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# Cytotoxic Effect of Pantoprazole on Onion (*Allium cepa*) Root Tip cells

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**Abstract:** The increasing use of pharmaceuticals like Pantoprazole, a proton pump inhibitor (PPI), has raised environmental concerns due to their persistence and potential cytotoxic. This study investigates the cytotoxic effects of Pantoprazole on the root meristem cells of *Allium cepa* (onion), a well-established plant bioindicator. The root tips were exposed to various concentrations of Pantoprazole (10 and 20 mg/l) for 72 hours. The mitotic index (MI) and root growth inhibition were evaluated. The results indicated a significant dose-dependent decline in MI. These findings suggest that Pantoprazole, when present in the environment, can induce genetic damage in plant systems and may potentially affect broader ecological processes.

**Keywords:** Pantoprazole, *Allium cepa*, genotoxicity, chromosomal aberrations, mitotic index.

## 1. INTRODUCTION

Pharmaceuticals play a central role in modern medicine and are indispensable for maintaining health and fighting disease. Pharmaceuticals, once consumed, are often excreted unmetabolized into sewage systems, eventually reaching aquatic and terrestrial environments. Studies in the United Kingdom and the United States demonstrated that a variety of pharmaceuticals remain stable even after wastewater and drinking-water treatment, indicating their ability to persist in aquatic environments (Ashton et al., 2004; Stackelberg et al., 2004). It is also reported that *E. hirta* methanolic extract, which is used frequently in traditional medicine, clearly exhibits chromotoxic and mitodepressive effects (Ping et al., 2012). Shandilya et al. (2025) also reported that prolonged exposure of high paracetamol concentration may irreversible impact on genome integrity.

Pantoprazole, a proton pump inhibitor commonly prescribed for gastric disorders, is one such pharmaceutical now frequently reported in environmental monitoring. Although Pantoprazole is clinically important for human health, little is known about its long-term impact on non-target organisms. Plants, particularly their root meristematic tissues, are highly sensitive to environmental contaminants and provide effective models for studying cytotoxic changes. The *Allium cepa* assay, first standardized by Fiskesjo (1985) and later validated by Rank and Nielsen (1994) is widely accepted as a reliable test system because of its rapid cell division, large chromosomes, and strong correlation with mammalian genotoxicity assays. While the therapeutic benefits of Pantoprazole for humans are well documented, its long-term effects on non-target organisms remain largely unexplored.

In this context, the present research focuses on the evaluation of cytotoxic effects of Pantoprazole on Allium cepa root tips. By tracing changes in mitotic activity and chromosomal behavior across different concentrations of Pantoprazole, this study aims to reveal how prolonged or increasing exposure to this drug influences cytogenetic stability in plant cells, thereby providing important insights into its potential environmental risks.

## 2. Materials and Methods

### Test Material: Onion root tip cells (*Allium cepa*)

The onion bulbs were first allowed to develop roots measuring about 1–2 cm in distilled water for 48 hours. After rooting, they were exposed to two different concentrations of Pantoprazole (PPZ).

**Chemical used: Pantoprazole Drug**

The Pantoprazole drug of ALKEM was obtained from a certified pharmaceuticals supplier, the two concentrations of Pantoprazole 10mg/l (PPZ-I, dose-I) and 20 mg/l (PPZ-II, dose-II). The exposure periods was 72 hours, while a control group was maintained separately in distilled water without the addition of Pantoprazole.

After each exposure period of Pantoprazole, root lengths were measured using a ruler scale. Reduction in root growth compared to control was recorded as an indicator of toxicity.

The root tips were fixed in Carnoy's fixative (3:1 ethanol and acetic acid) for 24 hours. Following fixation, they were stained with acetocarmine and gently squashed on slide and observed under microscope for mitotic index study. About 3000 cells were observed.

