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Evaluation of the Allelopathic Potential of Aqueous Leaf Extracts of Selected Rashi Vanam Species on the Germination and Seedling Growth of Vigna radiata (Green gram).

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Abstract

Allelopathy plays a significant role in regulating plant–plant interactions through the release of bioactive secondary metabolites that influence germination and early seedling development. The present study investigated the allelopathic potential of aqueous leaf extracts of five selected Rashi Vanam species—*Azadirachta indica*, *Elaeocarpus sphaericus*, *Ficus religiosa*, *Pterocarpus santalinus*, and *Tectona grandis*—on the germination and seedling growth of *Vigna radiata* (L.) R. Wilczek under controlled laboratory conditions. Aqueous extracts were prepared at three concentrations (25%, 50%, and 100%), and their effects were evaluated in terms of germination percentage, root length, shoot length, and seedling vigor index (SVI).

The results revealed a clear concentration-dependent response. Among the tested species, *Elaeocarpus sphaericus* and *Azadirachta indica* exhibited strong inhibitory effects, significantly reducing germination and seedling growth parameters, particularly at 100% concentration. Root growth was more severely affected than shoot growth, indicating higher sensitivity of radicle development to allelochemicals. In contrast, *Ficus religiosa*, *Pterocarpus santalinus*, and *Tectona grandis* showed negligible to mild stimulatory effects at lower concentrations, suggesting a hormetic response. The response index (RI) values further confirmed the inhibitory potential of *Elaeocarpus sphaericus* and *Azadirachta indica*, while other species exhibited neutral or slightly positive effects.

The study demonstrates that allelopathic effects are species-specific and concentration-dependent. The strong inhibitory potential of certain Rashi Vanam species highlights their possible application in natural weed management, while also indicating the need for careful species selection and spatial planning in agroforestry systems. Further studies focusing on the isolation and characterization of allelochemicals are recommended to better understand their mechanisms of action.

Key words: Allelopathy, Aqueous Leaf Extracts, *Vigna radiata*, Rashi Vanam

Introduction

Allelopathy refers to the direct or indirect influence of one plant on another through the release of bioactive compounds, known as allelochemicals, into the surrounding environment. These compounds can significantly affect seed germination, seedling growth, and overall plant development, either

through inhibition or stimulation depending on their concentration and chemical nature (Rice, 1984; Inderjit & Duke, 2003). In recent years, allelopathy has gained increasing importance as an eco-friendly and sustainable approach for weed management and crop productivity enhancement, offering a viable alternative to synthetic agrochemicals (Weston & Duke, 2003; Kumar et al., 2024).

Allelochemicals are released through various pathways, including leaf leachates, root exudates, volatilization, and decomposition of plant residues (Einhellig, 1995). Among these, the decomposition of leaf litter plays a crucial ecological role, as it not only contributes to soil organic matter and humus formation but also releases a variety of secondary metabolites into the soil. These compounds can alter soil properties and influence seed germination and seedling establishment. Leaf litter may act as both a facilitator and an inhibitor while it can physically hinder seed emergence, it often enhances soil moisture retention and nutrient availability, thereby supporting seedling survival under suitable conditions. Thus, litter-mediated allelopathy represents an important mechanism regulating plant–plant interactions in natural and managed ecosystems.

A growing body of research has demonstrated the significant role of allelopathy in influencing germination and early growth stages of plants. Leela et al. (2014) reported that aqueous leaf extracts of *Tectona grandis* affected germination and seedling growth, indicating the presence of active allelochemicals. Similarly, Kavitha et al. (2014) observed that *Vitex negundo* leaf extracts altered germination behavior and seedling development. Ramakrishnan et al. (2014) further highlighted that allelochemicals can interfere with key enzymatic processes essential for seed germination. Bimal et al. (2016) demonstrated the inhibitory effects of the invasive species *Solanum sisymbriifolium* on the germination and seedling growth of several agricultural crops. In addition, aqueous extracts of *Zingiber officinale* were found to influence germination, vigor, and growth parameters of crop species (2015).

Gantayet et al. (2017) reported that *Lantana camara* significantly reduced germination percentage and growth performance due to its strong allelopathic properties. Earlier studies by Manimegalai et al. (2012) and Hemanth et al. (2014) also confirmed the inhibitory effects of plant-derived allelochemicals on vegetative growth and early developmental stages. Furthermore, species such as *Chromolaena odorata* and *Gmelina arborea* have been reported to exhibit suppressive effects on seed germination and seedling vigor, reinforcing the ecological importance of allelopathy in shaping plant communities.

