



Evaluation of the Formulation of *Praxelis clematidea* and Soap Nut (*Sapindus rarak*) Extracts on the Germination of *Rottboellia exaltata*

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Abstract: *Rottboellia exaltata* is an invasive weed species that rapidly spreads through seeds and exhibits vigorous growth, leading to severe yield losses in agricultural lands. Weed management through the exploitation of plant allelopathy offers a sustainable approach to controlling such species. *Praxelis clematidea* and the pulp of soap nut (*Sapindus rarak*) are known to possess allelopathic properties that can inhibit weed germination. This study aimed to evaluate the effect and identify the most effective formulation of *P. clematidea* and *S. rarak* extracts in suppressing the germination of *R. exaltata*. The research was conducted from July to October 2025 in the Weed Science Laboratory and greenhouse of the Faculty of Agriculture, University of Lampung. A Completely Randomized Design (CRD) with a single factor and six replications was employed. The treatments consisted of different extract formulations of *P. clematidea* and *S. rarak*: P0 = control (distilled water), P1 = 50% *P. clematidea* extract, P2 = 50% *S. rarak* extract, P3 = 25% + 75%, P4 = 50% + 50%, and P5 = 75% + 25%. Data were analyzed using analysis of variance (ANOVA) after testing homogeneity (Bartlett test) and additivity (Tukey test), followed by the Least Significant Difference (LSD) test at a 5% level. The results demonstrated that both single and mixed extract formulations of *P. clematidea* and *S. rarak* inhibited germination percentage and germination rate of *R. exaltata*. The strongest inhibitory effect was observed with the 75% *P. clematidea* + 25% *S. rarak* formulation, which significantly reduced germination percentage, germination speed, root and shoot length, and dry biomass. The inhibitory effect was more pronounced on root growth than shoot growth, indicating that root length serves as a more sensitive indicator of allelopathic effects during germination.

Keywords: allelopathy; germination rate; invasive species; *Rottboellia exaltata*

1. Introduction

Rottboellia exaltata (itchgrass) is an annual grass weed species native to India that has widely spread throughout tropical and subtropical regions (Maddox et al., 2018). It now infests more than 30 countries across the Americas, Africa, Asia, and Oceania, becoming a major weed problem in various annual crops, including legumes, cassava, cotton, maize, groundnut, pineapple, sorghum, sugarcane, upland rice, and rainfed rice. It also infests perennial crops such as banana, citrus, mango, and oil palm. Due to its rapid seed dispersal and high growth rate, *R. exaltata* can cause yield losses of 80–100% under tropical and subtropical conditions (Castillo et al., 2016).

Weed control through the utilization of plant allelopathy as a source of natural herbicidal compounds offers an eco-friendly and sustainable approach. Allelopathic plants can be used to manage weeds throughout the growing season, reduce the reliance on repeated herbicide applications, and prevent further evolution of herbicide-resistant weed populations. Plant-derived herbicides generally

utilize extracts from plant organs containing allelochemicals that interfere with seed germination and seedling growth. Therefore, allelopathy has considerable potential in sustainable weed management (Won et al., 2013).

Praxelis clematidea has been reported to exhibit strong allelopathic effects on the germination of various plant species. According to Thepphakhun and Intanon (2020), extracts of *P. clematidea* at high concentrations contain high levels of phytochemicals such as phenolics, flavonoids, and antioxidants. Similarly, aqueous extracts of *S. rarak* were found to inhibit the germination and growth of *Leptochloa chinensis* and *Fimbristylis miliacea* at concentrations of 50% and 75% (Pujisiswanto, 2022). Wardini et al. (2023) also reported that *P. clematidea* extract at 50% concentration significantly suppressed seed germination rate and shoot length of *Asystasia gangetica*.

Furthermore, *S. rarak* extracts at 25–100% concentrations were shown to inhibit the germination of *A. gangetica* and *Eleusine indica* up to two weeks after application (Pujisiswanto

et al., 2017). The soap nut fruit contains secondary metabolites such as alkaloids, saponins, tannins, quinones, terpenoids, and phenols (Fajriaty et al., 2017).

2. MATERIALS AND METHODS

This study was conducted in the greenhouse and Weed Science Laboratory, Faculty of Agriculture, University of Lampung, from September to October 2025. The materials used included *Praxelis clematidea* weeds, the pulp of *Sapindus rarak* (soap nut) fruits, seeds and seedlings of *Rottboellia exaltata*, Whatman filter paper No. 41, farmyard manure, soil, distilled water, and methanol. The equipment utilized consisted of a digital balance, measuring cylinders, funnels, ovens, Erlenmeyer flasks, blenders, stirring rods, sieves, a knapsack sprayer, trays, and labels.

2.1. Preparation of Plant Extracts

Extract preparation was carried out in the Weed Science Laboratory, Faculty of Agriculture, University of Lampung. The extraction method followed a modified maceration technique based on Tanganurat et al. (2023). Samples of *P. clematidea* were collected, cut into 1–2 cm pieces, and oven-dried for 48 hours at 40°C. The *S. rarak* fruits were cleaned, and the pulp was separated from the seed and peel, oven-dried under the same conditions, ground into powder, and sieved through a 40-mesh screen.