Mitotic Index is calculated by following formulas:

$$\text{MI} = \frac{Total\ no.of\ dividing\ cells}{Total\ no.of\ cells\ observed} \times 100$$

**Statistical analysis:**

The statistical analysis of data was performed by using t-test.

**3. Results and Discussion:-**

**Root Growth Inhibition:**

The cell treated with Pantoprazole at dose I there is insignificant effect on root growth. But at dose II the root growth was inhibited in comparison to the control (Table – 1).

**Table 1. Mean Root Length (cm) after 72 hours of exposure**

| Experimental Variant | Root Length (cm) Mean ± SE | Inhibition (%) |
|---|---|---|
| **Control** | 4.5 ± 0.2 | 0 |
| **PPZ- I (10mg/l)** | 4.1 ± 0.1 | 8.8 |
| **PPZ-II (20mg/l)** | 1.1 ± 0.1* | 75.5* |

***Indicate * significant p > 0.05***

The study demonstrates that Pantoprazole exerts root growth inhibition effects on *Allium cepa* root tip cells.

**Mitotic Index (MI)**

In PPZ- I (dose-I) the MI was decrease to 9.8% compared to control (12.1%). In phase distribution there is no significant difference in prophase, metaphase, and anaphase but significant differences were observed in telophase compared to the control (Table 2). In PPZ- II (dose- II) the MI significantly decreases from 12.1% to 7.1% and in phase distribution MI of prophase and metaphase decreases significantly. This decrease in MI was mainly due to decrease in the population of cells belonging to prophase and metaphase (Table 2). Similar results were observed (Kumari et al., 2019; Rana and Kumari, 2022). Numerous studies have shown that wherever there is root growth inhibition in *A. cepa,* there is also a reduction in dividing cells, the MI declines with increasing concentration of PPZ.

**Table 2. Mitotic Index (%) after 72 hours exposure**

| Experimental Variant | Total no. of screened cells | Total no. of dividing cells | Total mitotic index | Phase distribution | | | |
|---|---|---|---|---|---|---|---|
| | | | | Prophase No. % ±SE | Metaphase No. % ±SE | Anaphase No. % ±SE | Telophase No. % ±SE |
| **Control** | 2800 | 340 | 12.1±0.5 | 45.0 ± 1.0 | 50.8 ± 0.8 | 1.7 ± 0.1 | 2.3 ± 0.1 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **PPZ-I** | 2,650 | 260 | 9.8 ± 0.4* | 47.0 ± 0.9 | 48.8 ± 0.7 | 1.5 ± 0.2 | 1.9 ± 0.5* |
| **PPZ-II** | 2,101 | 150 | 7.1 ± 0.6* | 46.0 ± 1.1* | 51.3 ± 1.0* | 1.3 ± 0.25* | 1.3 ± 0.6* |

***Indicate * significant at p > 0.05***

The findings of this study clearly demonstrate that Pantoprazole exerts cytotoxic effects on *A. cepa* root meristematic cells. A consistent decline in the mitotic index with increasing drug concentration and suggests a suppression of cell division. Such mitodepressive activity has also been reported in earlier work. A clear decline in root growth and mitotic activity were observed. The reduction in mitotic index and rise in abnormal mitotic figures indicate that Pantoprazole interfered with the normal process of cell division. Root growth inhibition was concentration dependent with the highest suppression recorded at 20mg/l.

The inhibition of root growth observed in the present study complements these cytogenetic findings, suggesting that Pantoprazole interferes not only with chromosome behavior but also with overall meristematic cell activity. Similar root growth suppression linked to cytotoxic stress has been documented in pharmaceutical monitoring studies, including those of Freeling *et al.* (2024), who demonstrated that Pantoprazole metabolites are persistent in aquatic environments and may contribute to oxidative stress or spindle disruption in non-target organisms.

These findings indicate that Pantoprazole exposure induces a concentration dependent root growth inhibition and cytotoxic effects in *A. cepa*.

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