Rashi Vanam plantations, which include a diverse assemblage of medicinal and ecologically significant tree species, represent a potential source of allelochemicals that may influence surrounding vegetation. Species such as *Elaeocarpus sphaericus, Azadirachta indica, Pterocarpus santalinus, Tectona grandis*, and Ficus religiosa are known for their rich phytochemical composition and biological activity. The leaf litter and extracts of these species may exert significant allelopathic effects on agricultural crops, although systematic evaluation remains limited.

Vigna radiata (green gram) was selected as the test crop in the present study due to its rapid germination, uniform growth, and high sensitivity to external biochemical influences, making it a suitable bio-indicator for allelopathic studies. Its economic importance as a widely cultivated pulse crop further enhances the relevance of such investigations.

In light of these considerations, the present study aims to evaluate the allelopathic potential of aqueous leaf extracts of selected Rashi Vanam species on the germination and seedling growth of *Vigna radiata*. The study focuses on key growth parameters, including germination percentage, root length, shoot length, and seedling vigor. The findings are expected to contribute to a better understanding of plant–plant interactions and support the development of sustainable and eco-friendly agricultural practices, including the exploration of natural herbicides and plant-based growth regulators.

MATERIALS AND METHODS

Collection and Identification of Plant Material

Mature and healthy leaves of five plant species, namely *Azadirachta indica*, *Elaeocarpus sphaericus*, *Ficus religiosa*, *Pterocarpus santalinus*, and *Tectona grandis*, were collected from Rashi Vanam located at the Government Arts & Science Degree College, Kamareddy, Telangana, India. The collected plant specimens were identified and authenticated using standard taxonomic literature, including *Flora of Telangana* (Reddy & Reddy, 2016) and *Flora of Telangana: The 29th State of India* (Pullaiah, 2015). Voucher specimens were prepared and preserved for future reference. Care was taken to collect disease-free leaves, which were transported to the laboratory in clean polyethylene bags for further processing.

Preparation of Aqueous Leaf Extracts

The collected leaves were washed thoroughly with tap water followed by distilled water to remove dust and impurities. The leaves were shade-dried at room temperature for 7–10 days and then ground into a fine powder using a mechanical grinder. The powdered material was used to prepare aqueous extracts by soaking a known quantity of leaf powder in distilled water (1:10 w/v ratio) for 24 hours at room temperature. The extracts were then filtered using muslin cloth followed by Whatman No. 1 filter paper. The filtrate obtained was considered as 100% extract, which was further diluted with distilled water to obtain 50% and 25% concentrations.

Seed Material and Experimental Setup

The seeds of *Vigna radiata* (green gram) were surface-sterilized using 0.1% mercuric chloride ($HgCl_2$) solution for 1–2 minutes and thoroughly rinsed with distilled water to prevent microbial contamination. The experiment was conducted using the Petri dish method under controlled laboratory conditions. Sterilized Petri dishes were lined with Whatman No. 1 filter paper, and ten seeds were placed uniformly in each dish. Each treatment (25%, 50%, 100% extract, and control with distilled water) was maintained

in triplicates. The filter papers were moistened with respective extract solutions, and moisture was maintained throughout the experimental period.

Observation of Germination and Growth Parameters

The Petri dishes were incubated at room temperature (25 ± 2°C), and observations were recorded after five days. A seed was considered germinated when the radicle protruded at least 2 mm. The following parameters were measured:

- Germination Percentage (GP)
- Root Length (RL)
- Shoot Length (SL)

Calculation of Seedling Vigor Index

Seedling vigor was calculated using the following formula:

Seedling Vigor Index (SVI) = Germination Percentage × (Root Length + Shoot Length)

Statistical Analysis

All experiments were conducted in triplicate, and the results were expressed as mean ± standard deviation. The data obtained were analyzed to determine the effect of different concentrations of leaf extracts on germination and seedling growth.

Data collection and analysis

The following parameters were recorded during the experiment to assess the effect of aqueous leaf extracts on seed germination and seedling growth of *Vigna radiata*.

Germination Percentage (GP)
Germination percentage was calculated using the formula:

$$GP\ (\%) = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds}} \times 100$$

The radicle and shoot length of germinated seeds were measured by using centimetre ruler. After measuring the radicle and shoot lengths, the seeds were separated into shoot and radicle parts.

To calculate the Response Index (RI),

Average root /shoot length of treatment group divided by Average root / shoot length of control group and the value is subtracted from 1. Then the value is treated as Response index.

The Calculation

$$RI = \left(\frac{Meanvalueoftreatment}{Meanvalueofcontrol} - 1\right)$$

where the mean value represents either root length or shoots length.

RI < 0 indicates an inhibitory effect

RI > 0 indicates a stimulatory effect

A negative RI value suggests that the leaf extracts inhibited the growth of Vigna radiata, whereas a positive value indicates enhancement of growth.

