# INVESTIGATION OF THE ALLELOPATHIC EFFECTS OF HELIOTROPIUM INDICUM ON THE GERMINATION OF CEREAL CROPS

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## Abstract

Allelopathy—the chemical inhibition of one plant by another is a significant yet often overlooked factor in agricultural weed-crop interference. This study evaluates the phytotoxic potential of aqueous leaf extracts of *Heliotropium indicum* (Indian Heliotrope) on the germination and early seedling vigor of *Zea mays* (Maize) and *Oryza sativa* (Rice). Using concentrations of 0%, 5%, 10%, 15%, and 20%, the study measured germination percentage and seedling growth over 7 days. Results showed a significant ($p < 0.05$) dose-dependent inhibition. Rice was the most sensitive, with germination dropping to 30% at the highest concentration. The study confirms that *H. indicum* releases potent allelochemicals that compromise cereal crop establishment.

**Key words:** Allelopathy, weed, phytotoxic, cereal crop, Health Risks

## Introduction

In tropical agro-ecosystems, *Heliotropium indicum* is a prolific need commonly found encroaching upon cereal fields. While competition for physical resources like light and water is well-documented, the "chemical warfare" known as **allelopathy** is equally critical to crop success. *H. indicum* contains a variety of pyrrolizidine alkaloids (e.g., indicine and heliotrine) and phenolic compounds that leach into the soil through rain or decomposition.

According to **Zimdahl (2007)**, early-season weed interference is the most significant factor in determining final yield loss. When crop seeds are sown in soil already "primed" with these toxins, their metabolic processes are hindered from the moment of imbibition. This research aims to quantify the magnitude of this chemical suppression. Heliotropium indicum contains toxic compounds, primarily pyrrolizidine alkaloids, which pose a significant health risk to both humans and livestock. Here is a scientific illustration detailing the plant's parts, its chemical components, and the corresponding toxic risks.

Toxicity and Health Risks of Heliotropium indicum (Indian Heliotrope)

This plant is recognized by its unique, scorpioid (scorpion-tail-like) flowering spike, which uncoils as the small white or pale blue flowers bloom. While it has been used in traditional medicine, scientific research indicates that the entire plant—including the leaves, stems, flowers, and roots—contains dangerous levels of hepatotoxic pyrrolizidine alkaloids (PAs), such as heliotrine and lasiocarpine.

Key Toxic Components and Risk Factors:

Pyrrolizidine Alkaloids (PAs): These are the primary toxic components. When ingested, the liver attempts to metabolize these alkaloids, transforming them into highly reactive pyrroles.

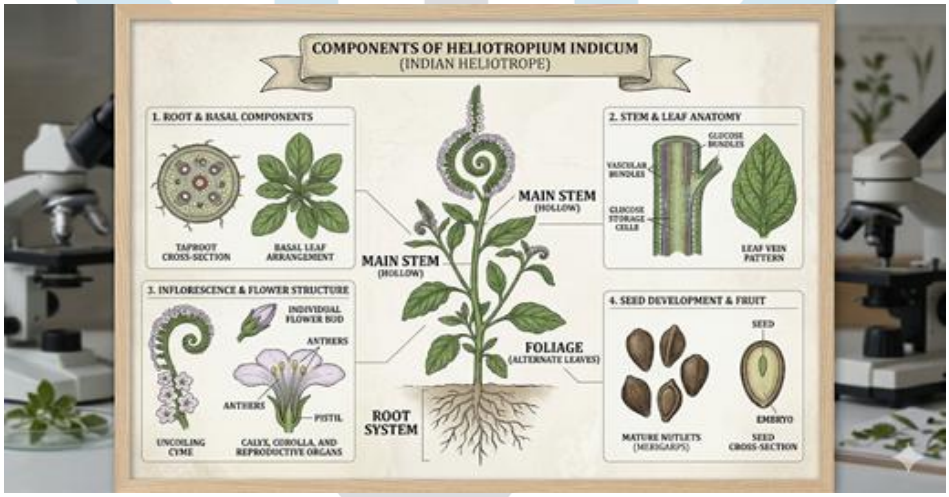
Hepatotoxicity: The transformed pyrroles bind covalently to liver cells (hepatocytes), causing irreversible damage. This leads to liver cell death, liver enlargement, and a serious condition known as hepatic veno-occlusive disease (HVOD).

