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ASSESSMENT OF THE EFFECT OF CERTAIN TRACE ELEMENTS ON CAROTENOID CONTENT OF RAPHANUS SATIVUS CV PUSA RASHMI

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ABSTRACT

The present study aimed to investigate the impact of trace elements on the quantity of carotenoid pigment in Raphanus sativus cv pusa rashmi seedlings. The experiment involved immersing the seeds in different concentrations of copper sulphate, cadmium chloride, lead nitrate, nickel sulphate, and zinc chloride, ranging from 10 to 500 parts per million (ppm). Control condition was also used (treated with distilled water). The seeds were then propagated in petri dishes, and after 10 days, the carotenoid content was examined by applying spectrophotometric analysis. Analysis (statistical) of the results showed a significant difference between the control group and the treatments, while no significant differences were observed among the various chemicals or their concentrations. The findings demonstrated a decrease in carotenoid content as the concentration of heavy metals increased. Copper, cadmium, lead, nickel, and zinc exhibited a negative impact on the carotenoid content of Raphanus sativus cv Pusa rashmi. Among these metals, cadmium was found to be the most detrimental to carotenoid levels. These results align with previous studies highlighting the inhibitory effects of heavy metals on photosynthesis and plant growth. The presence of pollutants like copper, along with other toxic elements such as zinc, lead, arsenic, and nickel, in high concentrations disrupts soil fertility and can have detrimental effects on plant health and productivity.

Keywords: *Heavy Metals, Carotenoid Content, Raphanus Sativus, Cultivar Pusa Rashmi, Petridish Culture.*

Introduction

The genus Raphanus sativus, initially established by Tournefort and later published by Linnaeus in 1735, encompasses a diverse group of 8-10 species. Among these, Raphanus sativus, commonly known as Muli and belonging to the family Brassicaceae, is a highly esteemed root crop widely cultivated throughout India. The cultivation of Raphanus sativus has resulted in the development of numerous varieties, each exhibiting distinct characteristics in terms of root size, shape, and colour. Notably, within the Asian or tropical varieties of Muli, prominent cultivars include Pusa chetki, Pusa rashmi, and Japanese white. In the context of this discussion, the focus is specifically on Pusa rashmi, which is renowned as a main season cultivar within the Asian group. Pusa rashmi is characterized by its impressive root length, ranging between 30 to 65 cm.

In light of the alarming pollution levels persisting in India's river waters, which serve as a primary source of irrigation, it became imperative to assess the potential impact of trace elements on the pigment content, particularly carotenoids, in Raphanus sativus. To investigate this, a series of laboratory

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experiments were conducted employing petri dishes as experimental platforms. The aim was to determine the influence of trace elements on the concentration and composition of pigments, thereby shedding light on the potential repercussions of water pollution on the nutritional and aesthetic properties of this vital crop. By exploring the intricate relationship between trace elements and carotenoid content, these experiments sought to provide valuable insights into the broader implications of environmental factors on the quality and viability of Raphanus sativus as an agricultural resource.

Objectives

- Assess the impact of trace elements, specifically copper sulphate, nickel sulphate, cadmium chloride, lead nitrate, and zinc chloride, on the carotenoid content of Raphanus sativus cv Pusa rashmi.
- Investigate the concentration and composition of pigments, particularly carotenoids, in Raphanus sativus cv Pusa rashmi under the influence of trace elements.
- Determine the effect of increasing concentrations of copper, cadmium, lead, nickel, and zinc on the carotenoid content of Raphanus sativus cv Pusa rashmi.
- Analyze the statistical significance of the observed differences in pigments (carotenoid content) between the control group and treatments involving different trace elements.
- Compare the carotenoid content of Raphanus sativus cv Pusa rashmi in the control condition to the content under heavy metal treatments at various concentrations.
- Assess the relative hazardous effects of different heavy metals on the carotenoid content in Raphanus sativus cv Pusa rashmi, with a focus on cadmium as the most detrimental element.

Material and Methods

In the present investigation, certified seeds of Raphanus sativus L. variety Pusa rashmi were procured from National Seed Corporation, New Delhi, then kept in stoppered bottles of glass. The seeds after checking for uniformity were surface sterilised with 0.1% $HgCl_2$ for 2 minutes and rinsed repeatedly under distilled water. Different 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. The experiment was conducted with three replications for each treatment.

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

After 10 days of experiment in the laboratory (at 25 degree ± 2 degree C°). The visual emergence of radicals was taken as criteria for germination.

In order to assess the carotenoid content, the technique described by Mahadevan and Sridhar (1982) and Arnon (1949) was employed. Leaves of Raphanus sativus cultivar pusa rashmi, which had matured for ten days, were selected for the study. For each treatment, fifty milligrams of leaf material were collected and homogenized with 50 ml of 80 percent acetone.

The sample was subjected to centrifugation at a speed of 2000 parts per million (ppm) for a duration of 10 minutes. Subsequently, the resulting volume was adjusted to 10 ml using 80% Acetone. The transparent extract was analyzed for carotenoid content using a spectrophotometer at wavelengths of 480 nm and 510 nm.

