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PHYTOTOXIC AND BIOHERBICIDAL POTENTIAL OF FIVE WILD PLANT EXTRACTS AGAINST *Euphorbia heterophylla* L.: EFFECTS ON SEED GERMINATION, PLANT GROWTH AND POLLEN GERMINATION

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Abstract

Euphorbia heterophylla L. is a competitive weed for which alternative management approaches are needed. This study evaluated the phytotoxic effects of aqueous extracts prepared from *Achyranthes aspera*, *Jatropha gossypiifolia*, *Lantana camara*, *Leucas aspera* and *Mesosphaerum suaveolens* against *E. heterophylla* at seed, established-plant and pollen stages. Seed germination and seedling observations were assessed at 3, 6, 9 and 12% (w/v) extract concentrations under greenhouse conditions. Mortality of 25-day-old plants treated with extracts prepared from dried plant material was monitored over 15 days, while a separate fresh-material assay evaluated endpoint mortality using fresh material standardized to the dry-weight equivalents used for the powdered extracts. Pollen germination was examined using 2% aqueous extracts in Brewbaker medium. By week 3, all five extracts reduced cumulative seed germination relative to the untreated control (92.71%), with the lowest germination generally occurring at 12%. In the dried-material plant assay, no mortality was observed during days 1–5, whereas mortality increased during days 6–10 and reached 100% by days 11–15 for every extract and concentration. *Leucas aspera* showed the highest mortality during days 6–10 (87.5% at 3%), although early mortality was not consistently concentration-dependent. In the separate fresh-material endpoint assay, mortality ranged from 0 to 93.75%, with the highest value recorded for *L. aspera* at 12%. No pollen germination was observed in the examined microscopic fields treated with any 2% extract, compared with 22.73% in the untreated control. Because replicate-level raw data were not available for all endpoints, the results are presented descriptively without inferential statistical testing. The findings demonstrate phytotoxic activity of the tested crude aqueous extracts against *E. heterophylla* under the experimental conditions and support further work on active constituents, concentration–response relationships, crop selectivity and field efficacy.

Keywords: *Euphorbia heterophylla*; phytotoxicity; aqueous extracts; seed germination; seedling growth; plant mortality; pollen germination; weed management

1. Introduction

Weeds are major constraints to agricultural productivity because they compete with crops for nutrients, water, light and space. Repeated reliance on synthetic herbicides can contribute to environmental concerns and the selection of herbicide-resistant weed populations. Plant-derived phytochemicals therefore continue to attract interest as possible components of integrated weed-management systems (Bhadoria, 2011; Jabran et al., 2015; Khamare et al., 2022).

Euphorbia heterophylla L. (wild poinsettia) is a competitive weed associated with several agricultural systems, including maize, soybean and groundnut. Its rapid growth, prolific seed production and ability to establish under diverse environmental conditions make management difficult (Bannon et al., 1978; Brecke, 1995; Wilson, 1981; Lati et al., 2019). Extracts of *E. heterophylla* itself have also shown allelopathic and phytotoxic activity, with organic acids and other metabolites implicated in the activity of root extracts (da Silva et al., 2019).

Aqueous extracts of plants may contain water-soluble secondary metabolites capable of interfering with seed germination, seedling development and other physiological processes. Previous studies have documented phytotoxic or allelopathic activity associated with *A. aspera*, *J. gossypiifolia*, *L. camara*, *L. aspera* and *M. suaveolens* (Tanveer et al., 2019; Lopes et al., 2022; Gindri et al., 2020; Alemayehu et al., 2024; Islam et al., 2014; Pattanayak and Maiti, 2026). However, comparative information on the activity of these five species against *E. heterophylla* across multiple developmental stages remains limited.

The present study therefore evaluated aqueous extracts of these five plant species for their effects on *E. heterophylla* seed germination, seedling observations, established-plant survival and pollen germination. The objective was to identify extracts showing promising phytotoxic activity under controlled greenhouse and laboratory conditions while recognizing that crude-extract activity does not by itself establish practical bioherbicidal efficacy.

2. Materials and Methods

2.1 Plant material and collection

Plant materials of *A. aspera, J. gossypiifolia, L. camara*, *L. aspera* and *M. suaveolens* were collected near the Bengaluru North University P.G. Centre, Suvarna Gange Campus, Mangasandra, Kolar, Karnataka, India. The materials were cleaned to remove soil, dust and debris. For the dried-material extracts, plant material was dried until completely dry, ground to a fine powder and stored in airtight containers until extraction. The species were identified on the basis of morphological characteristics by a botanist Mohammed Khalid.

2.2 Preparation of aqueous extracts

Dried-material extracts were prepared at 3, 6, 9 and 12% (w/v) by suspending 30, 60, 90 and 120 g, respectively, of dried plant powder in 1000 mL sterile distilled water. The suspensions were mixed thoroughly, left at room temperature for 3hrs and filtered through a sieve. Extracts were used immediately after preparation.

For fresh plant material, freshly collected tissues were washed thoroughly and used without drying. Because fresh tissues contain variable amounts of inherent water, fresh weights were standardized to the dry-weight basis used for the powdered extracts. A fresh-to-dry weight ratio (FDR) was determined for each plant species

by weighing a known quantity of fresh material (F) and recording its corresponding weight after complete drying (D).

$$FDR = F/D$$

Where, F is the fresh weight (g) and D is the corresponding dry weight (g).

The resulting species-specific FDR values were used to determine the quantity of fresh material equivalent to the dry-weight quantities used for extract preparation. The fresh-weight/dry-weight ratios were determined for each plant species as shown in Table 1. The required fresh material was calculated from the species-specific ratio, homogenized with sterile distilled water and filtered. Fresh extracts were prepared immediately before use.

Plant species	Dry-weight basis (g)	Equivalent fresh weight (g)
A. aspera	1	3.1
J. gossypiifolia	1	4.3
L. camara	1	3.9
L. aspera	1	4.9
M. suaveolens	1	3.2

Table 1. *Fresh-weight equivalents corresponding to 1 g dry weight of plant material used for fresh-material extract preparation.*

2.3 Growth conditions and nutrient solution

Seeds and seedlings were maintained in cocopeat under greenhouse conditions. Commercial Hydro Grow A and B (Hydro Farm Technologies Pvt. Ltd.) was used as the nutrient source because the growth substrate did not contain soil. The nutrient solution was prepared by diluting equal volumes of Parts A and B separately in water and applying them without mixing the concentrated stocks. In the seed-germination experiment, trays were watered twice daily and nutrient solution was supplied on alternate days. Greenhouse conditions were approximately 28 °C and 65–70% relative humidity with a photoperiod of approximately 8–11 h day−1.