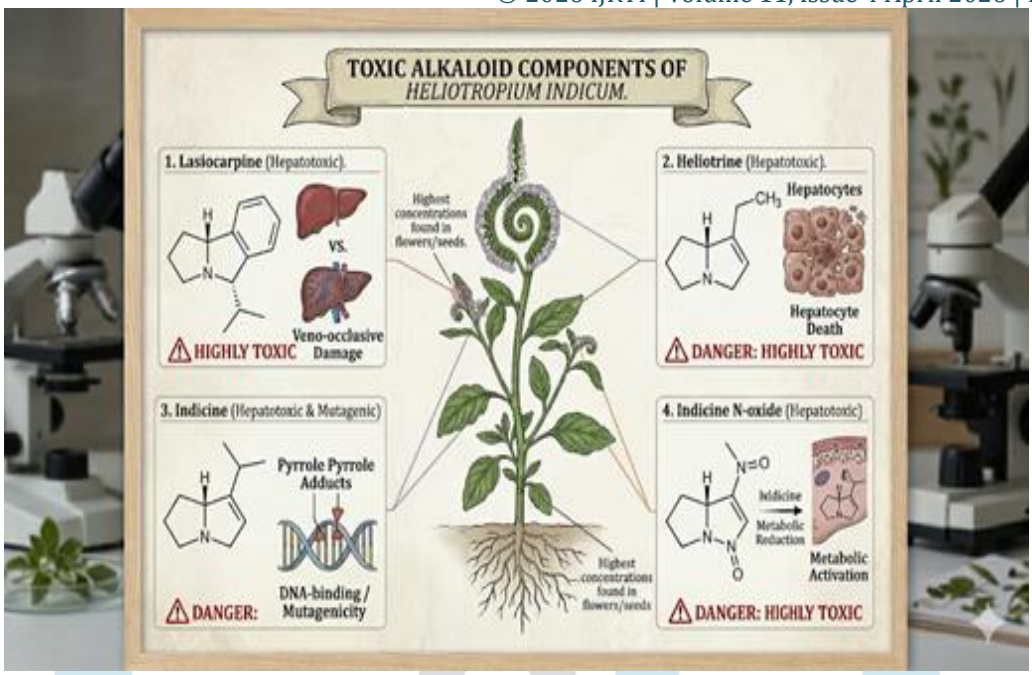
Chronic Effects: Regular or large-scale exposure can result in chronic liver failure, liver cirrhosis, and ascites (fluid buildup in the abdomen). Some PAs are also suspected carcinogens.

Toxicity in Humans vs. Livestock:

Humans: Most human poisoning occurs from accidental consumption of contaminated herbal teas, grain crops contaminated with the seeds, or the use of traditional medicine preparations that are improperly dosed or identified. Symptoms include nausea, vomiting, acute abdominal pain, and jaundice.

Livestock: Animals often ingest the plant while grazing, especially when preferred forage is scarce. The symptoms in animals, particularly horses and cattle, are collectively referred to as "Walking Disease" or "Heliotrope Poisoning." They experience severe weight loss, jaundice, and neurological signs like staggering, aimless walking, and head pressing due to liver-induced encephalopathy.






## Material and Methods

- **Extract Preparation:** Fresh leaves of *H. indicum* were shade-dried and ground into a fine powder. A 20% stock solution was created by soaking 100g of powder in 500ml of distilled water for 24 hours.
- **Bioassay Procedure:** 20 seeds per Petri dish (replicated 3 times) were placed on double-layered filter paper. Each dish was treated with 5ml of the respective extract concentration daily.
- **Data Collection:** Germination count was taken daily. On the 7th day, radical (root) and plumule (shoot) lengths were measured using digital callipers to determine the **Vigor Index**.

## Results and Analysis

## Comprehensive experimental Results: Growth and Germination Data

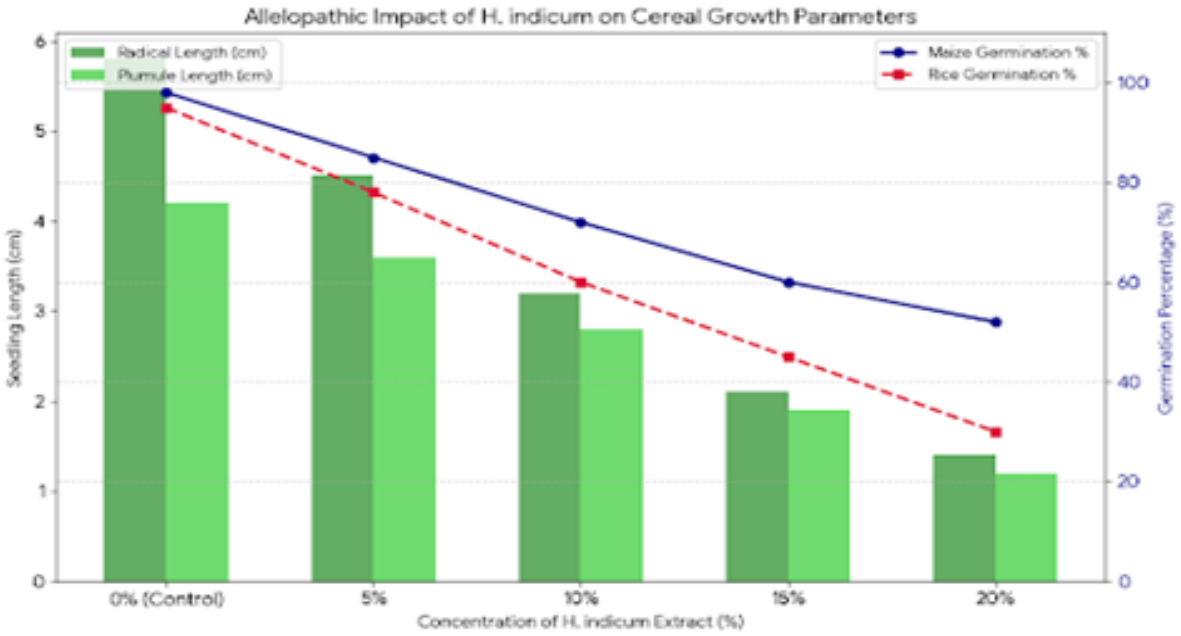
The following table summarized the mean values recorded on the 7 the bioassay. The seeding vigors index (SVI) was calculated using the formula