The powdered materials of *P. clematidea* and *S. rarak* were extracted with methanol through maceration. The filtrates obtained were concentrated and diluted to obtain desired concentrations for further application.

2.2 Experimental Design

The experiment was arranged in a Completely Randomized Design (CRD) with a single factor and six replications. The treatments were as follows:

- **P0** = control (distilled water)
- **P1** = 50% *P. clematidea* extract
- **P2** = 50% *S. rarak* extract
- **P3** = 25% *P. clematidea* + 75% *S. rarak* extract
- **P4** = 50% *P. clematidea* + 50% *S. rarak* extract
- **P5** = 75% *P. clematidea* + 25% *S. rarak* extract

Data were subjected to analysis of variance (ANOVA) after testing variance homogeneity using Bartlett's test and additivity with Tukey's

test. Means were compared using the Least Significant Difference (LSD) test at a 5% probability level.

2.3 Application and Observation

Each tray contained 25 *R. exaltata* seeds sown in a soil–manure mixture. The extract formulations were applied using a knapsack sprayer with a red nozzle calibrated to deliver 400 L ha⁻¹ (equivalent to 400 mL for a 10 m² plot). The extracts were applied once, one day after sowing.

Observation variables included:

1. **Germination percentage** – the proportion of normal seedlings recorded on day one after sowing (Talukdar, 2011).
2. **Germination rate (GR)** – calculated as the cumulative percentage of germinated seeds over time according to the formula:

$$GR = \sum \frac{\Delta KN}{t}$$

where ΔKN is the increase in normal seedling percentage per day, and t is the number of days since sowing.

3. **Root and shoot length (cm)** – measured using a ruler from the base to the tip of the root or shoot on day 30 after sowing.
4. **Dry biomass (g)** – measured after oven-drying seedlings at 70°C for 48 hours.

3. Results and Discussions

3.1 Effect of Extract Formulations on Germination Percentage

The germination test revealed that both single and combined formulations of *P. clematidea* and *S. rarak* extracts effectively inhibited the germination of *R. exaltata* seeds (Table 1, Figure 1). During the first to fourth weeks after sowing, all formulations exhibited significant suppression compared with the control. The strongest inhibition was observed with the 75% *P. clematidea* + 25% *S. rarak* combination.

This result aligns with Thepphakhun and Intanon (2020), who reported that *P. clematidea* extract inhibited the germination of Chinese cabbage. Similarly, Pujiswanto et al. (2021) found that 50% soap nut extract suppressed germination and germination rate of *Fimbristylis miliacea* seeds. The inhibitory mechanism may

be attributed to phenolic compounds and saponins that interfere with cellular respiration and water uptake in seeds, leading to delayed germination (Table 1).

Table 1. Effect of *p. Clematidea* and *s. Rarak* extract formulations on germination percentage (%) of *r. Exaltata* seeds (1–4 weeks after sowing)

Formulation	Germination Percentage (%)			
	1 WAS	2 WAS	3 WAS	4 WAS
control (distilled water)	44,80 a	89,60 a	96,0 0 a	98,4 0 a
50% <i>P. clematidea</i> extract	19,20 bc	49,60 bc	56,8 0 b	68,8 0 b
50% <i>S. rarak</i> extract	28,00 b	63,20 b	70,4 0 b	79,2 0 b
25% <i>P. clematidea</i> + 75% <i>S. rarak</i> extract	17,60 bc	47,20 bc	60,0 0 b	71,2 0 b
50% <i>P. clematidea</i> + 50% <i>S. rarak</i> extract	20,80 bc	58,40 b	64,8 0 b	74,4 0 b
75% <i>P. clematidea</i> + 25% <i>S. rarak</i> extract	13,60 c	33,60 c	36,8 0 c	44,0 0 c
LSD 5%	11,20	19,48	17,0 5	15,5 8

Means followed by the same letter in a column are not significantly different at the 5% LSD test.

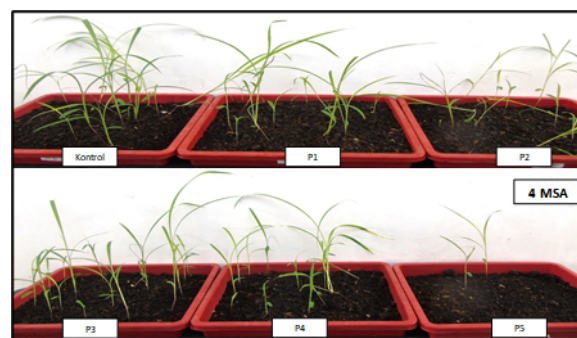
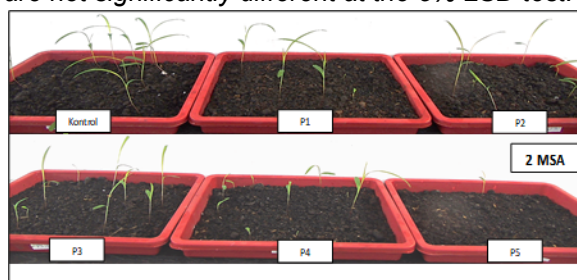


Figure 1. Effect of *P. clematidea* and *S. rarak* extract formulations on the germination percentage (%) of *R. exaltata* seeds at 2 and 4 weeks after sowing (WAS).