2.4 Seed germination and seedling-growth assay

Forty-two 16-well nursery trays were used, comprising two trays for each of the 20 extract concentration combinations and two untreated control trays. Three *E. heterophylla* seeds were sown per well, giving 96 seeds per treatment. The corresponding extract was incorporated into the cocopeat at 1 mL of the respective concentration per well before sowing. Control trays received no plant extract. Trays were randomized at setup and repositioned during the experiment to reduce positional effects. Cumulative germination, shoot-length range and leaf number were recorded at weekly intervals for three weeks.

2.5 Established-plant mortality assay using dried-material extracts

Mature *E. heterophylla* seeds were collected from healthy plants near the BNU P.G. Centre, Mangasandra, Kolar. Uniform 25-day-old seedlings were treated with approximately 1 mL of the respective aqueous extract at the base of the stem near the root–stem transition. Each concentration was applied to three replicate trays. Untreated plants maintained under identical conditions served as controls. Extract treatments were applied twice daily for 15 days. Mortality was recorded at the end of days 1–5, 6–10 and 11–15 and expressed as cumulative mortality based on the pooled number of plants across the three replicate trays. Visible phytotoxic

symptoms, including growth inhibition, discoloration, chlorosis, necrosis, stem abnormalities and organ abscission, were also monitored.

2.6 Fresh-material extract assay

Fresh-material extracts were evaluated in a separate established-plant assay. Mortality was recorded for each treatment and concentration at the assay endpoint and expressed as a percentage. The fresh-material dataset is reported as a single mortality value for each treatment and no additional time-course mortality values are inferred for the fresh-material assay.

2.7 Pollen-germination assay

Mature *E. heterophylla* pollen was collected at anthesis. A 2% aqueous extract of each test plant was evaluated using Brewbaker medium; the untreated control contained the medium without plant extract. Pollen germination was assessed by the hanging-drop method. Three microscopic fields of view were examined per treatment, and the total numbers of pollen grains observed and germinated were recorded. The pollen-germination medium was treated as a preliminary assay system and was not used to infer effects on fertilization or seed production.

Brewbaker medium consisted of 10 g sucrose, 0.01 g boric acid (H_3BO_3), 0.03 g calcium nitrate tetrahydrate [$Ca(NO_3)_2 \cdot 4H_2O$], and distilled water to a final volume of 100 mL.

2.8 Data handling and statistical considerations

Germination and mortality were summarized as percentages. Established-plant mortality from the dried-material assay was calculated from pooled data across the three replicate trays for each treatment and concentration. Fresh-material mortality was summarized as endpoint percentages for each treatment and concentration. Pollen-germination percentages were calculated from the observed pollen counts in the three examined fields. Because complete replicate-level raw data were not available for all endpoints, inferential statistical tests, estimates of variance and formal concentration–response modelling were not performed. Accordingly, the results are interpreted descriptively and no claims of statistical significance are made.

3. Results

3.1 Seed germination and seedling observations

The untreated control produced 67.00%, 72.00% and 92.71% cumulative germination at weeks 1, 2 and 3, respectively. Its shoot-length ranges were 0.5–4 cm, 3–7 cm and 7–19 cm across the three weeks. In the extract treatments, shoot-length ranges were recorded weekly and were generally 0.2–3 cm in week 1, 0.2–7 cm in week 2 and 7–17 cm in week 3 where seedlings were present; the 12% *A. aspera* and *J. gossypiifolia* treatments had no germinated seedlings in week 1. All five aqueous extracts reduced cumulative germination relative to the control. At week 3, germination under *A. aspera* ranged from 31.25 to 60.42%, *J. gossypiifolia* from 42.71 to 66.67%, *L. camara* from 35.42 to 38.54%, *L. aspera* from 29.17 to 41.67%, and *M. suaveolens* from 33.33 to 53.12%. For most extracts, the lowest observed week-3 germination occurred at 12%, although some intermediate concentrations did not follow a strictly monotonic pattern. Shoot-length ranges and leaf numbers were recorded as descriptive seedling-growth observations rather than as statistically compared quantitative endpoints.

Plant extract	Conc. (%)	Week 1 germination (%)	Week 2 germination (%)	Week 3 germination (%)	Shoot-length range (cm), W1 / W2 / W3	Average number of leaves
Control	0	67.00	72.00	92.71	0.5–4 / 3–7 / 7–19	4
A. aspera(AC)	3	8.33	20.83	60.42	0.2–3 / 0.2–7 / 7–17	2
A. aspera(AC)	6	6.25	17.71	53.12	0.2–3 / 0.2–7 / 7–17	2
A. aspera(AC)	9	5.21	21.88	48.96	0.2–3 / 0.2–7 / 7–17	2
A. aspera(AC)	12	0.00	8.33	31.25	— / 0.2–7 / 7–17	2
J. gossypiifolia(JA)	3	11.46	33.33	66.67	0.2–3 / 0.2–7 / 7–17	4
J. gossypiifolia(JA)	6	6.25	25.00	62.50	0.2–3 / 0.2–7 / 7–17	2
J. gossypiifolia(JA)	9	4.17	16.67	47.92	0.2–3 / 0.2–7 / 7–17	2
J. gossypiifolia(JA)	12	0.00	12.50	42.71	— / 0.2–7 / 7–17	2
L. camara(LA)	3	1.04	10.42	35.42	0.2–3 / 0.2–7 / 7–17	2
L. camara(LA)	6	3.12	16.67	37.50	0.2–3 / 0.2–7 / 7–17	2
L. camara(LA)	9	3.12	15.62	38.54	0.2–3 / 0.2–7 / 7–17	2
L. camara(LA)	12	3.12	14.58	35.42	0.2–3 / 0.2–7 / 7–17	2
L. aspera(LU)	3	3.12	8.33	40.62	0.2–3 / 0.2–7 / 7–17	2
L. aspera(LU)	6	3.12	11.46	41.67	0.2–3 / 0.2–7 / 7–17	2
L. aspera(LU)	9	2.08	8.33	29.17	0.2–3 / 0.2–7 / 7–17	2
L. aspera(LU)	12	3.12	8.33	31.25	0.2–3 / 0.2–7 / 7–17	2
M. suaveolens(ME)	3	6.25	26.04	51.04	0.2–3 / 0.2–7 / 7–17	4
M. suaveolens(ME)	6	4.17	21.88	53.12	0.2–3 / 0.2–7 / 7–17	4
M. suaveolens(ME)	9	4.17	17.71	40.62	0.2–3 / 0.2–7 / 7–17	2
M. suaveolens(ME)	12	1.04	8.33	33.33	0.2–3 / 0.2–7 / 7–17	2