The values of pigments were expressed in terms of mg/g fresh weight as suggested by Arnon (1949) and Mahadevan and Sridhar (1982).

Following formula was used to find out the carotenoid content:

$$\text{Carotenoid content} = \frac{7.6\,\text{O.D.}\,480 - 1.49 \times \text{O.D.}\,510}{a \times 100 \times W} \times V \text{ mg/g}$$

O.D. = Optical density (light absorption measured using 1 cm cell)

V = Volume of extract in ml

a = Length of light path in cell (cm)

W= Fresh weight of seedling leaves (in gram)

The carotenoid content of Raphanus sativus cv Pusa rashmi was recorded and tabulated. The collected data was then subjected to statistical analysis using the F-test method (Bishop 1966, Peterson 1939) at significance levels of 1% and 5%.

Result and Discussion

Statistical analysis of figures showed a highly significant difference between control and the treatments. The various treatments did not differ significantly among themselves. No such differences were obtained among chemicals themselves (Table 1).

Table 1: Exhibiting the effect of certain trace metals on carotenoid content (milligram/gram fresh weight) in seedlings of Raphanus sativus cultivar Pusa rashmi.

S. No.	Name of the chemical	Concentration (ppm)					
		Control	10	50	100	200	500
1.	Copper sulphate	0.18	0.16	0.14	0.13	0.12	0.10
2.	Cadmium chloride	0.18	0.13	0.10	0.08	0.05	nd
3.	Lead nitrate	0.18	0.14	0.12	0.10	0.07	0.05
4.	Nickel sulphate	0.18	0.17	0.15	0.14	0.13	0.12
5.	Zinc chloride	0.18	0.15	0.13	0.12	0.10	0.08

(The values presented are the means obtained from three replicates.)

ANOVA

F-ratios

- Control versus treatment = 60.00***
- Among chemicals = -8.9375 (Ins)
- Among treatments = 1.8159

Ins = Insignificant

nd = not detectable

Carotenoid content of Raphanus sativus cv Pusa rashmi was found decreased with increasing amounts of copper, cadmium, lead, nickel and zinc. In heavy metals treatment at 500 ppm concentration, the amount of carotenoid content was reduced as 0.10 mg/g (Copper), nil (Cadmium), 0.05 mg/g (Lead), 0.12 mg/g (Nickel) and 0.08 mg/g fresh weight (Zinc).

Various interpretations have been proposed for the decrease in pigment (carotenoid) quantity, by using trace elements. Yang et al (1989) also observed that cadmium ions significantly reduced photosynthesis (photosystem II) activity in spinach chloroplast.

Naguib et al (1986) observed symptoms of iron deficiency in wheat and rice seedlings in the presence of cadmium. Zinc toxicosis has been reported in several plants in greenhouse studies, when excessive levels of zinc were used (Boawn and Rasmussen 1971).

High concentrations of Hg, Cd, and Pb disturb the biological equilibrium in soil fertility, plant deficiency and yield (Vallee and Ulmer 1972).

Copper is a common environmental pollutant arising from the metal mining process as well as from numerous other industries, urban and agricultural activities (Foy et al 1978).

Out of the trace elements used in the present investigation, it was noticed that Cd was the most toxic for carotenoid content in cultivar Pusa rashmi of Raphanus sativus.

Conclusion

In conclusion, the findings of this experiment showed significant differences between control and treatments, indicating a clear impact of trace elements on the carotenoid content of Raphanus sativus cv Pusa rashmi. The treatments themselves did not show significant differences, suggesting that the various trace elements had similar effects on carotenoid levels. Furthermore, no significant differences were observed among the different chemicals tested.

The carotenoid content of Raphanus sativus cv Pusa rashmi exhibited a consistent decrease with increasing concentrations of copper, cadmium, lead, nickel, and zinc. The treatment with concentrations of 500 ppm led to a reduction in carotenoid content, such as 0.10 mg/g (Cu), nil (Cd), 0.05 mg/g (Pb), 0.12 mg/g (Ni), and 0.08 mg/g fresh weight (Zn).

The decrease in carotenoid quantity after using heavy metals can be attributed to various factors. Previous studies have suggested that cadmium ions inhibit photosynthesis, particularly photosystem II activity, while iron deficiency symptoms have been observed in the presence of cadmium. Excessive levels of zinc have also been reported to cause toxic effects in plants. High concentrations of mercury, cadmium, and lead can disrupt soil fertility, plant development, and yield.

Among the heavy metals considered, cadmium emerged as the most detrimental element to the carotenoid content in Raphanus sativus cv Pusa rashmi.

These findings emphasize the importance of mitigating water pollution and minimizing the presence of trace elements in agricultural environments to preserve the nutritional value and quality of crops like Raphanus sativus. Further research on the mechanisms underlying the impact of heavy metals on carotenoid content can provide valuable insights for sustainable agricultural practices.

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