3.2 Effect on Germination Rate

All extract formulations significantly reduced the germination rate of *R. exaltata* compared to the control (Table 2). The highest inhibition was observed in the 75% *P. clematidea* + 25% *S. rarak* treatment. The presence of phenolic compounds in *P. clematidea* may influence the duration of incubation and allelopathic activity, as phenolics are known to interfere with enzymatic activity during seed germination (Li et al., 2010).

Table 2. Effect of extract formulations on germination rate (% day⁻¹) of *r. Exaltata*

Formulation	Germination Rate (%/day)
control (distilled water)	4,82 a
50% <i>P. clematidea</i> extract	2,86 bc
50% <i>S. rarak</i> extract	3,46 b
25% <i>P. clematidea</i> + 75% <i>S. rarak</i> extract	2,78 bc
50% <i>P. clematidea</i> + 50% <i>S. rarak</i> extract	3,53 b
75% <i>P. clematidea</i> + 25% <i>S. rarak</i> extract	1,88 c
LSD 5%	1,14

Means followed by the same letter in 2 WAS are not significantly different at the 5% LSD test.

Seed germination in the control began on day 3 after sowing, while in the 75% *P. clematidea* + 25% *S. rarak* treatment, germination was delayed until day 5–7, confirming the extract's inhibitory potential (Figure 2).

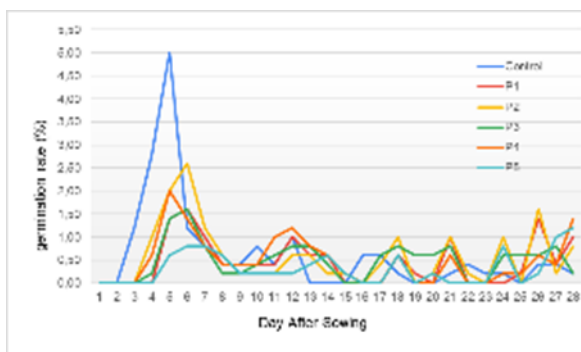


Figure 2. Effect of *P. clematidea* and *S. rarak* extract formulations on the germination rate (% per day) of *R. exaltata* seeds.

3.3 Effect on Root and Shoot Growth

All formulations significantly inhibited root length (Table 3). The greatest inhibition occurred at 75% *P. clematidea* + 25% *S. rarak*, followed by 50% *P. clematidea* and the 50:50 combination. Root inhibition was generally more pronounced than shoot inhibition, indicating higher sensitivity of root tissues to allelochemicals.

The 25% *P. clematidea* + 75% *S. rarak* formulation had no significant effect on shoot length compared to the control. Similar findings were reported by Thepphakhun and Intanon (2020), where 25% and 50% *P. clematidea* extracts slightly inhibited germination but markedly suppressed root elongation (Table 3).

Table 3. Effect of *p. Clematidea* and *s. Rarak* extracts on root length, shoot length, and dry biomass of *r. Exaltata*

Formulation	Root Length (cm)	Shoot Length (cm)	Dry Biomas (g)
control (distilled water)	13,00 a	28,80 a	0,76 a
50% <i>P. clematidea</i> extract	6,39 cd	19,20 bc	0,32 bc
50% <i>S. rarak</i> extract	9,73 b	23,30 b	0,49 b
25% <i>P. clematidea</i> + 75% <i>S. rarak</i> extract	9,20 bc	24,00a b	0,49 b
50% <i>P. clematidea</i> + 50% <i>S. rarak</i> extract	6,73 bcd	20,40 b	0,42 b
75% <i>P. clematidea</i>	4,86 d	14,00 c	0,18 c

clematidea + 25% *S. rarak* extract

LSD 5%	3,09	5,32	0,17
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Means followed by the same letter in a column are not significantly different at the 5% LSD test.

All treatments also significantly reduced dry biomass, with the strongest suppression observed at 75% *P. clematidea* + 25% *S. rarak*. Similar biomass reductions were reported by Thepphakhun and Intanon (2020) when lettuce was grown in soil mixed with *P. clematidea* residues.

4. CONCLUSIONS

The combined and individual formulations of *Praxelis clematidea* and *Sapindus rarak* extracts effectively inhibited the germination of *Rottboellia exaltata*. The formulation consisting of 75% *P. clematidea* and 25% *S. rarak* exhibited the strongest inhibitory effects on germination percentage, germination rate, root and shoot length, and seedling dry biomass. Root growth was more sensitive than shoot growth to the allelopathic extracts, suggesting that root length is a more reliable indicator of allelopathic effects during seed germination. The results demonstrate the potential of *P. clematidea* and *S. rarak* extracts as eco-friendly bioherbicides for sustainable weed management.

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