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Studies on the Role of Certain Heavy Metals on Seed Germination of Raphanus Sativus CV Pusa Chetki in Soil.

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ABSTRACT:

Agricultural soils are significantly affected by pollution, particularly heavy metal contamination from various sources such as domestic and industrial effluents, pesticides, fertilizers, and sewage. This research focuses on the impact of heavy metals, including Copper (Cu), Cadmium (Cd), Lead (Pb), Nickel (Ni), and Zinc (Zn), on the germination of Raphanus sativus variety Pusa chetki seeds after 10 days of growth. The study investigates the threshold at which heavy metal concentrations in the soil reduce plant growth, considering factors such as crop type, soil pH, and organic matter content. The occurrence of hazardous metals in the soil negatively affects soil respiration and litter decomposition rates.

Pot culture experiments were conducted using Raphanus sativus seeds, with different concentrations of heavy metals added to the soil. The results showed that all concentrations of heavy metals inhibit seed germination compared to the control group. The percentage of seed germination significantly decreased at higher concentrations of heavy metals. Statistical analysis indicated that the heavy metals had similar detrimental effects on seed germination, with no significant differences observed among them.

Previous studies have also reported similar inhibitory effects of heavy metals on seed germination in different plant species. The findings highlight the potential damage heavy metal contamination can cause to agriculture and the subsequent impact on the food chain and human health. The research contributes to understanding the environmental quality and the specific effects of heavy metals on susceptible plants.

Keywords: Pot culture experiments, Heavy metals, Seed germination, Raphanus sativus, Cultivar Pusa chetki

Objectives:

- This study aims to examine the impact of specific heavy metals (copper, cadmium, lead, nickel, and zinc) on the seed germination process of Raphanus sativus variety Pusa chetki over a period of 10 days.
- Determine the threshold amount of harmful metals in the soil at which seed germination is reduced, considering factors such as crop type, soil pH, and organic matter content.
- Assess the inhibitory effects of different concentrations of heavy metals on seed germination.
- Compare the relative toxicity of heavy metals (Cu, Cd, Pb, Ni, and Zn) on the germination of Raphanus sativus seeds.
- Determine the statistical significance of the differences between the control group and the heavy metal treatments, as well as among various concentrations of heavy metals.
- Compare the effects of heavy metals on seed germination in Raphanus sativus with previous studies on other plant species.

Introduction:

Pollution of agricultural soils has become a widespread and persistent issue, and its prevalence is expected to continue in the future. The contamination of soils by heavy metals is a significant concern, especially considering that soils often contain a mixture of these contaminants. The sources of soil pollution include domestic and industrial effluents, sewage, sludge, residues of pesticides, fertilizers, and detergents. Consequently, soils accumulate elevated levels of heavy metals such as Copper (Cu), Zinc (Zn), Nickel (Ni), Lead (Pb), and Cadmium (Cd).

The presence of metallic contaminants in farmland soils can have detrimental effects on essential soil processes. Soil respiration, a vital indicator of microbial activity and nutrient cycling, can be adversely affected by heavy metal contamination. Furthermore, litter decomposition rates, which play a crucial role in organic matter breakdown and nutrient release, can be negatively influenced by the presence of these contaminants.

The present research focuses on examining the impact of specific heavy metals, namely Cu, Cd, Pb, Ni, and Zn, on the seed germination of Raphanus sativus variety Pusa chetki. After a period of ten days of growth, the germination rates of the seeds were assessed. It is worth noting that the threshold abundance of trace metals in the soil, at which growth reduction occurs, varies depending on several factors, including the crop type, soil pH, and organic matter content.

Interestingly, certain heavy metals that are considered to have low toxicity to humans, such as Nickel and Zinc, can be highly toxic to certain plants, posing significant agricultural risks. Moreover, heavy metals present in contaminated plants can enter the food chain, potentially causing health issues for humans. Therefore, monitoring the damage inflicted upon susceptible plants by heavy metals serve as an indicator of environmental quality and the specific metal's impact on the ecosystem.

Material and methods:

To investigate the impact of heavy metals on seed germination, pot culture experiments were conducted using Raphanus sativus var. Pusa chetki seeds. The plants of this particular cultivar were grown under natural environmental conditions to ensure realistic results.

A set of pots, measuring 15 × 15 inches, were utilized and filled with 10 kg of air-dried garden soil. Each pot was equipped with a drainage hole for control purposes. In the prepared pots, 20 seeds of Raphanus sativus variety Pusa chetki were sown at a depth of 5 cm, maintaining equal distances between them. Each treatment was replicated three times to ensure the reliability of the data. Standard cultural practices were followed throughout the experiment.

To prevent any potential contamination and ensure uniform light conditions, the experimental pots were appropriately spaced. After a growth period of 10 days, the pots were carefully examined to assess seed germination under heavy metal treatment.