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Plate 1: Field Sampling and Experimental Setup for Allelopathic Effects on Seed Germination; Plate 2: Assessment of Germination Parameters and Seedling Growth under Experimental Conditions

Results and Discussion

The present study demonstrated a clear concentration-dependent allelopathic effect of aqueous leaf extracts of selected Rashi Vanam species on the germination and early seedling growth of *Vigna radiata* (Table 1). The degree of inhibition or stimulation varied significantly among species and extract concentrations, indicating species-specific responses of allelochemicals.

Germination Percentage

Germination percentage was comparatively less affected than seedling growth parameters. *Elaeocarpus sphaericus* exhibited a gradual decline in germination from 100% at 25% concentration to 90% at 50% and 80% at 100%, indicating a 20% inhibition at higher concentration. Similarly, *Azadirachta indica* maintained 100% germination at lower concentrations but decreased to 90% at 100% extract.

In contrast, *Ficus religiosa*, *Pterocarpus santalinus*, and *Tectona grandis* showed no reduction in germination (100% across all treatments), suggesting that allelochemicals present in these species did not interfere with seed viability. This observation is consistent with earlier reports that germination is often less sensitive than seedling growth to allelopathic stress (Elroy L. Rice, 1984).

Root and Shoot Growth

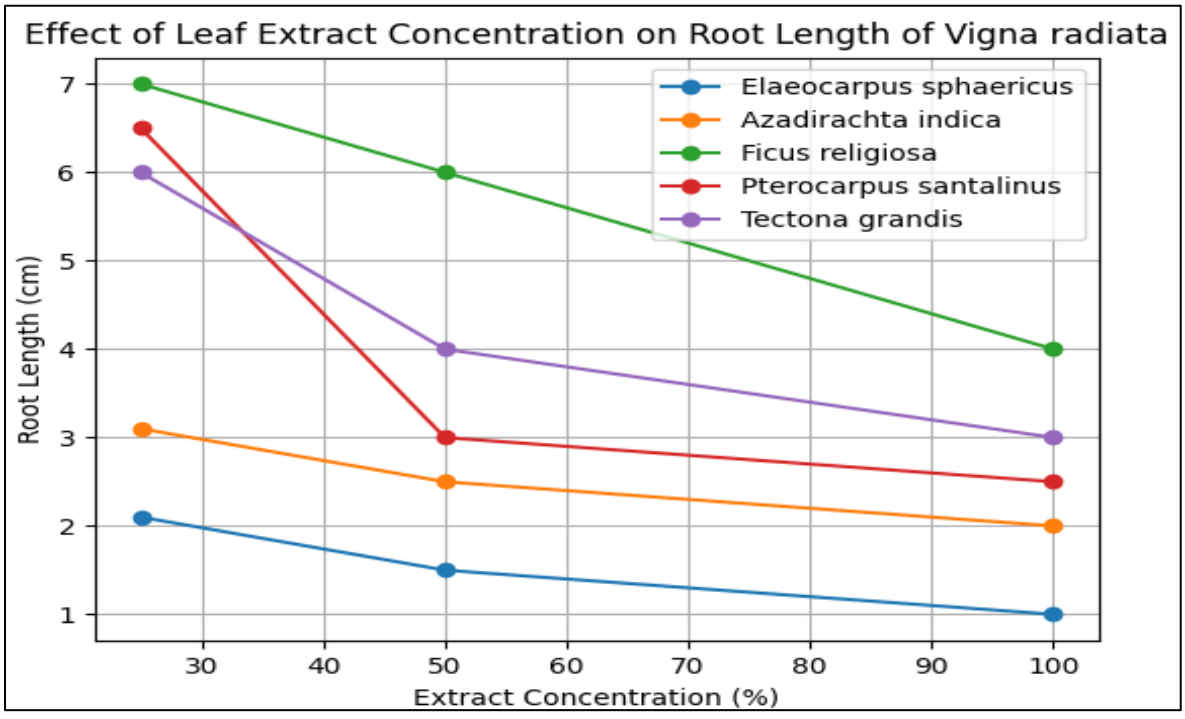

Figure 1. Effect of aqueous leaf extracts on root length of *Vigna radiata* at different concentrations.