Table 2. Cumulative seed germination and descriptive seedling-growth observations of *E. heterophylla* during the three-week assay. Germination percentages are based on 96 seeds per treatment. Shoot-length ranges are reported for each weekly observation; a dash(—) indicates that no seedlings were present for measurement. *Representative photographic observations are presented in Figures 1–3.*

3.2 Mortality of established plants treated with dried-material extracts

No mortality was observed during days 1–5 for any dried-material extract or concentration. By days 6–10, mortality ranged from 12.5 to 87.5% across treatments. *L. aspera* showed the highest early mortality (87.5% at 3%), followed by *M. suaveolens* (81.25% at 3%) and *A. aspera* (81.25% at 12%). *L. camara* reached 75% at 6%, whereas *J. gossypiifolia* reached 56.25% at 12%. By days 11–15, cumulative mortality reached 100% for every extract and concentration. No mortality was observed in control plants.

Plant extract	Concentration (%)	Days 1–5 cumulative mortality (%)	Days 6–10 cumulative mortality (%)	Days 11–15 cumulative mortality (%)
A. aspera(AC)	3	0	43.75	100
A. aspera(AC)	6	0	31.25	100
A. aspera(AC)	9	0	68.75	100
A. aspera(AC)	12	0	81.25	100
J. gossypiifolia(JA)	3	0	43.75	100
J. gossypiifolia(JA)	6	0	43.75	100
J. gossypiifolia(JA)	9	0	50	100
J. gossypiifolia(JA)	12	0	56.25	100
L. camara(LA)	3	0	43.75	100
L. camara(LA)	6	0	75	100
L. camara(LA)	9	0	12.5	100
L. camara(LA)	12	0	68.75	100
L. aspera(LU)	3	0	87.5	100
L. aspera(LU)	6	0	68.75	100
L. aspera(LU)	9	0	62.5	100
L. aspera(LU)	12	0	62.5	100
M. suaveolens(ME)	3	0	81.25	100
M. suaveolens(ME)	6	0	50	100
M. suaveolens(ME)	9	0	25	100
M. suaveolens(ME)	12	0	18.75	100

Table 3. Cumulative mortality of established *E. heterophylla* plants following treatment with respective aqueous extracts prepared from dried plant material. Mortality percentages were calculated from pooled data across three replicate trays for each treatment and concentration. *Representative photographic observations are presented in Figures 4–5.*

3.3 Mortality of established plants treated with fresh-material extracts

In the separate fresh-material endpoint assay, mortality ranged from 0 to 93.75%. *A. aspera* produced 18.75–68.75% mortality, *J. gossypiifolia* 37.50–62.50%, *L. camara* 12.50–68.75%, *L. aspera* 0–93.75%, and *M. suaveolens* 25.00–81.25%. The highest observed mortality was 93.75% for *L. aspera* at 12%, while the lowest was 0% for *L. aspera* at 3%. The concentration response was not strictly monotonic for all extracts.

Plant extract	Concentration (%)	Endpoint mortality (%)
A. aspera(AC)	3	18.75
A. aspera(AC)	6	50
A. aspera(AC)	9	43.75
A. aspera(AC)	12	68.75
J. gossypiifolia(JA)	3	37.50
J. gossypiifolia(JA)	6	56.25

Plant extract	Concentration (%)	Endpoint mortality (%)
J. gossypiifolia(JA)	9	43.75
J. gossypiifolia(JA)	12	62.50
L. camara(LA)	3	12.50
L. camara(LA)	6	68.75
L. camara(LA)	9	68.75
L. camara(LA)	12	62.50
L. aspera(LU)	3	0
L. aspera(LU)	6	75.00
L. aspera(LU)	9	68.75
L. aspera(LU)	12	93.75
M. suaveolens(ME)	3	25.00
M. suaveolens(ME)	6	62.50
M. suaveolens(ME)	9	62.50
M. suaveolens(ME)	12	81.25

Table 4. Endpoint mortality of established *E. heterophylla* plants following treatment with aqueous extracts prepared from fresh plant material. Mortality percentages are presented for each treatment and concentration. *Representative photographic observations are presented in Figures 6–7.*

3.4 Pollen germination

In the untreated control, 10 of 44 observed pollen grains germinated (22.73%). No germination was observed among the examined pollen grains exposed to 2% extracts of *A. aspera*, *J. gossypiifolia*, *L. camara*, *L. aspera* or *M. suaveolens*.

Treatment	Extract concentration (%)	FOVs examined (n)	Pollen grains observed (n)	Pollen grains germinated (n)	Germination (%)
Control	0	3	44	10	22.73
A. aspera(AC)	2	3	48	0	0
J. gossypiifolia(JA)	2	3	39	0	0
L. camara(LA)	2	3	37	0	0
L. aspera(LU)	2	3	33	0	0
M. suaveolens(ME)	2	3	42	0	0

Table 5. Pollen germination of *E. heterophylla* in the presence of respective 2% aqueous plant extracts. Counts represent the three microscopic fields examined per treatment. *Representative photographic observations are presented in Figure 8*