Five heavy metals, namely Copper, Cadmium, Lead, Nickel, and Zinc, were introduced to the soil in the form of their respective salts—Copper sulphate, Cadmium chloride, Lead nitrate, Nickel sulphate, and Zinc chloride. The soil was treated with four different concentrations of these heavy metals: 100, 500, 700, and 1000 mg/kg. Each concentration was thoroughly mixed with the garden soil. To ensure robust results, each treatment was replicated three times. A set of pots without any heavy metal treatment was maintained as a control group. Daily watering was carried out to provide the necessary moisture for seed germination.

Result and Discussion:

Table 1 presents the impact of different levels of noxious metals on the germination of Raphanus sativus cv Pusa chetki seeds. All concentrations of deleterious elements were observed to inhibit seed germination. Under normal conditions (control), the germination percentage ranged from 95% to 100%. However, upon applying a concentration of 1000 mg/kg of various hazardous metals, the germination percentages significantly decreased to 56% (Cu), 30% (Cd), 42% (Pb), 63% (Ni), and 55% (Zn).

Initially, at a concentration of 100 mg/kg of toxic substances, the germination percentages were 85% (Cu), 75% (Cd), 80% (Pb), 85% (Ni), and 90% (Zn). Notably, the germination percentages dropped substantially at the 500 mg/kg level compared to the 700 and 1000 mg/kg levels of heavy metals in the soil. This indicates a significant difference in germination percentages between the 100 and 500 mg/kg levels of detrimental elements. However, the differences in germination percentages among the 500, 700, and 1000 mg/kg levels of noxious metals were relatively minimal.

Furthermore, statistical analysis confirmed highly significant differences between the control group and the treatment group, as well as among the various levels themselves. It was evident that all harmful metals posed nearly equal harm to seed germination, as the differences among the different toxic substances were insignificant.

In this study, we aimed to assess the impact of various heavy metals, including Copper (Cu), Cadmium (Cd), Lead (Pb), Nickel (Ni), and Zinc (Zn), on the seed germination process of Raphanus sativus cv Pusa chetki through pot culture experiments. The germination percentages of seeds exposed to 800 mg/kg and 500 mg/kg concentrations of Cadmium were measured at 75% and 53.3%, respectively, compared to the control group with 100% germination. Our pot culture experiments revealed a gradual decline in seed germination with increasing concentrations of Copper, Nickel, and Zinc. Particularly, Cadmium and Lead exhibited a significant reduction in seed germination as the concentrations increased from 100 to 1000 mg/kg of soil. In the control group, the seed germination rate ranged from 95% to 100%, which decreased to 56% (Cu), 30% (Cd), 42% (Pb), 63% (Ni), and 55% (Zn).

Previous studies by Jain (1978) on Phaseolus aureus varieties, Khan and Khan (1994) on lentils, and Maury et al. (1986) on certain pasture plants have also reported the inhibition of seed germination due to Cadmium, Copper, and other heavy metal pollutants.

Veer (1990) observed that spinach was most sensitive to Zn toxicity as compared to Ni. Davies (1977) investigated the variable sensitivities of different crops namely Rye grass, French beans, Clover, Barley and Red beet to the 3 heavy metals Zn, Cu and Ni added to the soil as metal salts.

He found that copper was less toxic than zinc to Rye grass, Clover and Barley.

Table 1 - Showing the results of the effect of trace metals on germination of seeds (%) in Raphanus sativus cv Pusa chetki in soil.

Sr. No.	**Name of the chemicals**	**Concentration (mg/kg soil)**				
		Control	**100**	**500**	**700**	**1000**
1	Copper sulphate	95	85	70	60	50
2	Cadmium chloride	100	75	53.3	40	30
3	Lead nitrate	95	80	60	50	40
4	Nickel sulphate	95	85	73.3	65	60
5	Zinc chloride	100	90	75	65	55

(Values represent the means of 3 replicates)

Analysis of Variance:

F-ratios for seed germination-

(i) Control Vs Treatment = 43.6522***

(ii) Among Concentrations = 8.4916***

(iii) Among Chemicals = -8.3421 (Ins)

Ins = Insignificant

*** = Highly significant

Conclusion:

In conclusion, this particular research shows the impact of toxicological metal elements (Ni, Cd, Zn, Cu, and Pb) on the seed germination of Raphanus sativus variety Pusa chetki. The results revealed that all concentrations of heavy metals had inhibitory effects on seed germination compared to the control group. As the concentration of heavy metals increased, the percentage of seed germination significantly decreased. Statistical analysis indicated that the heavy metals had similar detrimental effects on seed germination, with no significant differences observed among them.

These findings emphasize the potential damage caused by heavy metal contamination in agricultural soils. Such contamination can have adverse effects on agriculture, the food chain, and ultimately human health. Understanding the threshold concentration of heavy metals at which seed germination is reduced is crucial for implementing appropriate soil management strategies. Furthermore, the study underscores the need for effective measures to prevent heavy metal pollution in soils and mitigate its potential risks to ecosystems and human well-being.

Future research can focus on exploring the long-term impacts of heavy metals on plant development, as well as investigating the specific mechanisms by which these contaminants hinder seed germination. Such insights will contribute to the development of sustainable agricultural practices and safeguarding environmental quality.

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