal toxicity might hinder the development of crucial transport tissues—phloem and xylem—critical for water and nutrient supply to radish seedlings. This inhibition might result from heavy metals affecting hormone levels in the root and shoot apex, suppressing normal growth processes.

Previous studies by various researchers have explored the diverse explanations surrounding heavy metal toxicity and its impact on plant growth.

Kumar et al. (1997) documented a decrease in shoot and root growth in black gram (Phaseolus mungo) and green gram (Phaseolus aureus) at higher concentration of the effluent is due to the presence of high levels of total dissolved slides like chlorides and sulphates, etc in the wastes which prevent the seed germination by enriching the conductivity of solute being absorbed by seeds before germination and which interfered with the uptake of other elements like potassium calcium, phosphorus, and magnesium by the plants.

Thukral and Kaur (1987) noted that cadmium had the most detrimental impact on the root growth of Cyamopsis tetragonoloba. This effect was possibly linked to the inhibition of enzymatic activities, mitochondrial transport and respiration. It was reported that adverse effects of Cu on seedling growth of soybean have been due to its inhibitory effect on root growth elongation in the apical region.

Lepp (1977) also reported decreased growth of lettuce shoot and root when Cu, Pb, Cd, or Ni solutions were applied individually.

Hence, it can be concluded that the retardation in plant growth of Raphanus sativus cv Pusa rashmi due to heavy metals toxicity might be due to inhibition of enzyme activity and suppression of endogenous levels of plant hormones causing changes in cells and altering plant morphology.

4. Conclusion

This study illuminates the profound influence of copper, cadmium, lead, nickel, and zinc on Raphanus sativus cv Pusa rashmi seedling growth. Elevated metal levels distinctly impede both shoot and root lengths, with cadmium and lead notably stunting shoot growth and all metals affecting root development, particularly at higher concentrations. Interestingly, the radish variety exhibits a degree of resilience, showing relative tolerance at lower copper and nickel levels, showcasing varying sensitivities to different metals.

These findings deepen our comprehension of how heavy metal toxicity intricately disrupts plant growth. The research uncovers a complex interplay involving enzyme activities, hormonal disruptions, and cellular changes contributing to growth inhibition. By delineating distinct metal sensitivities and exploring potential mechanisms, this study enhances our understanding of how heavy metal pollution hampers radish growth.

In summary, this investigation offers crucial insights into the intricate relationship between heavy metal concentrations and their adverse impacts on Raphanus sativus cv Pusa rashmi, advancing our understanding of plant responses to environmental stressors.

Declaration of generative AI and AI - assisted technologies in the writing process

During the preparation of this work the author used ChatGPT in order to enhance the written English. After using this tool/service, the author reviewed and edited the content as needed and took full responsibility for the content of the publication.

References

[1] Kumar, P., Pandit, B. R. and Kumar, M.1997. Effect of dairy effluent on seed germination, seedling growth and pigment of green gram (*Phaseolus aureus*) and black gram (*Phaseolus mungo* L.). Ad. Plant. Sci.1**0:** 129 - 136
[2] Lepp, N. W.1977. Interaction between cadmium and other heavy metals in affecting growth of lettuce seedlings. Z. Pflanzenphysiol.8**4:** 363 - 367
[3] Thukral, A. K. and Kaur, P.1987. Effect of some trace elements of polluted waters on the germination of Cyamopsis tetragonoloba Taub. Indian J. Ecol.1**4:** 185 - 188