4. Discussion

The present study demonstrates that crude aqueous extracts of five plant species can suppress *E. heterophylla* at several developmental stages under the experimental conditions. The seed-germination assay showed a clear difference between the untreated control and extract-treated seeds, with week-3 germination remaining below the control for every extract and concentration. The strongest suppression generally occurred at 12%, although the response was not perfectly monotonic at intermediate concentrations. Such departures from a simple concentration–response relationship may occur in crude plant extracts because the abundance and interactions of multiple water-soluble compounds can vary with concentration and plant material. The seed-germination findings are consistent with previous reports of phytotoxic or allelopathic activity against *E. heterophylla* and other weeds. Aqueous mixtures of *Urochloa ruziziensis* and *Sorghum bicolor* have been reported to inhibit *E. heterophylla* germination and seedling growth, while aqueous *Ilex paraguariensis* extracts have also shown inhibitory effects on this weed (dos Santos Novakoski et al., 2020; da Silva et al., 2019). Activity of *A. aspera*, *J. gossypiifolia*, *L. camara*, *L. aspera* and *M. suaveolens* has likewise been reported in phytotoxicity or allelopathy studies (Tanveer et al., 2019; Lopes et al., 2022; Gindri et al., 2020; Alemayehu et al., 2024; Islam et al., 2014; Pattanayak and Maiti, 2026).

The established-plant assay indicates that the effects of the dried-material extracts were strongly time-dependent. No mortality occurred during the first five days, but mortality increased by days 6–10 and reached 100% by days 11–15 in all treatments. *L. aspera* showed the greatest early activity at 3%, whereas the early response of several other extracts varied across concentrations. Because the replicate-level data were pooled and no inferential tests were possible, these differences should be viewed as descriptive rather than evidence of statistically different extract performance. The fresh-material assay provides complementary evidence that extracts prepared without drying can also affect established plants. The maximum observed endpoint mortality was 93.75% for *L. aspera* at 12%. The lack of a uniform concentration response across all species reinforces the need for controlled concentration–response experiments using independent biological replicates and appropriate statistical models before selecting an optimal application rate. The pollen assay showed no observed germination after exposure to 2% extracts, whereas 22.73% of control pollen grains germinated in the examined fields. This observation suggests that the crude extracts can interfere with pollen germination under the assay conditions. However, the assay used only three microscopic fields per treatment and the pollen-germination medium requires further validation; therefore, the result should not be interpreted as proof of reduced fertilization or seed production in whole plants.

The phytotoxic effects may be associated with secondary metabolites such as phenolics, flavonoids, terpenoids or other water-soluble compounds, but the present study did not characterize the chemical composition of the extracts. Similar compound classes have been implicated in allelopathic activity in studies of *J. gossypiifolia* and *M. suaveolens* (Lopes et al., 2022; Pattanayak and Maiti, 2026). Consequently, mechanisms of action cannot be assigned from these data alone. Future work should combine chemical profiling with dose–response analysis, crop-selectivity assays, non-target testing, greenhouse trials with independent replicates and field validation.

5. Limitations and implications for future work

Several limitations should be considered when interpreting the findings. First, replicate-level raw data were not available for all endpoints, preventing formal statistical inference and estimation of variability. Second, seedling-growth measurements were recorded descriptively as ranges and leaf counts rather than as replicate-level quantitative measurements. Third, the pollen assay was based on three microscopic fields per treatment

and therefore represents a preliminary screening observation. Fourth, the extracts were crude aqueous preparations and were not chemically characterized, so the compounds responsible for the observed effects remain unknown. Finally, the experiments were conducted under controlled greenhouse and laboratory conditions and do not establish crop selectivity, environmental safety or field-level bioherbicidal efficacy. Future studies should preserve replicate-level raw data, increase independent biological replication, quantify seedling biomass and growth responses, establish full concentration–response curves, characterize active constituents, evaluate crop selectivity and non-target effects, and validate promising treatments under greenhouse and field conditions.

6. Conclusions

Aqueous extracts prepared from *A. aspera*, *J. gossypiifolia*, *L. camara*, *L. aspera* and *M. suaveolens* exhibited phytotoxic activity against *E. heterophylla* under the experimental conditions. All five extracts reduced seed germination relative to the untreated control, and the strongest suppression generally occurred at the highest tested concentration. Dried-material extracts produced no mortality during days 1–5 but reached 100% cumulative mortality by days 11–15 at all tested concentrations. In the separate fresh-material endpoint assay, mortality reached 93.75% for *L. aspera* at 12%. No pollen germination was observed in the examined fields exposed to 2% extracts. These findings support further investigation of the tested plants as sources of phytotoxic compounds, but they do not establish practical bioherbicidal efficacy. Chemical characterization, independent replicated experiments, concentration–response modelling, crop selectivity, non-target assessment and greenhouse and field validation are required before agricultural application can be recommended.