Seedling growth parameters were more sensitive to allelopathic effects than germination. In *Elaeocarpus sphaericus*, root length decreased from 2.1 cm (25%) to 1 cm (100%), while shoot length declined from 3.5 cm to complete inhibition (0 cm). Consequently, the Seedling Vigor Index (SVI) drastically reduced from 560 to 80, indicating strong phytotoxicity. Similarly, *Azadirachta indica* showed a reduction in root length (3.1 cm to 2 cm) and shoot length (8.2 cm to 5 cm), with SVI decreasing from 1130 to 630. The graphical representation (Figure 1) clearly illustrates the declining trend in root length with increasing extract concentration, particularly in *Elaeocarpus sphaericus* and *Azadirachta indica*, confirming their strong inhibitory effect.

The greater inhibition of root growth compared to shoot growth suggests that radicle tissues are more sensitive due to direct exposure to allelochemicals. This observation agrees with findings of Frank A. Einhellig (1995), who reported that allelochemicals primarily affect root elongation by disrupting cell division and elongation processes.

In contrast, *Ficus religiosa* exhibited comparatively higher growth values at lower concentrations (root length: 7 cm; shoot length: 8.5 cm; SVI: 1550), followed by a gradual decline at higher concentrations, indicating mild inhibitory effects. *Tectona grandis* also showed a decreasing trend in both root (6 cm to 3 cm) and shoot length (9 cm to 4 cm), with SVI declining from 1500 to 700 as concentration increased.

Interestingly, *Pterocarpus santalinus* exhibited a differential response, where root length decreased (6.5 cm to 2.5 cm) with increasing concentration, whereas shoot length increased significantly from 3.5 cm (25%) to 10 cm (100%). This resulted in an increase in SVI from 1000 to 1250 at higher concentration. Such contrasting responses between root and shoot growth may be attributed to selective sensitivity of plant tissues to specific allelochemicals or activation of compensatory growth mechanisms.

The observed stimulatory effects at lower concentrations in some species indicate a hormetic response, where low levels of allelochemicals promote growth while higher concentrations inhibit it. Similar biphasic responses have been reported in allelopathic studies (Inderjit & Stephen O. Duke, 2003).

Response Index (RI)

The Response Index (RI) further confirmed the allelopathic potential of the studied species. Negative RI values obtained for *Elaeocarpus sphaericus* and *Azadirachta indica* indicate strong inhibitory effects on seedling growth. In contrast, *Ficus religiosa*, *Pterocarpus santalinus*, and *Tectona grandis* exhibited positive or near-zero RI values at lower concentrations, suggesting stimulatory or neutral effects.

These findings reinforce that allelopathic interactions are highly dependent on species composition and concentration of bioactive compounds. The inhibitory effects observed in *Elaeocarpus sphaericus* and *Azadirachta indica* may be attributed to the presence of phenolics, flavonoids, and other secondary

metabolites known to interfere with physiological and biochemical processes during early plant development (Ramakrishnan et al., 2014; Kumar et al., 2024).

Table 1: Effect of Aqueous Leaf Extracts on Germination and Seedling Growth of *Vigna radiata*

Sl. No	Plant Species	Conc. (%)	Germination (%)	Root Length (cm)	Shoot Length (cm)	SVI
1	*Elaeocarpus sphaericus*	25	100	2.1	3.5	560
		50	90	1.5	2	315
		100	80	1	0	80
2	*Azadirachta indica*	25	100	3.1	8.2	1130
		50	100	2.5	6.5	900
		100	90	2	5	630
3	*Ficus religiosa*	25	100	7	8.5	1550
		50	100	6	6.8	1280
		100	100	4	5.1	910
4	*Pterocarpus santalinus*	25	100	6.5	3.5	1000
		50	100	3	6	900
		100	100	2.5	10	1250
5	*Tectona grandis*	25	100	6	9	1500
		50	100	4	7	1100
		100	100	3	4	700
6	Control	-	100	5	10	1500

Conclusion

The present study clearly demonstrates that aqueous leaf extracts of selected Rashi Vanam species exert varying allelopathic effects on the germination and early seedling growth of *Vigna radiata*. Among the species tested, *Elaeocarpus sphaericus* and *Azadirachta indica* exhibited strong inhibitory effects, particularly at higher concentrations, indicating the presence of potent allelochemicals. In contrast, *Ficus religiosa, Pterocarpus santalinus,* and *Tectona grandis* showed either mild or no inhibitory effects, and in some cases, slight stimulation at lower concentrations.

These findings highlight that allelopathic interactions are both species-specific and concentration-dependent. From a practical perspective, species such as *Elaeocarpus sphaericus* and *Azadirachta indica* should be carefully considered when integrated into agroforestry systems or home gardens, as their proximity may negatively influence the growth of sensitive crops like green gram.

Further research is needed to isolate and characterize the specific allelochemicals responsible for these effects and to evaluate their behaviour under field conditions. Such studies could contribute to the development of eco-friendly weed management strategies and support sustainable agricultural practices.

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