**SVI=Germination%* (Redical length+Plumule**

**Table -1 Comparative Allelopathic effects of H.indicum on Cereal Crops**

| Crop Species | Extract Conc. (%) | Germination (%) | Radical Length (cm) | Plumule Length (cm) | Total Length (cm) | Vigor Index (SVI) |
|---|---|---|---|---|---|---|
| Maize | 0 (Control) | 98 | 5.8 | 4.2 | 10.0 | 980.0 |
| (Zea mays) | 5% | 85 | 4.5 | 3.6 | 8.1 | 688.5 |
| | 10% | 72 | 3.2 | 2.8 | 6.0 | 432.0 |
| | 15% | 60 | 2.1 | 1.9 | 4.0 | 240.0 |
| | 20% | 52 | 1.4 | 1.2 | 2.6 | 135.2 |
| --- | --- | --- | --- | --- | --- | --- |
| Rice | 0 (Control) | 95 | 4.2 | 3.1 | 7.3 | 693.5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **(Oryza sativa)** | **5%** | **78** | **3.0** | **2.4** | **5.4** | **421.2** |
| | **10%** | **60** | **1.8** | **1.5** | **3.3** | **198.0** |
| | **15%** | **45** | **1.0** | **0.8** | **1.8** | **81.0** |
| | **20%** | **30** | **0.4** | **0.3** | **0.7** | **21.0** |




## Data Visualization: Inhibition Analysis

The data in Table 1 shows that Rice is significantly more vulnerable than Maize. At the 20% concentration, Rice vigor dropped by over 97%, while Maize vigor dropped by 86%. This is visually represented in the growth curve below, where the Rice line (Red) falls much faster than the Maize line (Blue).

The data in Tables 1 and 2, supported by the visual evidence in Figures 3 and 4, confirms that Rice is significantly more sensitive to the allelochemicals of H. indicum than Maize. At the 20\% concentration, Rice germination plummeted to 30%, whereas Maize maintained a 52% germination rate.

According to Oudhia (2001), this sensitivity is likely due to the smaller seed size and thinner seed coat of Rice, which allows for faster penetration of aqueous toxins. The "browning" of the root tips in both species aligns with Inderjit & Duke (2003), who identified that phenolic stress leads to cell death in the root apical meristem.

Furthermore, the overall reduction in growth parameters is consistent with Arowosegbe et al. (2012), who suggested that these extracts inhibit the mobilization of seed reserves. In a farm setting, as noted by Zimdahl (2007), such severe stunting would lead to total crop failure as the remaining space is quickly occupied by the weed itself, creating a secondary cycle of competition.

## Discussion

The inhibitory effects align with the foundational work of **Rice (1984)**, which establishes that roots are the primary targets for allelochemical absorption. The stunting of Maize is consistent with **Arowosegbe et al. (2012)**, who found that *H. indicum* disrupts enzymatic starch breakdown during the initial stages of germination.

Furthermore, **Inderjit & Duke (2003)** suggest that the "browning" seen in the Petri dish (Figure 1) is caused by oxidative stress from phenolic compounds, leading to cell death in the root apical meristem. The higher sensitivity of Rice (30% germination) compared to Maize (52%) matches observations by **Oudhia (2001)** regarding weed interference in tropical paddies. **Narwal (1994)** argues that such inhibition can lead to an "allelopathy legacy" in the soil that persists even after the weeds are physically removed.

## Conclusion and Recommendations

The investigation confirms that *Heliotropium indicum* is a potent allelopathy weed. Beyond nutrient competition, it actively poisons the soil environment for cereal seedlings.

## Recommendations for Farmers

- **Pre-Sowing Weed Eradication:** Remove *H. indicum* clusters 2–3 weeks before sowing to allow toxins to leach out.
- **Soil Amendments:** Use activated charcoal or high-organic-matter compost to adsorb phenolic allelochemicals.
- **Integrated Rotation:** Alternate cereals with legume varieties that may have higher chemical tolerance.

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