7. Figures

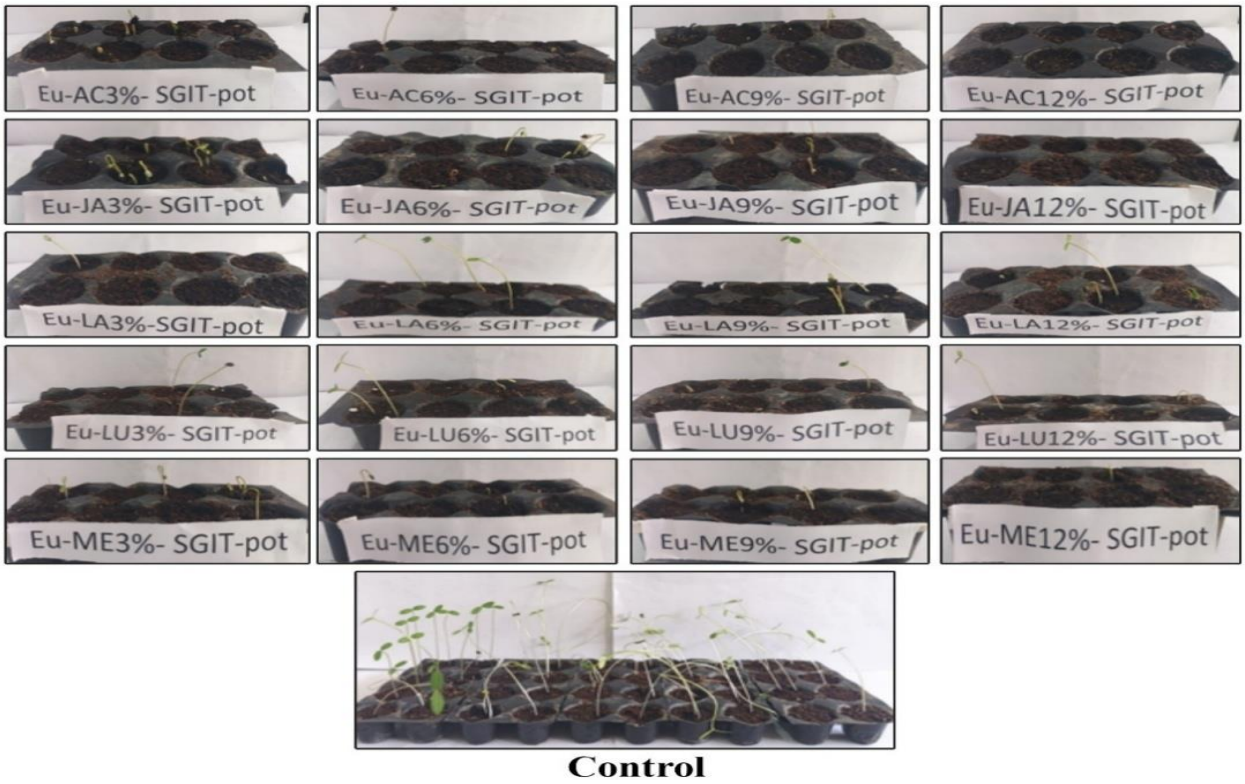


Figure 1. Representative images of *E. heterophylla* seed germination after one week in cocopeat incorporated with dried material extract at 3, 6, 9 and 12%. *(3.1 Seed germination and seedling observations)*

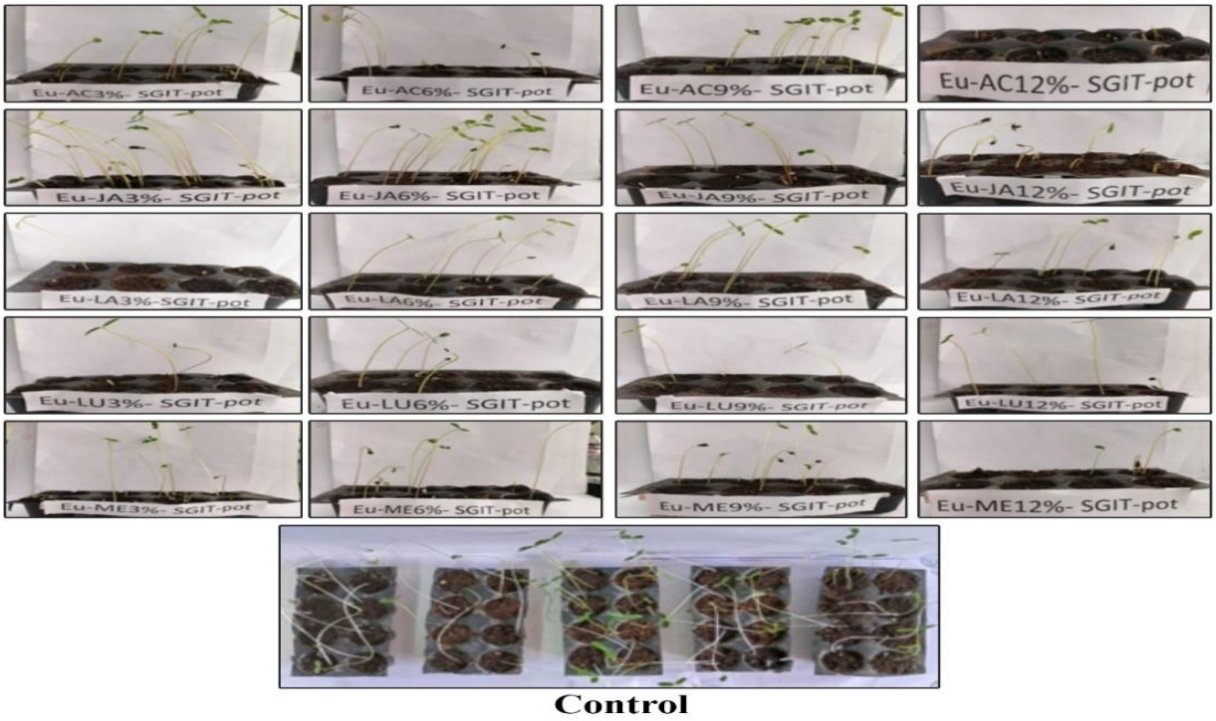


Figure 2. Representative images of *E. heterophylla* seed germination after two weeks in cocopeat incorporated with dried-material extract at 3, 6, 9 and 12%. *(3.1 Seed germination and seedling observations)*

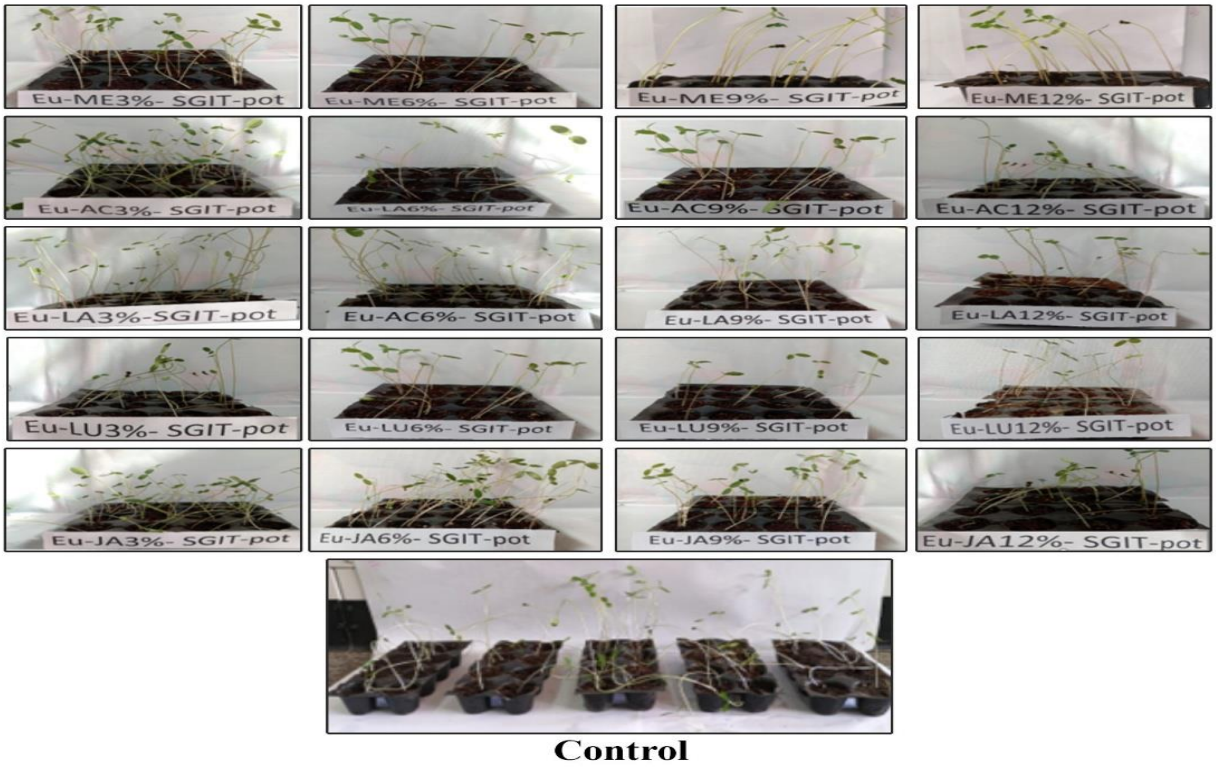


Figure 3. Representative images of *E. heterophylla* seed germination after three weeks in cocopeat incorporated with dried-material extract at 3, 6, 9 and 12%. *(3.1 Seed germination and seedling observations)*

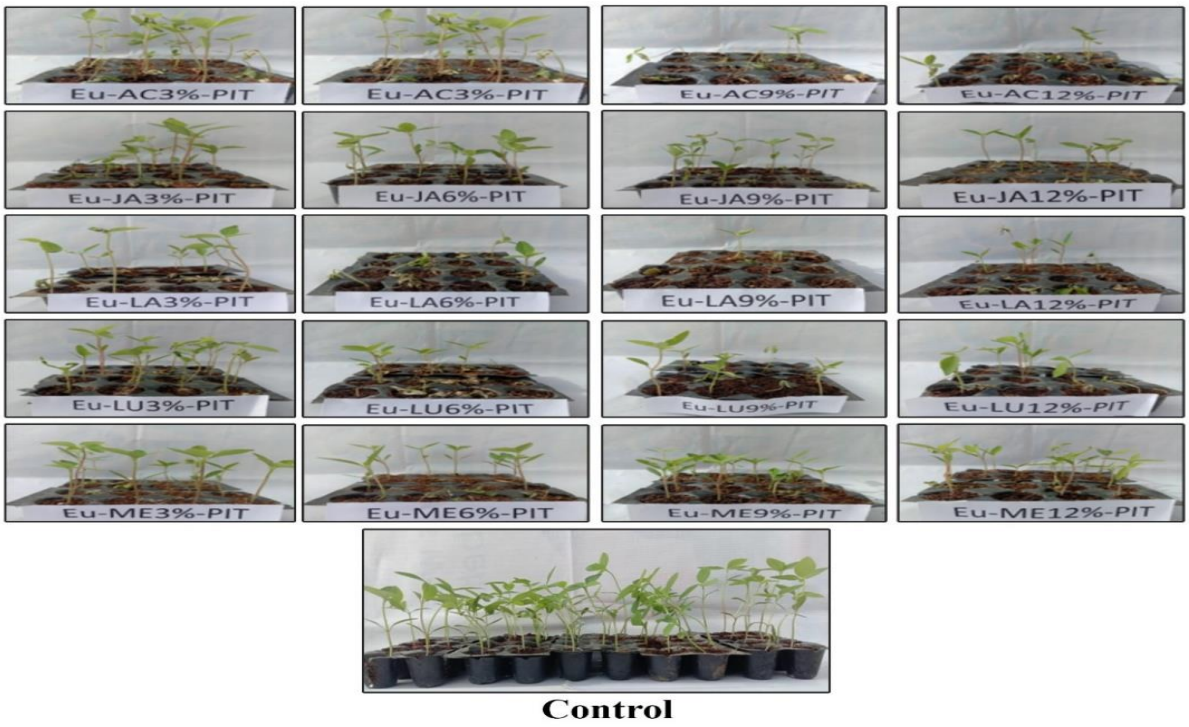


Figure 4. Representative images of *E. heterophylla* plant growth during the first week after treatment with dried-material aqueous extracts. *(3.2 Mortality of established plants treated with dried-material extracts)*

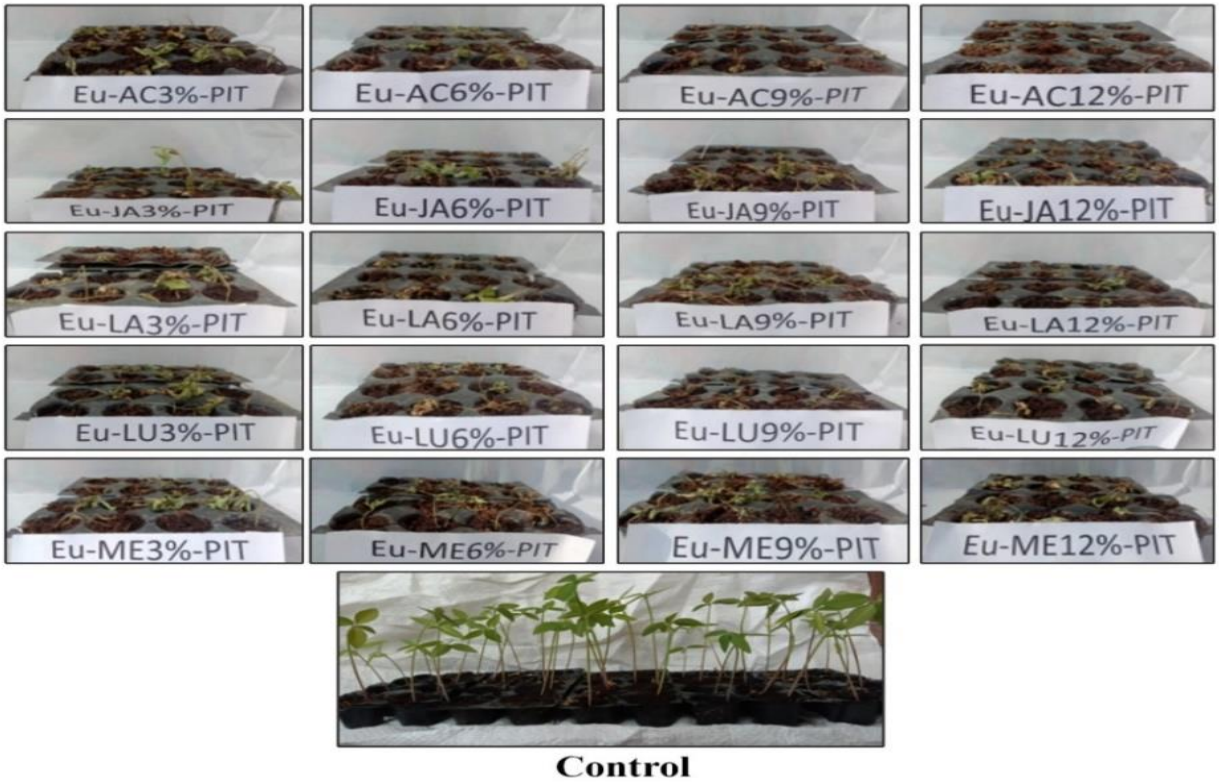


Figure 5. Representative images of *E. heterophylla* plant growth during the second week after treatment with dried-material aqueous extracts. *(3.2 Mortality of established plants treated with dried-material extracts)*

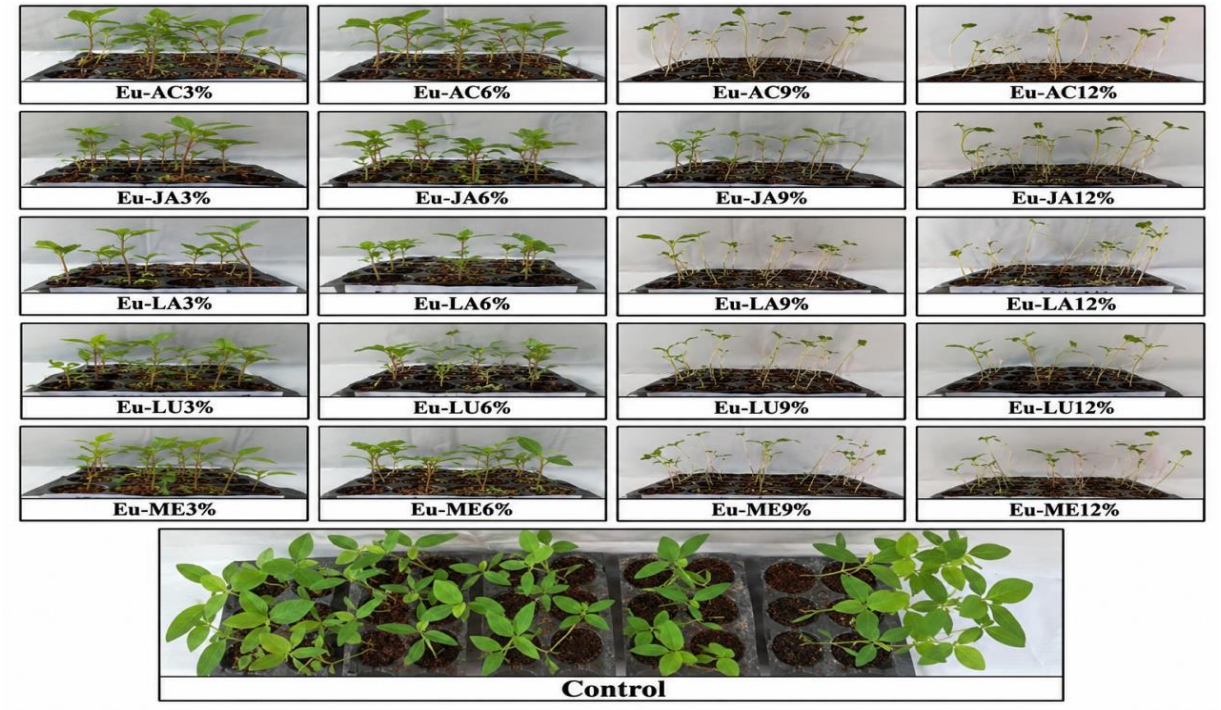


Figure 6. Representative images of *E. heterophylla* plant growth during the first week after treatment with fresh-material aqueous extracts. *(3.3 Mortality of established plants treated with fresh-material extracts)*

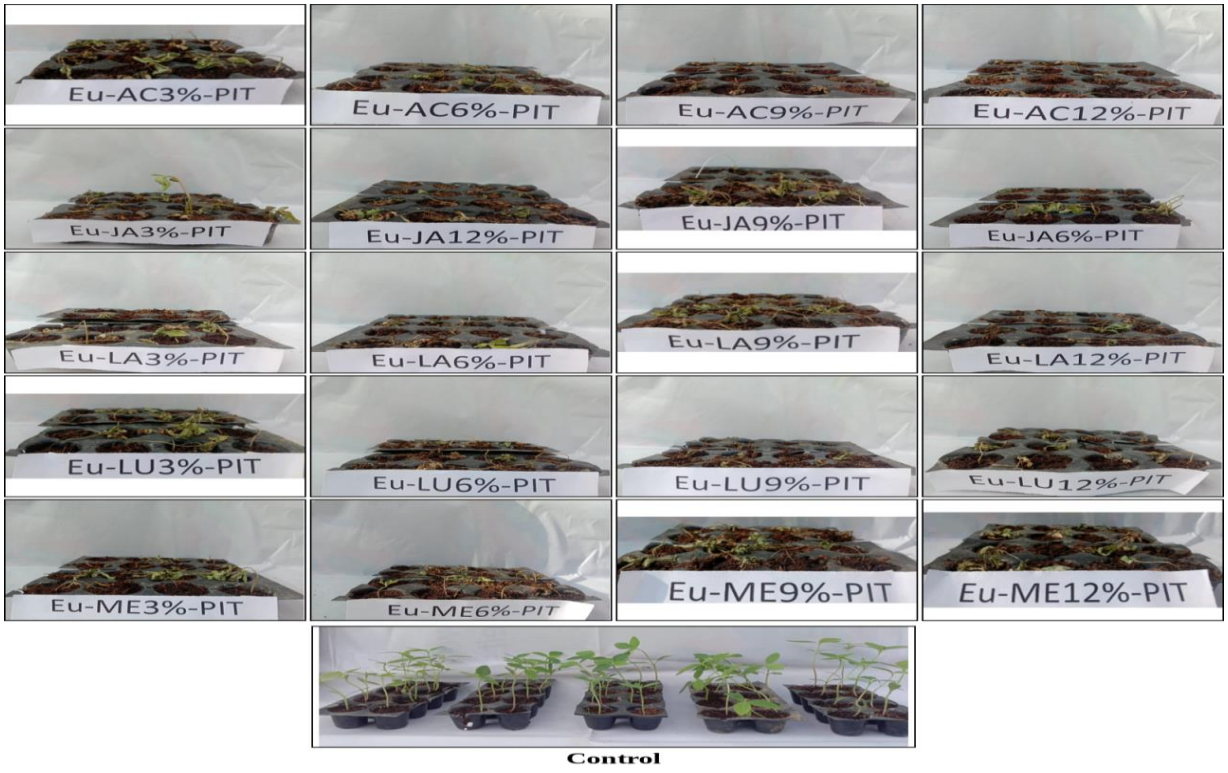


Figure 7. Representative images of *E. heterophylla* plant growth during the second week after treatment with fresh-material aqueous extracts. *(3.3 Mortality of established plants treated with fresh-material extracts)*

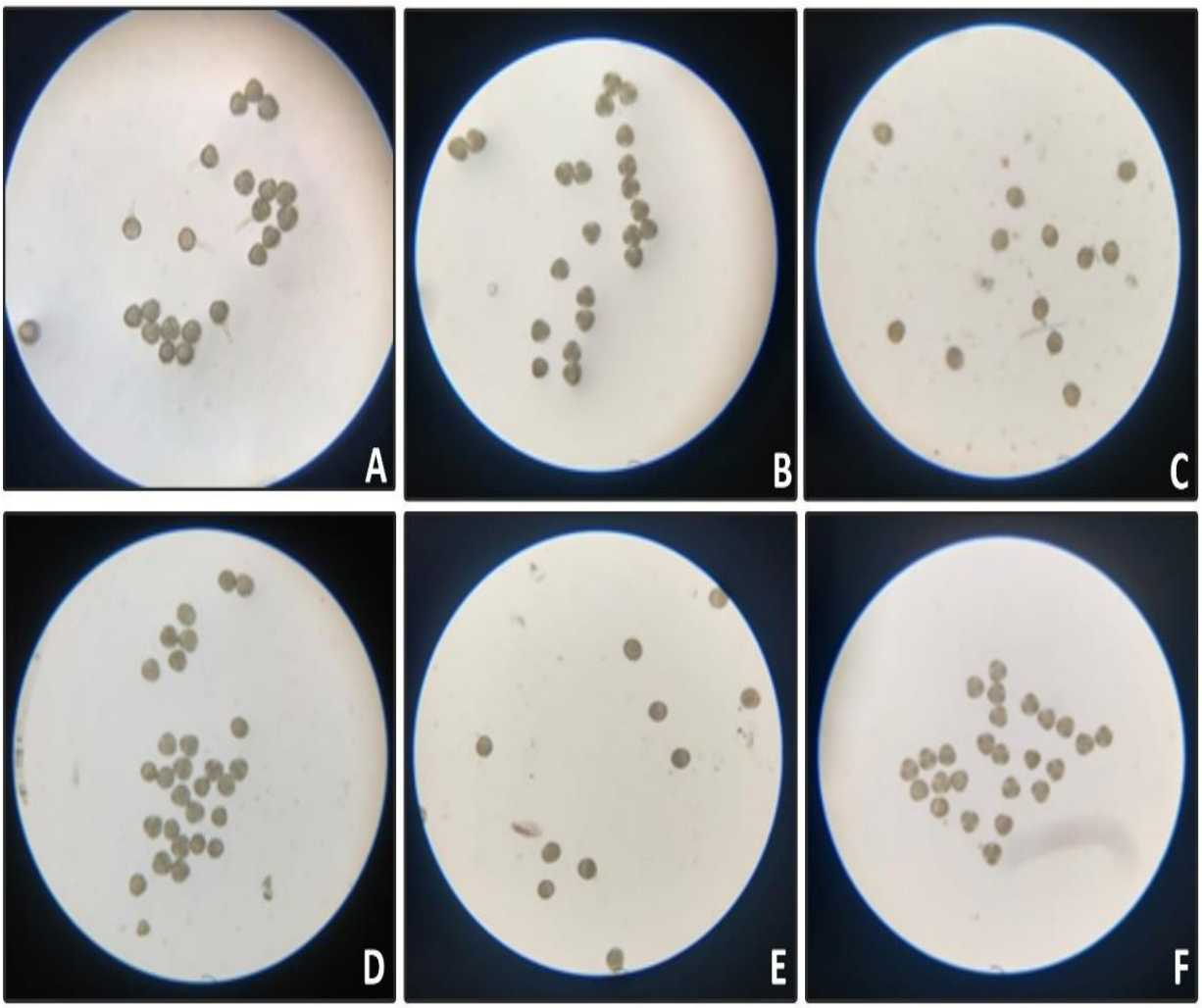


Figure 8. Pollen-germination assay showing the effects of 2% aqueous plant extracts. **A**, control; **B**, *A. aspera*; **C**, *J. gossypiifolia*; **D**, *L. camara*; **E**, *L. aspera*; **F**, *M. suaveolens. (3.4 Pollen germination)*

8. Author Contributions

Mohammed Khalid: Writing–review & editing, Writing–original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Conceptualization, Funding acquisition, Data curation.
Rifath Tanzeem Y: Writing–original draft, Formal analysis, Data curation.
Ayesha Tabassum: Writing–review & editing, Funding acquisition, Conceptualization.
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9. Declarations

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11. References

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